Lecture Compendium

ADVANCES IN PACKAGING OF DAIRY AND FOOD PRODUCTS

The Fifteenth Short Course

FEBRUARY 13th – MARCH 5th, 2003

Organised under the aegis of

CENTRE OF ADVANCED STUDIES

DIVISION OF DAIRY TECHNOLOGY
NATIONAL DAIRY RESEARCH INSTITUTE
KARNAL - 132001
Food is the base of life. The journey of life begins with food in the form of mother’s milk. The food sector is the fastest growing sector in India. The green and white revolutions have taken the country to the position of strength and self-reliance. Yet time and again a considerable quantum of foods, fresh produce are lost due to spoilage and damages. Being seasonal in character, there is a glut at a particular period and the scarcity at other times. These factors influence both cost and availability of foods.

Dairy products, edible oils, farm produce, fruit juices, concentrates, hot & cold beverages, extruded & breakfast foods, biscuits & confectionary are some major foods of daily necessities where packaging has excellent potential and growth areas. The achievements of food packaging industry are reflected in the availability of an array of spectacular range of packaging materials and systems. The development of active packaging, aseptic packaging, gas/vacuum packaging, biobased packaging have revolutionised the food industry. The growing consumer consciousness, convenience needs, increasing disposal problems, environmental concerns, and health & hygiene sense demand further advancement in the packaging technology. Packaging of foods for space expeditions has added a new dimension to packaging technology.

Dairy Technology Division of National Dairy Research Institute, the premier institute of dairying is endeavouring for the human resource development in dairy and food sector of the country. Centre of Advanced Studies (CAS) offers short courses to the faculty of SAUs and ICAR Institutes to abreast them with the latest developments in the field of dairy and food technology. CAS in Dairy Technology is now offering 15th short course on ‘Advances in Packaging of Dairy and Food Products’.

In our country food packaging is still in its infancy and this short course under the aegis of CAS is an attempt to enlighten the participants with the recent developments taking place in the field of packaging of dairy and food products. I hope this course will benefit the participants and through them their respective institutes. This Compendium will serve as a useful reference material and provide an insight in the field of packaging of dairy and food products.

NAGENDRA SHARMA
Director, NDRI
ACKNOWLEDGEMENT

The Dairy Technology Division of National Dairy Research Institute, Karnal is recognized as a Centre of Advanced Studies by Indian Council of Agricultural Research (ICAR). Since 1996 the CAS (DT) has offered 14 courses to benefit the teachers and scientists based in various SAUs and ICAR institutes. Naturally we would not have accomplished this ominous task without benevolence of the ICAR particularly Dr. J. C. Katyal, DDG (Education) and Dr. H. S. Nainawati, ADG (HRD-II) for taking keen interest in the progress of our short courses and also for timely release of funds.

I express my sincere gratitude to our Director Dr. Nagendra Sharma who helped us in each and every way and placed all the support at our disposal for managing the activities of this CAS course. I also thank Dr. N. Balaraman, Joint Director (Research) for his valuable suggestions.

The credit of coordinating entire programme goes to Dr. G. K. Goyal, Principal Scientist and Course Coordinator. He has worked diligently for making this programme successful. For accomplishing this work smoothly I must thank chairman and the members of various committees. I also thank Dr. R.R.B. Singh, Dr. A.A. Patel, Dr. R.S. Mann, Dr. Dharam Pal, Dr. S.K. Kanawjia, Dr. Alok Jha, Dr. Latha Sabikhi and Dr. A.K. Singh for their help in this course.

I am thankful to the guest speakers Prof. K. R. Kumar, Head, Food Packaging Technology, CFTRI Mysore; Mr. P. K. Sharma, Joint Director, BIS, New Delhi and Dr. (Ms) Vijay Sethi, Principal Scientist, IARI, New Delhi who contributed the lectures in time and travelled all the way to Karnal to share their valuable expertise with the participants. I must convey my special thanks to our faculty for timely submission of lectures and for actively participating in conduct of theory and practical classes. The faculty of other Divisions particularly Dairy Chemistry, Dairy Microbiology, Dairy Engineering and Computer Centre needs special mention for helping us in this endeavour.

I specially thank Mr. I. P. Paltani for his keen interest and very significant contribution in designing the cover page and preparation of this Compendium. I also express my appreciation for help extended by Mr. Ved Prakash, Private Secretary and Ms. Kusum Lata, Sr. Clerk for word-processing. I thank all my colleagues in the Dairy Technology Division for their contribution and support. I also acknowledge the help of Mr. A. K. Sharma, D.S. and Technical staff of Experimental Dairy in smooth conduct of practical training of the participants.

G. R. Patil
Head, DT Division &
Director, CAS (DT)
COMMITTEES FOR ORGANISATION OF THE

15th SHORT COURSE ON ‘ADVANCES IN PACKAGING OF DAIRY AND FOOD PRODUCTS’ FROM 13th FEB TO 5th MAR 2003

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<td>Mr. F.C. Garg</td>
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9:30 AM- 9.55 AM  Registration  Dr. S.K. Kanawjia
10.00 AM-10.40 AM  Inauguration  Mr. S.K. Talwar
10.40 AM-11.30 AM  Visit to Audio-Visual Lab.  Mr. A.K. Sharma, D.S
11.30 AM-12.15 PM  Visit to Experimental Dairy  Mr. P. Muruganatham
12.15 PM- 1.00 PM  Visit to Library  Mr. P. Muruganatham
1.00 PM – 2.00 PM  LUNCH
2.15 PM- 3.15 PM  Visit to Computer Centre  Dr. D.K. Jain
3.15 PM - 3.30 PM  TEA BREAK
3.30 PM – 4.00 PM  Status of packaging in India  Dr. G.R.Patil
4.00 PM – 4.30 PM  Visit to D.T. Division  Mr. Ram Swarup

14.2.2003  FRIDAY
9.45 AM –1.00 PM  Study of Model Dairy Plant  Mr. B.B. Raina &
(TEA BREAK 11.15-11.30 AM)  Dr. A.K. Singh
1.00 PM – 2.00PM LUNCH
2.15 PM - 3.15 PM  Testing of packaging materials  Mr. F.C. Garg
3.15 PM - 3.30 PM  TEA BREAK
3.30 PM –4.30 PM  Library consultation for literature search  Mr. P. Muruganatham

15.2.2003  SATURDAY
9.45 AM – 1.00 PM  In-plant training in Experimental Dairy  Mr. A.K.Sharma D.S.
(TEA BREAK 11.15-11.30 AM)
1.00 PM – 2.00 PM  LUNCH
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**16.2.2003**
**SUNDAY**

**17.2.2003**
**MONDAY**

- **9.45AM – 1.00 PM**
  - In-plant training in Experimental Dairy
  - Mr. A.K. Sharma D.S.
- **1.00 PM – 2.00 PM**
  - LUNCH
- **2.15 PM – 3.15 PM**
  - Packaging of meat, poultry & fish
  - Dr. R. R. B. Singh
- **3.15 PM – 3.30 PM**
  - TEA BREAK
- **3.30 PM – 4.30 PM**
  - Aseptic packaging of foods
  - Dr. R. R. B. Singh

**18.2.2003**
**TUESDAY**

- **9.45 AM – 1.00 PM**
  - In-plant training in Experimental Dairy
  - Mr. Hari Ram Gupta
  - (TEA BREAK 11.15-11.30 AM)
- **1.00 PM – 2.00 PM**
  - LUNCH
- **2.15 PM-3.15 PM**
  - Control of microbiological spoilage in food products during packaging and storage
  - Dr. D. N. Gandhi
- **3.15 PM – 3.30 PM**
  - TEA BREAK
- **3.30 PM – 4.30 PM**
  - Determination of thickness of plastic films/laminates (Practical)
  - Mr. F.C. Garg & Dr. B.B. Verma

**19.2.2003**
**WEDNESDAY**

- **9.45 AM- 11.15 PM**
  - Literature search in library
  - Mr. P. Muruganatham
- **11.15 AM- 11.30 AM**
  - TEA BREAK
- **11.30 AM -12.30 PM**
  - Indian standards on packaging code for foodstuffs
  - Mr. P. K Sharma
- **12.30 PM - 1.00 PM**
  - Discussion
- **1.00 PM – 2.00 PM**
  - LUNCH
- **2.15 PM – 3.15 PM**
  - Non-thermal preservation and packaging of fruits and vegetables
  - Dr. (Ms) Vijay Sethi
- **3.15 PM – 3.30 PM**
  - TEA BREAK
3.30 PM – 4.30 PM  Packaging and storage of dried products  
                     Dr. (Ms) Vijay Sethi

**20.2.2003 THURSDAY**

9.45 AM – 1.00 PM  In-plant training in Experimental Dairy  
                     Mr. Hari Ram Gupta  
                     (TEA BREAK 11.15-11.30 AM)

1.00 PM – 2.00 PM  LUNCH

2.15 PM – 3.15 PM  Toxicological aspects of packaging materials  
                     Dr. J.S.Sindhu

3.15 PM – 3.30 PM  TEA BREAK

3.30 PM – 4.30 PM  Packaging of traditional Indian dairy products: present status & future prospects  
                     Dr. Dharam Pal

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9.45 AM – 1.00 PM  In-plant training in Q.C. Lab.  
                     Dr. Jessa Ram  
                     (TEA BREAK 11.15-11.30 AM)

1.00 PM - 2.00 PM  LUNCH

2.15 PM – 4.30 PM  Determination of grease resistance of packaging materials (Practical)  
                     Mr. F.C. Garg & Mr. Ram Swarup  
                     (TEA BREAK 3.15-3.30 PM)

**22.2.2003 SATURDAY**

9.45 AM – 10.45 AM  Retort packaging for long shelf-life foods  
                     Dr. Alok Jha

10.45 AM – 11.15 AM  Discussion

11.15 AM- 11.30 AM  TEA BREAK

11.30 AM – 12.30 PM  Metal containers for food packaging  
                     Prof. I.K. Sawhney

12.30 PM - 1.00 PM  Discussion

1.00 PM - 2.00 PM  LUNCH

2.15 PM – 4.30 PM  Determination of tearing resistance of packaging Materials (Practical)  
                     Mr. F.C. Garg & Dr. G.K. Goyal  
                     (TEA BREAK 3.15-3.30 PM)

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10.45 AM – 11.15 AM Discussion
11.15 AM - 11.30 AM TEA BREAK
11.30 AM – 12.30 PM Developments in the packaging of milk and cream Dr. V.K. Gupta
12.30 PM - 1.00 PM Discussion
1.00 PM - 2.00 PM LUNCH
2.15 PM – 4.30 PM Determination of moisture absorptiveness of packaging materials (Practical) Mr. F.C. Garg & Dr. B.B. Verma

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10.45 AM – 11.15 AM Discussion
11.15 AM - 11.30 AM TEA BREAK
11.30 AM – 12.30 PM Shelf life of packaged foods Dr. A.A. Patel
12.30 PM - 1.00 PM Discussion
1.00 PM - 2.00 PM LUNCH
2.15 PM – 4.30 PM Determination of bursting strength of packaging materials (Practical) Mr. F.C. Garg & Dr. G.K. Goyal

26.2.2003 WEDNESDAY
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10.45 AM – 11.15 AM Discussion
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11.30 AM – 12.30 PM Role of sensory evaluation in selection of packaging materials for dairy products Dr. Dharam Pal
12.30 PM - 1.00 PM Discussion
1.00 PM - 2.00 PM LUNCH
2.15 PM – 4.30 PM Influence of different chemicals on shelf life of fresh produce (Practical) Dr. A.K. Singh

(TEA BREAK 3.15-3.30 PM)
27.2.2003

**THURSDAY**

9.45 AM – 10.45 AM  Application of Internet for dairy and food packagers  Mr. A.K. Sharma  (Computer Section)

10.45 AM – 11.15 AM  Discussion

11.15 AM – 11.30 AM  TEA BREAK

11.30 AM – 12.30 PM  Packaging systems for food applications  Prof. K.R. Kumar

12.30 PM - 1.00 PM  Discussion

1.00 PM - 2.00 PM  LUNCH

2.15 PM – 4.30 PM  Multimedia Presentation (Practical)  Mr. A.K. Sharma  (TEA BREAK 3.15 –3.30)  (Computer Section)

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9.45 AM – 10.45 AM  Developments in the packaging of sugar and chocolate confectionery  Prof. K.R. Kumar

10.45 AM – 11.15 AM  Discussion

11.15 AM – 11.30 AM  TEA BREAK

11.30 AM – 12.30 PM  Bar coding in packaging  Prof. K.R. Kumar

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1.00 PM - 2.00 PM  LUNCH

2.15 PM – 4.30 PM  Determination of GSM of paper & Paperboard (Practical)  Mr. F.C. Garg & Dr. R.S. Mann  (TEA BREAK 3.15 –3.30)

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2.3.2003  **SUNDAY**

3.3.2003  **MONDAY**

9.45 AM – 10.45 AM  Disposal of packaging waste  Dr. D.K.Thompkinson

10.45 AM – 11.15 AM  Discussion

11.15 AM – 11.30 AM  TEA BREAK

11.30 AM – 12.30 PM  Advances in packaging of space foods  Dr. G. K. Goyal

12.30 PM - 1.00 PM  Discussion

1.00 PM - 2.00 PM  LUNCH

2.15 PM – 4.30 PM  Determination of specifications of glass bottles and thermal shock test (Practical)  Mr. F.C. Garg & Dr. G. K. Goyal  (TEA BREAK 3.15 –3.30)
4.3.2003  
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10.45 AM – 11.15 AM  Discussion
11.15 AM – 11.30 AM  TEA BREAK
11.30 AM – 12.30 PM  Modified atmosphere packaging for dairy and food industry  Dr. S.K. Kanawjia
12.30 PM - 1.00 PM  Discussion
1.00 PM – 2.00 PM  LUNCH
2.15 PM – 4.30 PM  Modified atmosphere packaging of dairy products (Practical)  Dr. S.K. Kanawjia & Mr. Ram Swarup
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5.3.2003  
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10.45 AM – 11.00 AM  Discussion
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1.0 INTRODUCTION

Packaging can be defined as a tool that protects and contains our goods with the aim of minimising the environmental impact of our consumption. Ideal packaging can be compared with that of a banana, orange peel, coconut and eggshell—the packaging provided by Mother Nature.

Considerable advancements have taken place in the area of food packaging. A major change has been our ability to protect and preserve products with packaging. We have ensured the availability of products out of season, over long distances in various forms, fresh as well as processed. Today, the consumer has a wider selection of food items. Armed with disposable income, he is keen to try new products. This makes us look at the additional requirements of packaging in competition with Mother Nature.

Packaging has become a socio-scientific discipline with the modern role of:

- Containing and safety that is of paramount importance.
- Facilitating the handling, storage and distribution.
- Protecting against biological, chemical and distribution damages
- Providing convenience
- Informing through the medium of labeling
- Security through a tamper-evident design
- Contributing to the product image through structural and graphic design
- Increasing the shelf-life and ensuring longer availability.
- As a marketing and advertising tool.
- Environment protection by taking responsibility of empty packaging after its use.

I think the best packaging, as defined by Mr. Robert Rausina, Tetra Pack Swedish founder is, "The one that saves more than its cost, including refrigeration, transportation, storage, handling, labor etc."

2.0 STATUS OF FOOD PACKAGING INDUSTRY IN INDIA

The packaging industry in India is a heterogeneous mix of both organised and unorganised sectors. The industry comprises of manufacturers of basic materials, converted package forms, ancillary materials and packaging machinery. The packaging conversion machinery and ancillary materials production units are primarily in the small-scale sector and being gradually updated to reach international standards.
status of food packaging in India

standards. The packaging lines generally occupy 50% of the floor space, and the packaging and related activities engage about 60% of the 5 million labour force concerned with the Indian food industry. It is estimated that during the year 1995 the money spent on food packaging materials and packages alone amount to nearly Rs. 29,000 million. Another Rs. 10,000 million is spent on packaging operations and related activities making a total of Rs. 30,000 millions. This constitutes nearly 1% of the total value of the primary processed foods and 15% of the value of secondary and tertiary processed foods produced in the country. It is estimated that the amount can nearly be doubled by the year 2000. The packaging materials manufactured by the industry are tinplate, aluminium, glass, plastics, paper and board, jute etc (Narayanan and Dordi, 1998).

Food industry is the major user of packaging materials both in terms of variety and quantity. The production of tinplate containers is estimated to be 0.46 million tonnes and more than 0.3 million tonnes are imported. The use of tinplate containers used for food packaging is estimated to be 0.4 million tonnes. The growth of this industry is threatened by the development of alternate materials like plastic containers, films, and laminates. Aluminium cans used for carbonated drinks and beer amounting to 0.035 million tonnes, and aluminium foil used as tagger, in laminates for food packaging applications and as tea chest liners account for 7,000 tonnes. The production of glass bottles and hollow wares for packaging purposes is estimated to be 0.9 million tonnes, of which one-third quantity is used in the food sector. Paper and paperboards are also used in the food industry as cartons, in laminates as combibloc, aseptic cartons, etc. Corrugated fibreboard boxes are the most popularly used media for distribution of goods. 0.9 million tonnes of boards are produced of which 17% is used for distribution of food products. Plastics are used in the food industry in the form of containers/bottles as well as films, co-extruded materials and laminates.

Table-1 gives the demand estimates of flexible packaging materials where the growth rate is predicted to be 20% per annum and Table 2 gives an overview of packaging materials used in dairy industry.

3.0 CHOICE OF AN APPROPRIATE PACKAGING MATERIAL

Choice of an appropriate packaging material is governed by several factors such as (Dhar, 2002):

- The specific sensitivities of the contents, e.g. moisture, oxygen, etc.
- Factors changing the contents viz. temperature, RH, pH, and the reaction mechanism involved.
- Weight and shape of the container
- Effect on filling and sealing speeds
- Contamination of food by constituents of the packing material
- Storage conditions - How long the product needs to be protected.
- Bio-degradability and recycling potential
Most of the food production has been in the rural pockets of the country, while the major markets are in urban areas. So the need for its transportation over long distances has become a necessity.

Dairy products being a highly perishable product, utmost care is needed in its preservation during storage, handling and transportation.

Dairy products spoil fast at high temperature, in the presence of oxygen and other contaminating agents present in the atmosphere.

There are many more peculiarities, which could be identified under the following headings for determining the packaging of dairy products:
- Product range
- Market
- Consumer needs
- Operating margins

### 3.1 Product range
- Heat-desiccated milk products - Peda, Burfi, Khoya, Basundi, Khurchan, etc.
- Concentrated milk products - Gulabjamun, Sandesh, Rasgulla, Rasmalai
- Frozen products - Kulfi, Ice-cream
- Fat-rich products - Ghee, Malai and Makhan Coagulated products - Channa and Paneer
- Fermented/cultured products - Dahi, Mishti Dohi, Lassi and Shrikhand

### 3.2 Market
The Indian dairy products market is huge with a domestic production of 83 million tons of milk.

The challenges before us are:
- Approximately 46% of the total milk production in the country is consumed as fluid milk.
- Only 15% of milk is packed.
- Only 14% of all the milk produced is processed. If we can create value-added products with appropriate packaging, things will be quite different in our country.
- The dairy industry is highly competitive and the margin of profit per unit is low in some basic products where consumption is high.
- The image of milk as a health beverage is being questioned. The milk segment of the beverage market is becoming vulnerable to attacks from other segments. One example is Sweden, where 'Light beer' is presented as a healthier alternative.

### 3.3 Consumer Needs
In deciding the type of packaging, consumer trends play a vital role. Some of the trends in the dairy industry in India are:
- Well-packed dairy products are associated with Quality.
- Packing is expected to make dairy products safe.
- Increasing mobile lifestyle.
- Time has become a precious commodity.
• The younger generation is looking for health and fitness conscious beverages.
• The consumer is ready to try new products.
• Concern for freshness.
• Seeking a home-meal dining experience. The traditional family meal no longer seems to exist.
• For children -innovative or fun flavored fortified milk.

3.3.1 Shift in Consumer perception of Packaging is noticeable from:
• Commodity to performance.
• Value and ease of use determine the cost of packaging.
• Package is not only the material it is a function for the product.
• The consumer has understood the effects of human consumption on the Environment and is looking for Environment Balance.
• Graphics have become a fashion industry, with tremendous improvement in pre-press and printing capabilities.

3.3.2 Attributes that consumer praise:
• Product quality and protection with a great emphasis on freshness.
• Easy to open, dispense, reseal and store.
• Appealing product presentation is gaining prominence.
• Durable and Eco friendly is being viewed together.
• Leak and spillage proof is a must for the producer as well as the consumer.
• Reusable packing.
• Less hassles, more convenience.
• Selection from a wider choice of available sizes.

3.4 Operating margins

Packaging for the growing dairy industry is an exciting topic. However, it is very difficult to deal with, because the dairy industry is highly competitive and the margin of profit per unit is low.

4.0 NEED FOR NEWER PACKAGING

The future of Packaging in increasing the consumption of Dairy products in our country seems to be bright. It must take into account the needs, markets and various other factors, such as:

4.1 External
• Rising disposable incomes.
• Programs to encourage milk consumption.
• Population growth.

4.2 Consumer
• Low fat/organic premium product.
• New tastes.
• Health food & drinks.

4.3 Retailers
• Convenient storage and distribution network.
- Modern retail network.
- Availability.
- Display.
- Doorstep delivery.

4.4 Manufacturers
- New product development.
- Value-adding.
- Target/Niche market.
- Competitive price.
- Branding.
- Abreast with technology demands.

5.0 FUTURE IN DAIRY PACKAGING:

In the dairy industry almost all types of Packaging materials have been used. Developments and innovations are aimed at various alternatives and systems.

5.1 Fluid Milk/UHT Milk
- Use of octane base to reduce cost and leakage losses.
- Recyclable polycarbonate containers for flavored milk.
- Plastic opaque bottles having brightly colored over-wraps and twist-off caps.
- A paper-milk cartons that features easy-open, easy pour with resealable cap. Offers convenience and locks in freshness; a stand-up, flexible single-service pouch which has an integrated sipping tube.
- A light and squeezable package made by precise injection molded neck finish so as to be spill resistant and easy to open.
- The popular commercial systems available for aseptic packaging of milk are Tetra pack, Brick pack, Combi block, Pure pak, Hind Pak, etc. TFA launched by Tetra Pak keeps the milk fresh without refrigeration for about 15 days.
- Doypack system, which provides a shelf life of almost 90 days.
- Bag in Box system, etc.
- After the grand success of bottled water, the evolution of milk in Pet bottles for the single-serve market has created a sector that many fillers may want to look into.

5.2 Butter

Embossed aluminum foil parchment paper has emerged for UV light protection and eye appeal. In some countries, a popular packaging style preferred is plastic tubs and lids in many different shape and sizes. For such applications PP & ABS are widely used.

5.3 Milk Fat & Margarine

Sachets made from a laminate of PVD/Aluminum foil PP is suitable for long term storage of anhydrous milk fat. A flexible laminate containing dolomite and Pp,
with outermost layer being PP has been claimed to be suitable for margarine and spread like products.

5.4 Sweetened Condensed Milk

In Russia a combination of foil, lacquer and PP known as Lamistar is widely used.

5.5 Ice-cream

A cellulose based edible coating has been successfully tried on ice-cream sundae cone wafers. It helped in preventing moisture migration from the ice cream in the cone to the wafer, enabling the cone to remain crisper. Likewise, a biodegradable edible film based on alginites has been used to eliminate dripping in the ice cream.

5.6 Yoghurt

Two compartmental packages -crunchy nuts and fresh dried fruit are housed in one and yoghurt in the other. After removing the foil lid the contents could be mixed before consuming.

5.7 Dried Milk Powder

Improved tin cans are proving to be an economical and effective medium. Paper sacks with four layers of paper and inner layer of PE

5.8 Cheese

Multivac packaging, which helps incorporation of gas.

5.9 New Concepts

On the basis of need and the economic considerations following packaging, concepts are also available for adoption by the dairy industry:

- Active packaging, self-heating and self-chilling.
- Shelf-life time temperature indicators
- Micro-oven able containers
- Edible films and coatings
- Resource efficiency-reduction and light weighting.
- Bio-degradable materials

5.9.1 Process Technology:

- Vacuum Packaging
- Shrink wrapping
- MAP
- Oxygen Scavengers
- Better sealing techniques
- Aseptic in-line dosing to test milk before the filler
5.9.2 Packaging machinery:

This group typically includes filling, strip and blister pack, form-fill and seal machines or machines for filling bottles, cans, cup, trays, etc. A big void exists here if we compare it with imported machines. The development that needs to be augmented relates to speed and variety, accuracy and precision, versatility and efficiency. The present machines are lacking. Concerted efforts are needed in the progress of this complementary sector.

6.0 CONCLUSION

Technological progress and revolutionary improvements in the efficiency and economy of distribution of milk and milk products have led to innovation in the packaging line. New systems, materials, machinery, designs and environmental concerns are some innovations in the dairy packaging sector. These innovations have provided greater convenience to consumers, extended the shelf-life of products, lowered costs and also led improvements in sales, better hygienic conditions and introduced new products and easier handling. We need selective utilisation in the Indian, environment to satisfy the needs of consumers.

Some of the specific areas where technological gaps exists and improved sophistication are needed would be:

- Glass containers and metal containers and component making machinery for light-weight glass containers and improved varieties of OTS cans. Currently available technological levels have considerable scope for improvement and modernisation.

- or the paper and paperboard based packages, the technology available is more suited to small scale sector and considerable upgradation needed for quality, higher speeds, machinery for production of leak-proof composite cans and web-labelling.

- Machinery for production of multilayer films and bottles is yet to commercialised. Conventional die making technology for stretch blown and Injection blown containers are observed to have constraints with respect to high material consumption and poor finish.

- The packaging machinery needs to be provided with systems as in the developed, countries, to increase speed, automatic web splicing, special feeding mechanisms, types of materials and form, product mix. Facility for vacuum packaging and gas flushing and micro-processor control for form-fill-seal and thermoform-fill-seal machines are needed.

Modified and controlled atmosphere packaging provide interesting features of long life, optimum product quality maintenance, good and reliable sealing, adaptability to meet various production programmes and such systems are of extreme importance in growing context of packaging in the country. Such systems are yet to be developed and commercially adopted.

Similar is the situation in respect of aseptic packaging, thermoform-fill-seal, bag-in-box, retort packaging and the like. Other significant areas include material
handling, cartoning, lined carton system, blister packaging, microwavable packaging. Modernisation and upgradation is needed for labeling, coding, marking, special coating etc. in the area of ancillary packaging machinery.

Packaging is only one means, though effective, in the overall post-harvest system, to prevent food spoilage and losses. The added features towards food conservation and preservation still need to be recognised. This endeavour demands a systems approach to ensure improvement in the overall infrastructural facilities including cold chain movement. Simultaneously the laws and regulations pertaining to the food sector also need to be up-dated and streamlined and mechanism organised to systematically implement them.

**TABLE 1: DEMAND ESTIMATES FOR FLEXIBLE LAMINATES**

<table>
<thead>
<tr>
<th>Product</th>
<th>Packaging material</th>
<th>Demand 1998-99 (Tonnes)</th>
<th>Growth rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>LD/LD</td>
<td>58,344</td>
<td>5</td>
</tr>
<tr>
<td>Milk powder</td>
<td>Foil/Poly</td>
<td>175</td>
<td>15</td>
</tr>
<tr>
<td>Baby/malted food</td>
<td>Foil/Poly</td>
<td>6,296</td>
<td>15</td>
</tr>
<tr>
<td>Ghee</td>
<td>LD/HD</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Chocolate bars</td>
<td>Foil/Poly</td>
<td>437</td>
<td>15</td>
</tr>
<tr>
<td>Confectioneries/candy</td>
<td>Paper wax</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>PET/Poly</td>
<td>6,758</td>
<td>20</td>
</tr>
<tr>
<td>Ready-to-eat Foods</td>
<td>PET or BOPP/Poly</td>
<td>8,294</td>
<td>20</td>
</tr>
<tr>
<td>Edible oil</td>
<td>3 and 5 layer films</td>
<td>8,545</td>
<td>25</td>
</tr>
<tr>
<td>GEMS like products</td>
<td>BOPP/Poly</td>
<td>315</td>
<td>15</td>
</tr>
<tr>
<td>Vanaspati</td>
<td>LD/HD and Nylon based films</td>
<td>1,515</td>
<td>2</td>
</tr>
<tr>
<td>Biscuits</td>
<td>Paper wax</td>
<td>953</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Glassine/Poly</td>
<td>572</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Foil/Paper</td>
<td>5,995</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>PET or BOPP/Poly</td>
<td>12,610</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Paper/Poly</td>
<td>3,315</td>
<td>5</td>
</tr>
<tr>
<td>Bread</td>
<td>Paper wax</td>
<td>19,448</td>
<td>5</td>
</tr>
<tr>
<td>Tea</td>
<td>PET/Poly</td>
<td>11,710</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Paper/Poly</td>
<td>116</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Foil/Paper</td>
<td>1,082</td>
<td>2</td>
</tr>
<tr>
<td>Coffee</td>
<td>PET/Poly</td>
<td>1,757</td>
<td>10</td>
</tr>
<tr>
<td>Extruded foods</td>
<td>PET or BOPP/Poly</td>
<td>6,996</td>
<td>15</td>
</tr>
<tr>
<td>Spices</td>
<td>PET/Poly</td>
<td>1,679</td>
<td>15</td>
</tr>
<tr>
<td>Salt</td>
<td>LD/LLD</td>
<td>2,488</td>
<td>20</td>
</tr>
<tr>
<td>Potato chips</td>
<td>Met.PET or Foil Poly</td>
<td>4,147</td>
<td>20</td>
</tr>
<tr>
<td>Juices</td>
<td>Foil/Poly</td>
<td>439</td>
<td>10</td>
</tr>
</tbody>
</table>
### TABLE-2: AN OVERVIEW OF PACKAGING MATERIALS USED IN DAIRY INDUSTRIES

<table>
<thead>
<tr>
<th>Product</th>
<th>Packaging material</th>
</tr>
</thead>
</table>
| Liquid milk        | - Glass bottles (obsolete) .  
                      - LOPE film in combination with LLDPE or octane/butane-based films.  
                      - Paper laminate for tetra packs |
| Milk powder        | - Tin plate containers, nitrogen packed and lacquered from outside.  
                      - Flexible laminates such as metallized PET/BOPP/Aluminium foil/Poly laminates  
                      - Refill packs: Lined cartons laminated with BOPP/PET, varnished on the outside. Paper laminated film also used.  
                      - Bag-in-box: Powder filled in laminate and packed in cartons |
| Butter             | - Duplex board with vegetable parchment paper  
                      - Tinplate containers  
                      - Aluminium foil |
| Cheese/Cheese spread | - Tin plate containers lacquered from inside  
                      - Packed in AI foil and then in duplex board carton  
                      - Injection moulded PPI HOPE container |
| Ghee               | - Tinplate container (lacquered inside)  
                      - Glass bottles  
                      - HOPE film pouches |
| Ice cream          | - Thermoformed/injection moulded plastic containers  
                      - Duplex board cartons which are polylaminated  
                      - Laminates of BOPP or PET |
| Indigenous products | - Injection moulded/thermoformed containers (shrikhand, gulab jamun)  
                      - Stand-up laminated pouches |

### 7.0 REFERENCES


1.0 INTRODUCTION

BUREAU OF INDIAN STANDARDS is responsible for formulation of national standards in India in various fields of technology and science. BIS has developed Packaging Code on foodstuffs and perishables.

One of the main aims of standardization is to enhance acceptance and movement of goods at National/Global market by providing guideline standards covering packaging requirements utilizing packaging sizes. Packaging is a product of consumer interest, the cost of which is borne indirectly by consumer involving factors as safety, health, and fitness for purpose, comfort, reliability, environment protection, and energy conservation. In view of this packaging of Dairy and Food products has attained top priority, which has increased both in quantum as well as in variety.

2.0 ROLES AND IMPORTANCE OF STANDARDIZATION

2.1 Need of standardization

Standardization and Quality Control are effective management tools applicable to areas like plastic industry. Any development thrust could be rendered meaningless if we are unable to produce plastics to meet global market demand at competitive cost. Hence the backbone of any programme of growth and advancement should be the availability of standards on the basis of which viability of skill and profitability of the enterprise can be assessed. Hence it is essential to have documented specification on Packaging Code, raw material, finished products methods of tests etc.

2.2 Assessment of Technology and Product

Standardization and quality control provide tools to assess and receive the high technology necessary in this area.

2.2.1 To help the manufactures, Transport engineering Department has formulated standards on Packaging Code by Transport Packages and Packaging Codes Sectional Committee, which gives guidelines on the packaging of foodstuffs and perishables. In this code shelf life requirements are kept in mind as there is increase in types of materials and processes.[ (IS 10106 (Part I/Sec 1)]. To assist packers to take reasonable precaution to protect packages and their contents from attack by microorganisms, the code provides essential information and details. The appropriate method depends upon the environment
Indian standards on packaging code for foodstuffs

and susceptibility of the package and its contents to spoilage [(IS 10106 (Part I/Sec 6)]. The standard lays down the guiding factors that affect the selection of package for a particular product. The aim is to provide a source of information on the methods and materials used in packaging and provide guidance as to how they should be selected and used, in a generalized way since packaging requirements of any two products may differ fundamentally and no two products will be precisely identical [(IS 10106 (Part I/Sec 1): 1982].

3.0 STANDARDIZATION IN THE FIELD OF PLASTICS FOR FOOD PACKAGING

Standards for other products have been formulated by concerned technical departments depending upon the end use.

3.1 Plastics are being used on a large scale for packaging of foodstuffs, where direct contact occurs between the packed commodity and plastics. There is a likelihood of transfer of polymer additives, impurities such as monomer; catalyst remnants etc. from plastics into the packaged material resulting in toxic hazard to consumers of product packed in plastics. Now to help the manufacturers of basic raw-materials and fabricators of articles to assess the quality of their product, plastics Sectional Committee given below had formulated Indian Standards:

a. Food Grade plastics
b. Food Contact Plastics Containers
c. Method of Test for Plastics
d. Plastic Products
e. Plastic Sheets and Films
f. Thermoplastics
g. Thermosetting Plastics

3.2 There are 12 different types of thermoplastics used as raw materials for manufacturing of plastic products along with separate standard on positive list of constituents that have been formulated. These standards prescribe requirements, methods of test and sampling for respective materials, vis-à-vis positive list of constituents of respective material such as homopolymer, polymer etc. The standards are used for food contact application and to be used in combination to provide a system of control to the plastic manufactures as well as fabricators of thermoplastics packaging material to derive maximum benefits.

3.3 Bureau has formulated a guide on suitability of plastics for food packaging (IS 10171). It provides guidance to the food packer in selecting the specific thermoplastic material to design an acceptable food packaging system. Since there is always the possibility of transfer of a part of packaging material to the contents of packed material due to intimate contact, it is essential that formulation of the package should be selected to ensure that any such transfer is at minimum and substances which do migrate from the package to the packed material are within limits and cause no toxic hazards when consumed.

3.4 Advances in Food Packaging: Plastics raw materials are available in various forms such as foil, sheet, bottle, jar, jerry can sachet and containers of all shapes and sizes for food packaging. These are normally based on single plastics materials.
3.4.1 For Special Applications: More than one plastic raw material may be used. Co-extruded film, sheet, bottle etc. are based on two or more raw material extruded together. These are specialized food packaging materials in which inner layer is in contact with food while the outer layer serves other functional requirements.

Lamination of film is another area in packaging, finding wide applications for food packaging, which is provided by the use of thermoplastic polyester (PET) and extruded, metallized and coated films respectively.

3.4.2. Migration Test: Through Indian Standards on food contact plastics, a new classification of food products based on its nature (acidic or not, aqueous) dairy products have been prepared. Safety of thermoplastics could be ensured by testing against simulants, which may be identified based on the nature of product. The ingredients in the plastic packaging material cause toxicity as a result of their migration to foodstuffs. It is very difficult to analyse actual foodstuffs for nature and quantity of migrants from plastics as well as to estimate all the migrants individually. Hence as a good measure, the Overall Migration of all the migrants is considered for safe use unless their limits are fixed. For Food grade plastics an Indian Standard IS 9845 – ‘Method of analysis for determination of overall migration of plastics constituents’ has been formulated to help the manufacturers in the above.

4.0 REGULATIONS

4.1 Indian Standards serve as a basis for official agencies to frame suitable legislations to ensure effective safe guards for the safety and health of consumers. Where thermoplastic for food contact applications are concerned, they help statutory bodies to effectively monitor the quality of plastics for end use.

4.2 Polystyrene- (Crystal and high impact) material are considered as safe for use as articles/components intended for use in producing, manufacturing, packing, processing, preparing treating, packaging, transporting or holding food in accordance with USFDA Regulations, British Plastics Federation and EEC Directives.

4.3 Additives – Information on efficient and cost-effective additives which can be safety used in contact with foodstuffs in available from British Indust4rial Biological Research Association (BIBRA).

4.4 Resins – Their use is guided by EEC directives 90/128/EEC in Europe, FDA regulations on USA, BVGW and hygiene Institute in Germany.

4.5 Tests – Regulations involved in method of tests are:
5.0 PRECAUTIONARY INFORMATION

a. The Indian Standards does not take any responsibility regarding suitability of the bonding material or printing ink used for food packaging applications.

b. It does not cover recycled plastics for food packaging applications.

6.0 LIST OF INDIAN STANDARDS

<table>
<thead>
<tr>
<th>No.</th>
<th>Standards Code</th>
<th>Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>IS 10141:2001</td>
<td>Positive list of constituents of polyethelene in contact with foodstuffs, Pharmaceuticals and drinking water (first revision)</td>
<td>Feb 1997</td>
</tr>
<tr>
<td>2.</td>
<td>IS 10142:1999</td>
<td>Polystyrene (crystae and high impact) for its safe use in contact with foodstuffs, pharmaceuticals and drinking water (first revision)</td>
<td>Feb 1997</td>
</tr>
<tr>
<td>3.</td>
<td>IS 10146:1982</td>
<td>Polyethylene for its safe use in contact with foodstuffs, pharmaceuticals and drinking water.</td>
<td>Feb 1997</td>
</tr>
<tr>
<td>4.</td>
<td>IS 10148:1982</td>
<td>Positive list of constituents of polyvinyl chloride and its copolymers for safe use in contact with foodstuffs pharmaceuticals and drinking water</td>
<td>Feb 1997</td>
</tr>
<tr>
<td>5.</td>
<td>IS 10149:1982</td>
<td>Positive list of constituent of polystyrene (crystal and high impact) in contact with foodstuffs, pharmaceuticals and drinking water</td>
<td>Feb 1997</td>
</tr>
<tr>
<td>6.</td>
<td>**IS10151:1982</td>
<td>Polyvinyl chloride (PVC) and its copolymers for its safe use in contact with foodstuffs, pharmaceuticals and drinking water</td>
<td>Feb 1997</td>
</tr>
<tr>
<td>8.</td>
<td>IS 10909:2001</td>
<td>Positive list of constituents of polypropylene and its copolymers in contact with foodstuffs, pharmaceuticals and drinking water (first revision)</td>
<td>Feb 1997</td>
</tr>
<tr>
<td>9.</td>
<td>IS 10910:1984</td>
<td>Polypropylene and its copolymers for its safe use in contact with foodstuffs, pharmaceuticals and drinking water polyester resin systems (First revision).</td>
<td>Feb 1997</td>
</tr>
<tr>
<td>10.</td>
<td>**IS 11704:1986</td>
<td>Ethylene acrylic acid (EAA) copolymers for their safe use in contact with foodstuffs, pharmaceuticals and drinking water</td>
<td>Feb 1997</td>
</tr>
<tr>
<td></td>
<td><strong>Standard Code</strong></td>
<td>Description</td>
<td>Date</td>
</tr>
<tr>
<td>---</td>
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<tr>
<td>11.</td>
<td>IS 11705: 1986</td>
<td>Positive list of constituents of ethylene/acrylic acid (KAA) copolymers for their use in contact with foodstuffs, pharmaceuticals and drinking water</td>
<td>Feb 1997</td>
</tr>
<tr>
<td>12.</td>
<td>IS 12229:1987</td>
<td>Positive list of constituents of polyalkylene terephthalates (PET &amp; PBT) for their safe use in contact with foodstuffs, pharmaceuticals and drinking water</td>
<td>Sep 2000</td>
</tr>
<tr>
<td>13.</td>
<td>IS 12247:1988</td>
<td>Nylon-6 polymer for its safe use in contact with foodstuffs, pharmaceuticals and drinking water</td>
<td>Sep 2000</td>
</tr>
<tr>
<td>14.</td>
<td>IS 12248: 1988</td>
<td>Positive list of constituents of nylon-6 polymer for its safe use in contact with foodstuffs, pharmaceuticals and drinking water</td>
<td>Sep 2000</td>
</tr>
<tr>
<td>15.</td>
<td>IS 12252: 1987</td>
<td>Polyalkylene terephthalates (PET &amp; PBT) for their safe use in contact with foodstuffs, pharmaceuticals and drinking water</td>
<td>Sep 2000</td>
</tr>
<tr>
<td>16.</td>
<td>IS 13360 (Part 11/Sec 11): 1999/ISO 3219:1993</td>
<td>Plastics – Methods of testing Part 11 Special properties Section 11 polymers/resins in the liquid state or as emulsions or dispersions – Determination of viscosity using a rotational viscometer with defined shear rate</td>
<td></td>
</tr>
<tr>
<td>19.</td>
<td>IS 13576 : 1992</td>
<td>Ethylene menthacrylic acid (EMAA) copolymers and terpolymers for their safe use contact with foodstuffs, pharmaceuticals and drinking water</td>
<td>Jun 1997</td>
</tr>
<tr>
<td>20.</td>
<td>IS 13577: 1992</td>
<td>Positive list of constituents of ethylene methacrylic acid (EMAA) copolymers and terpolymers in contact with foodstuffs, pharmaceuticals and drinking water</td>
<td>June 1997</td>
</tr>
<tr>
<td>21.</td>
<td>IS 13601: 1993</td>
<td>Ethylene vinyl acetate (EVA) copolymers for its safe use in contact with foodstuffs, pharmaceuticals and drinking water</td>
<td>Aug 1997</td>
</tr>
<tr>
<td>22.</td>
<td>IS 13449: 1992</td>
<td>Positive list of constituents of ethylene vinylacetate (EVA) copolymers in contact</td>
<td>Jun 1997</td>
</tr>
<tr>
<td></td>
<td></td>
<td>with foodstuffs, pharmaceuticals and drinking water</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>23.</td>
<td>IS 13463:1992</td>
<td>Polyamida (nylon 6) material for moulding and extrusion</td>
<td>Jun 1997</td>
</tr>
<tr>
<td>25.</td>
<td>IS 14971: 2001</td>
<td>Polycarbonate resins for its safe use in contact with foodstuffs, pharmaceuticals and drinking water</td>
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<tr>
<td>26.</td>
<td>IS 14972: 2001</td>
<td>Positive list of constituents of polycarbonate resins in contact with foodstuffs, pharmaceuticals and drinking water</td>
<td></td>
</tr>
<tr>
<td>27.</td>
<td>IS 14995:2001</td>
<td>Stretch Cling films</td>
<td></td>
</tr>
<tr>
<td>28.</td>
<td>IS 14996:2001</td>
<td>Positive list of constituents of modified poly(phenylene oxide) (PPO) in contact with foodstuffs, pharmaceuticals and drinking water</td>
<td></td>
</tr>
<tr>
<td>29.</td>
<td>IS14997:2001</td>
<td>Modified poly (Phenylene oxide) (PPO) for their safe use in contact with foodstuffs, pharmaceuticals and drinking water</td>
<td></td>
</tr>
<tr>
<td>30.</td>
<td>ISI 14998:2001</td>
<td>Positive list of constituents of melamine-formaldehyde resins in contact with foodstuffs, pharmaceuticals and drinking water</td>
<td></td>
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<tr>
<td>31.</td>
<td>IS14999-2001</td>
<td>Melamine-formaldehyde moulding materials for its safe use in contact with foodstuffs, pharmaceuticals and drinking water.</td>
<td></td>
</tr>
<tr>
<td>32.</td>
<td>IS 10106(p-1): 1982</td>
<td>Packaging Code : Part 1 Factors affecting the selection of packaging</td>
<td></td>
</tr>
<tr>
<td>33.</td>
<td>IS 10106 (P-1)/Sec 1: 1990</td>
<td>Packaging Code : Part 1 Product packaging – Section 1 Foodstuffs and perishables</td>
<td></td>
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<tr>
<td>34.</td>
<td>IS10106 (part 1) Sec 6: 1992</td>
<td>Packaging Code : Part 1 Product packaging-Section 6- Protection against spoilage of packages and their contents by microorganisms, insects, miles and Rodents</td>
<td></td>
</tr>
<tr>
<td>35.</td>
<td>IS 9845: 1998</td>
<td>Determination of Overall Migration of Constituents of Plastics materials and articles Intended to come in contact with food stuffs-Method of Analysis</td>
<td></td>
</tr>
</tbody>
</table>
1.0 DEFINITION

Packaging means a co-ordinated system of preparation of goods for shipment, distribution, storage and merchandising at optimum costs compatible with the requirements of the product. It also includes the art, science and technique used, preparatory to and during transportations and selling of goods and technical methods and work processes related to the above preparations.

2.0 TYPES OF PACKAGING

2.1 Individual Packaging: This means the packaging of individual items of goods and includes the technique of application of appropriate materials and containers etc. to protect each individual item of goods, or to increase the merchandise value as well as the conditions of the goods to which those techniques are applied.

2.2 Inner Packaging: This means the inner packaging of packaged goods, the techniques of application of the appropriate materials or containers etc., with consideration of the protection of goods against water vapour, light, heat, impact etc. as well as the condition of the goods to which these techniques have been applied.

2.3 External Packaging: This indicates the outer packaging of packed goods, in other words, the techniques of placing the goods in a box, bag or other container such as a barrel or can etc., or bundling without the use of a container, and adding markings to identify the goods as cargo; as well as the conditions of application of these procedures.

In case of food packaging, the word ‘goods’ can be substituted by ‘food’.

3.0 FUNCTIONS AND PURPOSE OF FOOD PACKAGING

The following three functions can be considered the major ones of food packaging:

i) Protection of contents
ii) Convenience and handling
iii) Marketing and Sales
4.0 FOOD PACKAGE DESIGN FACTORS:

The aim of food packaging design is wide market acceptance of the packed goods, at minimum cost. The factors that concern food packaging design is shown below:

It is important to analyse and evaluate factors related to food packaging. Package planning involves development based on market research. Once product demand is established, packaging specifications are decided. Full-scale commercial production may begin once the feasibility is established.

5.0 ESSENTIALS FOOD PACKAGE DESIGN:

The factors influencing the packaging system involve:

1. Physical/mechanical properties of packaging materials
2. Barrier properties to water vapour, gases and volatiles
3. Printing characteristics
4. Productivity and packaging speed
5. Automation, speed of production
6. Reliability of closures and sealers
7. Hygienic, sanitation and ecological factors.
8. Package forms suitable
9. Packaging method
10. Strength factors of external packages
11. Environmental conditions.
12. Display effect.

6.0 FORMS OF FOOD PACKAGING:

The container must be distinguishable from other competing merchandise on display shelf. It must convey an image suitable for the food product it contains and should influence the purchaser. The packaging forms of importance are:

6.1 Metal Cans: These can be classified into round, square, oval or pail-shaped, flat etc. Cans are often classified into 2-piece or 3-piece cans. The latter uses tin-plate as its basic material, and the can is jointed by soldering or welding. In the case of tin-free-steel (TFS) cans, body making is done using an organic adhesive agent. 2-Piece cans include cans punched out by a press machine, aluminum can made by impact extraction, D1 cans ironed after contraction process and DR cans manufactured by carrying out contraction process two or more times. D1 cans are used where high internal pressure resistance is required. Bonded and welded cans may be used as alternative to conventional soldered cans.

6.2 Glass bottles: Glass bottles and containers are available in many different shapes such as large “free-size” bottles, small “one-shot” styles, light-weight bottles for soft drinks, heavy-weight “hand-crafted” type liquor bottles returnable bottles etc.

6.3 Stretch-wrap packaging: In this method, food is placed in a tray and film is stretched over the food to cover it. Stretchable PVC films, PE films etc. are used as packaging materials. Shrink packaging is a form of packaging in which one or more items are covered with films, which shrinks when heated. The film is shrunk using either dry or moist heat. Films that are used for this application include PVC, PP and PE.

6.4 Flexible Pouches: A pouch is a container made of a flexible packaging material, such as plastic film, aluminum foil, paper etc, where are used either singly or in continuation.

6.5 Bag-in-box packages: Bag-in-carton or bag-in-box containers have double construction, with both an inner and an outer package. The former type is used for several food items including liquids while the latter is used for institutional use and for bulk shipment. The external package provides mechanical strength, while the inner bag protects the contents against water vapour, gases and volatiles. This can be made of single substance or multi-layer structure.
6.6 Cups: The types of cups used as container include thermo-formed, air-pressure formed and expanded plastic sheets. Recently, a cup with a barrier layer manufactured using pressurized air with laminated sheet and a composite cup with an inner layer of aluminum foil has been introduced. Paper cups, with PE, PP or PET inserts, thermoformed are also being used.

6.7 Paper-board Containers: The ‘pure-pak’ type containers, with its distinctive gable-top and the ‘brick-type’ smaller containers are the predominant packages used for milk products. Paper laminated to PE is used for ordinary milk while for long-life milk; fruit drinks etc, laminated aluminum foils are used.

7.0 PACKAGING MACHINERY

Packaging facilities concerning food fall into two categories, i.e. inner packaging and external packaging. Inner packaging intended for individual items include machines for weighing, filling, wrapping, sealing etc. Filling operations are for solids, powders, liquids and semi-liquid or paste foods. Filling methods are classified according to container form:

(a) filling a pre-formed container with product and
(b) filling a container with contents after the container is formed from a roll-stock.

The types of filling and packaging machines and their application for specific packaging types are indicated below:

<table>
<thead>
<tr>
<th>Product types</th>
<th>Machine types</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Filling and sealing machines for glass and plastic containers, metal cans</td>
<td>Container supply type filling and sealing machines</td>
</tr>
<tr>
<td>2. With supply system for flexible and pouches/bags</td>
<td>Bag-supply type filling and sealing machines</td>
</tr>
<tr>
<td>3. Vertical filling and scaling machines</td>
<td>Container-forming filling and sealing machines</td>
</tr>
<tr>
<td>a) Pillow-type bag making, filling and sealing</td>
<td></td>
</tr>
<tr>
<td>b) 4 or 3 sides seals filling and sealing, horizontal filling and sealing</td>
<td></td>
</tr>
<tr>
<td>i) Horizontal pillow type sealing</td>
<td></td>
</tr>
<tr>
<td>ii) Horizontal 4-sides and 3-sides seal, Stand-up pouch packing</td>
<td></td>
</tr>
<tr>
<td>Twist seal bag making, filling and sealing machines</td>
<td></td>
</tr>
<tr>
<td>Square bottom bag-forming, filling and sealing</td>
<td></td>
</tr>
<tr>
<td>Tying and packing machines</td>
<td></td>
</tr>
<tr>
<td>Lined folding carton packing</td>
<td></td>
</tr>
<tr>
<td>Thermoforming, filling and sealing</td>
<td></td>
</tr>
<tr>
<td>Packing machines with injection moulders for plasters</td>
<td></td>
</tr>
<tr>
<td>Folding type over-wrapping, twist-type wrapping, stretch film</td>
<td>Over-wrapping machines</td>
</tr>
</tbody>
</table>
1.0 DEFINITION

A bar code is a series of bars and spaces arranged according to the encodation rules of a particular specification in order to represent data. Its purpose is to represent information in a form that is machine-readable.

1.1 Benefits of the codes

The main benefits are speed and accuracy. Compared to manual key entry, capturing data automatically by reading bar code can be done in a fraction of a second. Generally the error rate is extremely low, of the order of one error per 10 lakhs readings. Other advantages include:

- Computer Aided Checkout.
- Avoidance of over and under charging.
- Self-service.
- Instant inventory control.
- Market survey – products sold and rate.

2.0 BAR CODE BASICS:

A bar code symbology is a set of rules discussing the way bar and spaces have to be organized to encode data characters. Only a few are being used on a large scale.

2.1 Code 39:

The code 39 symbology introduced in 1975 is widely used for industrial applications. It is a discrete, variable length symbology encoding the 36 numbers and uppercase alpha characters (A-Z, 0-9) and seven special characters, these being space, dollar sign ($), percent (%), plus (+), minus (-), dot (.) and slash (/). A symbol character comprises nine elements, 5 bars and 4 spaces. An element is either wide or narrow. There are 3 wide elements and 6 narrow elements in a symbol character.

A code 39 symbol begins with a start character and ends with a stop character. It can be read either from left or right.

![Fig. Code 39](barcode.png)

2.2 ITF:

Inter leaved two of five (ITF) is well adapted to materials and printing conditions frequently used on fibreboard cases. It is a continuous symbology encoding only numeric digits. A pair of digits is represented by 5 bars and 5 spaces. One of the pair is represented by the dark bars and the other by the light bars. These two are
Bar coding in packaging

interleaved. In addition to the digit characters, there are 2 auxiliary characters used as guard bars at the beginning and at the end of the digit representation.

2.3 Code 128: Code 128 was developed to address the need of a compact alpha-numeric code symbol that could be used to encode complex data, capable of being printed by existing data processing printers. Code 128 fulfils the need with most compact, complete, alphanumeric symbology available. In addition, code 128 has been designed with geometric features to improve scanner-reading performance and to be self-chickening.

2.4 EAN/UPC: European Article Numbering (EAN) system and Universal Products Code (UPC) system is a continuous symbology encoding fixed length number digits. Several variants exist, known as EAN-8, EAN-13, UPC-A and UPC-E. In addition, the symbology enables to encode 2 small symbols encoding 2 and 5 digits. These are called add-ons.

In the system, a symbol character is composed of 7 modules, 2 bars and 2 spaces. A bar or a space is composed of 1 to 4 modules. An EAN/UPC symbol begins and ends with a guard pattern. In EAN-8 and 13 as well as UPC-A version, a centre pattern separates the symbol into segments that can be read separately thereby making the symbol to be read omni directionally.

The EAN/UPC symbology is widely used to encode the identification number of consumer products.

3.0 TWO-DIMENSIONAL SYMBOLOGY

3.1 PDF 417: As distinct from the linear symbology, a system such as PDF 417 is a two-dimensional stacked bar-code symbology. In this, the basic data unit or minimum segment containing interpretable data is called a codeword. Every codeword in the symbol is of the exact same physical length, and each codeword can be divided into 17 equal modules. Within each codeword, there are 4 bars and 4 spaces. The minimum number of modules of any bar or space is 1, the maximum is 6. The PDF 417 symbology defines 929 distinct codewords and supports 12 modes. Each mode specifies the meaning of the codewords. The standard modes are Extended Alpha Numeric Compaction Mode, Binary / ASC 22 Plus Mode and Numeric Mode. The number of data characters that can be encoded in the extended alphanumeric compaction mode, the ma. No. of ASC II
character per symbol is 1850. In numeric mode, a symbol can encode a max. of 2725 digits.

4.0 PRINTING AND READING OF BAR CODES

Virtually any printing technology can be used to print bar codes, provided it is accurate enough to achieve the right level of required quality. The printing processes are of two categories, commercial and on-site, the choice being dependent on the nature of the information to be coded and the number of codes to be printed. If the information is of typical static type, i.e. the identification number of a product to be placed on a package, and if the number of codes to be printed is large, the traditional commercial method using film masters is appropriate. If the information is variable, e.g. different for each item or short series of items or if the quantity required is small, then on-site printing process is preferable.

Many types of devices are available to read bar codes. They all illuminate the symbol and analyse the resulting reflectance. High reflectance areas are interpreted as spaces while areas of low-reflectance are represented as bars.

The decoder assigns binary values to the signal and forms a complete message. This is checked by the decoder and transformed into data.

Fixed-beam readers depend on external motion to read the symbol. A popular reading device is the low-cost hand help contact scanner. Moving-beam readers use a mirrored moving surface to provide the illumination. The light source appears as a continuous line of light. The moving-beam reader is also called as laser scanner. Imaging devices (camera) are also used to read bar codes. The reflected image of the bar code is projected onto photodiodes composed of many photo-detectors. These in turn are sampled by microprocessors and produce a video signal that is then decoded.

5.0 APPLICATIONS

The bar coding technology has gained wide acceptance in numerous applications. Today, virtually all packages from the ultimate consumer to biggest transport units bear one or several codes, carrying their identification number and other data relevant to agencies of shipping, carrying and receiving goods.

Scanning at retail point of sale is a major application relying on the EAN/UPC identification number and the associated bar code symbol. Scanning at point of sale enables automatically to register the sales through price-lookup files. Further extensions include inventory management, automatic re-ordering and sales analyses.

Bar coding technology is also applied to supply chain goods ready for shipment are packed and each package is numbered and bar-coded with a unique number when processed by the receiver, the original message is matched and what has been ordered and delivered can be checked. Inventories can then be updated automatically.

6.0 SUGGESTED READINGS


1.0 INTRODUCTION

Metal containers were first developed in the early 19th century. As with many technological advances, their development was hastened by military necessity. The earliest can makers were tin-smiths who turned out tin plate containers with skill and imagination, at the rate of about ten per day in a variety of sizes and shapes. Both ends were soldered to the body, with a hole about 25mm in diameter at the top. After can was filled through this hole a metal disc was soldered into place. Mechanization of the can-making process was made possible by the development of a crimping method, called double seemsing, to attach ends to the soldered can body. Even though many of the fundamental manufacturing processes, such as double seaming and body forming were developed in the late 19th century, the evolution of can making continues. Related technologies such as metallurgy and food engineering are also advancing, creating new applications for the metal can.

2.0 MERITS AND DEMERITS

Metal cans offer impermeability to moisture, gases and light. They are produced from readily available and highly recyclable materials. Metal cans are compatible with many products and offer high stacking strength, thermal stability and a good surface for decoration and coating. They have potential for high-speed manufacturing and filling. Many designs today offer easy opening ends that do not require tools to access the contents. Two-piece design of cans deletes the chances of leaking of its contents as there are no side and bottom seams.

On the negative side, the cost of setting up of a production line for cans is high. Food processors also need a variety of sizes for different products harvested in different seasons enhancing the cost further to achieve this diversity.

3.0 CAN CONFIGURATIONS

The three basic types of cans are: three-piece cans, two-piece drawn and ironed cans and two-piece drawn and redrawn cans.

3.1 Three-piece can

As its name implies, it is made in three pieces: a body and two ends. The manufacture of three-piece cans involves the cutting of metal sheet into can-width strips on a machine called slitter. The slit strips are cut into body blanks and fed into a body maker, the first machine in an automatic can line. In the body maker, the body blanks are rolled, the corners are notched to remove the extra thickness of metal, and the side seam
is curled into the ends and passed on to side seamers. Within three-piece category cans, there are three further classifications determined by the method used to join the side seam of the body cylinder. The methods are soldering, cementing and welding.

3.1.1 Soldered seams: For soldered cans, the edges of the blank are curled, brushed with flux, passed over a gas flame and joined in a lap and lock seam while moving over a solder application seam. A second burner smoothens the seam and wiper removes excess solder. The soldering seam is then coated with a lacquer. The body blank is flanged to receive the can bottom which is double seamed. The top of the can is usually applied after a filling operation. The final step is application of a spray coating to the can interior, curing and testing for leaks.

3.1.2 Cemented seams: The cemented side seams permit all-round lithography with no base strip required at the solder point. The body former curves the sheet to form a cylinder and overlaps the edges. Cemented seams are produced by passing the body blank edges over an open flame and applying special cement with wheel. Chilling rolls then solidify the cement and trimming knives remove cement lodged between adjacent body blanks. The exposed edges if any are coated with lacquer. A thorough test is to be followed before the cemented side seams are used for cans under pressure.

3.1.3 Welded seams: The welded side seams are very strong and require a much narrower undecorated strip than that needed for soldering. In welding, the side seam is an overlap of the curled plate, which is subjected to a high-amperage electric current in a resistance welding process. The resulting exposed edge inside the can is coated in a striping operation using powder coating which is cured by infra red or high-frequency induction heating.

3.2 Two-piece drawn and ironed cans:

These cans were developed in 1960’s. This method of can manufacturing eliminates the side seam and separate bottom. The two-piece can body has an integral side and bottom and is made in a process that thins the sidewall while preserving the gauge of the bottom. The widest use of these is in the beer and soft drink markets.

To make a D&I can, a disc of metal sheet is formed into a shallow cup with a die. The cup is then pushed through several dies, each slightly smaller than the previous one, so that the sidewalls are stretched and thinned. Since the cup is held on the original punch, the inside dimension remains constant during this process. Starting with the plate thickness of 292 μm, the sidewalls are reduced to 97μm, while the bottom thickness remains same. This process of pushing the cup through progressively smaller die rings is called the ironing of sidewall. As the walls are ironed, the bottom is domed to provide strength and stability. The maximum ratio of height to diameter is 2:1.

The can bodies are then trimmed to length and cleaned in preparation for coating inside and out. The can is then necked or stepped in at the top and flanged to receive a top. The necking –in produced a can with a narrower top thereby saving material. After leak test the cans are prepared for shipping or filling.

3.3 Two-piece drawn and redrawn cans: In D&R method the cup is pushed through each succeeding die. The gauge of the bottom and the sidewall of container remains essentially the same as the starting
gauge but the inner dimensions of the cup becomes smaller. One or more punching operation may be used depending upon the depth of the can to be produced. These subsequent drawings or “redrawing” can be done once or twice. After drawing and redrawing, the can body is necked in at the bottom, to permit easy stacking and beaded or indented, in narrow bands to provide extra side wall strength for vacuum packaging. While coatings will not adhere to D&I cans during production and must be applied to after the can body is formed, they may be applied to the flat can stock in the D&R process prior to drawing. A typical can, say for vegetable would start with steel having 184.6 μm gauge and end up with a side wall of 179.5 μm. The maximum ratio of height to diameter is about 1.5:1.

4.0 CAN CLOSURES

4.1 Easy-open ends:

Easy –open ends could be a stay-on tab found on the beverage cans or a ring-pull ends which is found on pet food or heat sealable flexible membrane. The bevcan end is a tab less design with a raised conical profile and a central 19.1 mm pour spout. It is opened by pressing downward a circular panel which pops inward without leaving any hazardous edges. The recent advancement in the easy open membrane lids, which simply peel away and often are teamed with a friction fit plastic lid for protection in the distribution chain.

4.2 Threaded Closures:

Screw-top cans are containers with threaded closures. A wide variety of threaded spouts and applicators have been available. A closure could be specified by the size of the outside of the threads on the container. There are no industry standards for threaded profiles or helix angles, the caps from one manufacturer may not fit containers from another. Caps and containers must be purchased at the same time from the same source to ensure a good fit.

4.3 Slip cover closures:

Shallow cans with slip covers are made by blanking and drawing metal plate to the proper size and hammering or curling the edge. This category of closures includes simple reclosure type; firm reclosure type or friction closure type. There are still markets for highly decorated metal boxes, although the uses of these slip cover containers have greatly decreased due to the labour intensive cost of making these cans has soared and other types of mass-produced containers have developed.

5.0 CAN MATERIALS

Cans are made from either aluminium or steel. In many cases, can bodies are made with one material and ends with another. The steel can be chrome plated or laminated. The commonly called tin can is a misnomer. The sheet of these cans have only a thin coating of tin either on one side or on both sides.

5.1 Aluminium:

The composition of aluminium alloys for rigid containers varies according to the intended use, with upto 5 percent magnesium, 1.5 percent manganese and traces of iron, silicon, zinc, copper and titanium. As forming characteristics and resistance to corrosion
improve, yield strength usually goes down and heavier gauges are required to do the same job. When enamels or other coatings are baked on, there is also a slight drop in yield strength. Aluminium alloys/tempers commonly used are: a fully hard material such as 3004 H-19 and a softer one such as 5052 H-34 or 5082 H-251. Where 3004 or 5052 denote the aluminium alloy sheet and H-19, H-34 denotes the tempering. The hard tempered alloy H-19 allows the very thin gauges which make the aluminium containers bodies economical. Shallow-drawn parts, such as can ends, use alloys with less ductility and medium temper of H-34 for average conditions.

5.2 Steel:

Ferrous metal used in fabricating cans include base steel or “black plate”, tin-free steel which has thin coat of electrolytic ally deposited chromium and tin plate which has a thin coat of electrolytically deposited Grade-A commercially pure tin. Steel that has completed the tempering process is called ‘black-plate’. Traditionally, it is used for spice containers and a number of industrial-packaging applications. It also forms the base of tin plate and electrolytically chromium-coated steel. Ferrous materials are used for ends and bodies in both two-piece and three-piece technologies.

The tin coating originally was done by hot dipping process but was later on replaced by electroplating. An electrochemical passivation treatment, usually with sodium dichromate, stabilizes the surface and adds a thin film of metallic chrome to enhance the corrosion protection. Although the tin coating is only about 0.3μm thick, it resists the corrosion not only by the protective layer of tin on its surface but also a cathodic reaction that minimizes oxidation at any pin holes or base spots. A tin coating also prevents the iron from being dissolved in certain beverages and food products.

ECCS is chromium / chromium-oxide-coated steel. Using a one or two-step process an extremely thin layer of metallic chromium 0.008μm is electrolytically deposited on black plate and then oxidized. For three-piece cans, ECCS is not compatible with soldering but may be cemented. Side seam may also be welded if chromium layer is removed from the edge. Because of it is lower cost and functional attributes ECCS now dominates the market and is widely used for food cans.

5.3 Can linings and lacquers:

Metals used in can packaging often do not provide corrosion resistance, surface abrasion resistance and product-container compatibility. As a result, a variety of lacquers and lining materials have been developed to protect outer and inner surfaces and are also known as enamels. These are usually applied by roller or spray to flat sheet or coil and cured by oven or ultraviolet-light curing process.

The enamels protect the surface of can by serving as a barrier to gases, liquid and ions. Enamels generally are specified in terms of mg/in². Following table No. 1 gives the general properties and uses of can-lining materials.
Table 1: General properties and uses of can-lining materials

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Type</th>
<th>Flavour</th>
<th>Color</th>
<th>Adhesion</th>
<th>Cost</th>
<th>Sterilization</th>
<th>Acid</th>
<th>Alkali</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Epoxy-amine</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Milk, base coat for beverage</td>
</tr>
<tr>
<td>2.</td>
<td>Epoxy-phenolic</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>Meat, Fish</td>
</tr>
<tr>
<td>3.</td>
<td>Oleoresins</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>Vegetables, Fruits</td>
</tr>
<tr>
<td>4.</td>
<td>Phenolic</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>Fish, liver</td>
</tr>
<tr>
<td>5.</td>
<td>Polybutadiene</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Citrus, base coat for beverages</td>
</tr>
<tr>
<td>6.</td>
<td>Vinyl</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>Top coat for beverage</td>
</tr>
</tbody>
</table>

Rating scale 1=good, 2=fair, 3=poor

6.0 SHAPES AND SIZES

Metal containers offer a range of shapes, sizes and styles. Beverages and sanitary food cans account for majority of the metal container market. The desire for product differentiation has generated interest in new can shapes and can shaping technology. Cans with textured surfaces or non-round profiles have been created by mechanical, pneumatic and hydraulic forming processes. The outside of a can may be decorated by silk screening, offset flexography, offset lithography or labeling via glue, pressure sensitive shrink or heat transfer methods. Cost depends on the number of color, embossing and decorative effects. Following table No. 2 gives the typical can styles and sizes along with their special features and uses.

Table 2: Typical styles, uses and special features of food cans.

<table>
<thead>
<tr>
<th>Style</th>
<th>Capacity</th>
<th>Uses</th>
<th>Convenience features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beer beverage</td>
<td>12 or 16 oz</td>
<td>Soft drinks, Beer</td>
<td>Easy open Tab Top Unit</td>
</tr>
<tr>
<td>Sanitary or open-top</td>
<td>4 oz to 1 gal.</td>
<td>Fruits, vegetables, meat products, coffee, shortening</td>
<td>Tamper proof, ease of handling, large opening</td>
</tr>
<tr>
<td>can (three-piece)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spice can, oblong</td>
<td>25g to 500g</td>
<td>Seasonings</td>
<td>Dredge top, various dispenser openings</td>
</tr>
<tr>
<td>Key-opening reclosure</td>
<td>200g/500g/1kg</td>
<td>Nuts, candy, coffee, shortening, dried milk</td>
<td>Lugged cover reclosure, Lid may be hinged, good reclosure</td>
</tr>
<tr>
<td>Key Opening non-reclosure can</td>
<td>500g</td>
<td>Sardines, large hams, poultry processed meats</td>
<td>Contents can be removed without marring product</td>
</tr>
<tr>
<td>Hinged-lid pocket-type</td>
<td>25g</td>
<td>Tobacco</td>
<td>Firm reclosure</td>
</tr>
<tr>
<td>can</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slip cover cans</td>
<td>500g/1kg</td>
<td>Lard, Frozen fruits, eggs</td>
<td>Simple reclosure</td>
</tr>
<tr>
<td>Pear-shaped key opening can</td>
<td>500g/5kg</td>
<td>Hams</td>
<td>Easy access through key opening features</td>
</tr>
<tr>
<td>Two piece drawn and redrawn sanitary can</td>
<td>100g to 1kg</td>
<td>Food</td>
<td>Improved can integrity and stack ability feature</td>
</tr>
<tr>
<td>Oblong key opening can</td>
<td>200g to 10kg</td>
<td>Hams</td>
<td>Wide range of sizes</td>
</tr>
<tr>
<td>Easy open oblong can</td>
<td>100/200g</td>
<td>Sardines</td>
<td>Full panelled easy open tab</td>
</tr>
</tbody>
</table>
7.0 SELECTION FACTORS

There is no single acceptable container for a given application in all locations and at all times. The selection process is a dynamic one, influenced by price, availability of materials, volume and variety of containers required, research and development for new options.

Corrosion of the inside of the container determines the integrity of container and its compatibility with the product. Corrosion is usually of two general types. The first, a surface corrosion, proceeds gradually but does not penetrate deeply. It is fairly easy to control by following good practices in storage and processing operations such as proper coding and drying of retorted cans, protection from corrosive vapors and condensation during storage. The second type of corrosion is pitting or perforating in which effect is localized and difficult to see. It can cause leaks. Certain product or packaging components can aggravate corrosion and characteristics like acidity, pH and oxygen levels also have an influence. Corrosion accelerants include copper which can be picked up from pipes or mixing vessels, sulfur compounds from agricultural chemical residues or preservatives, nitrates from fertilizers, plant pigments and synthetic colorants such as azo dyes. All these product constituents call for the can lining or enamel formulated to suit a particular product.

Other factors such as lithography and container design are also considered. However, if one were to choose one overriding concern in choosing a metal can, it would be cost reduction. The constant search for metal cans has indeed produced the array of choices available today.

8.0 APPLICATIONS

There are three major markets for metal cans; beverage, including beer and soft drinks; food and non-food, comprising such products as paints, chemicals, etc. The beverage can market constitute a share of 61% and remaining 39% are for food and non-food products.

8.1 Beverage Cans: The beverage can market has been the fastest growing segment of the industry. Two-piece cans are predominant in the beverages as they are well suited to long production runs with infrequent label changes. Majority of market uses aluminium in manufacture of two-piece beverage cans, though in some European countries steel is still in use.

Aluminium cans manufactured by D&I process are extensively used for pasteurized beverages such as beer and soft drinks. Beer contains carbonic gas and when it is pasteurized after sealing (to extend the shelf life) the internal pressure may rise to ten times the pressure in food cans. The beer can therefore has to be designed to contain pressures up to 7.0 kg/cm$^2$.

Due to their lighter weight cm$^2$ aluminium cans reduce transportation cost. Remelting of aluminium cans to make aluminium ingots requires only five percent of the energy used to make virgin metal from bauxite ore. Thus the economics of recycling of aluminium cans have become quite favourable. This trend helps control the costs of materials and for the present, clearly favours the aluminium beverage package.
8.2 **Food cans:** Food cans are manufactured in a greater variety of sizes and shapes than beverage cans and are generally produced in shorter production runs with frequent change over between sizes and labels. Both three piece welded cans and two piece steel cans are commonly used. The welding process produces a high-integrity three-piece can that is lead free. Welding technology provides the flexibility to run various specifications. Two-piece cans, which eliminate the side seam, are well suited to short sizes but tend to use more metal in taller sizes. Aluminium cans have also been frequently used in packaging of processed foods, where some of them may require internal coating.

Shallow drawn aluminium cans are used extensively for processed foods such as vegetables, sardines, small herring, certain meat products, fillets of large fish in oil and various sauces. Deeper cans either drawn and ironed or impact extruded are used for vegetables in brine or sauces, soups. Crabs and lobsters packed in aluminium cans do not require parchment lining to avoid discoloration of the product. Tomato sauce and mustard sauce are corrosive products, so the foods prepared in them, if to be packed in aluminium cans should not exceed total 3% acidity, expressed as acetic acid. Other fresh foods packed in D&I cans include potted meats, boned chicken, etc.

An ideal container for dehydrated vegetables is metal cans. The cans may be sealed under vacuum, if they are reinforced to prevent collapse under vacuum. Powdered vegetables are also packed in cans.

A few products like roasted coffee, milk powder are canned in dry state. Heat processing and canning in such cases prevents loss of volatile, and moisture pick-up by hygroscopic powders, etc. Dry packed foods may be hermetically sealed under vacuum or sealed in an inert gas such as nitrogen. Aluminium cans have also been developed for packaging of jam, fruit juices and condensed milk. The shelf life of various food products packed in lacquered cans have been reported to vary from about one year for beer to more than seven years for carrots and garden peas.

9.0 **CONCLUSIONS**

Competition among metal, glass and plastic packaging products will continue to be a major force in overall container industry. Metal cans have been able to maintain a large share of the market owing to technological advances permitting efficient high speed production and conservation of materials and energy. Head to head competition between suppliers of steel and aluminium ‘can stock’ has helped control material costs. Aluminium is richly available in India and could save foreign exchange expenditure on imports of other packaging materials such as tin which is in short supply in our country. The prime purpose of packaging in a metal container is the physical and chemical protection of the product to be marketed. A perfect lacquered can is an ideal container for food with respect to all these.

10.0 **REFERENCES**


ASEPTIC PACKAGING OF FOODS

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1.0 INTRODUCTION

Aseptic packaging is a relatively new packaging concept aimed at developing new product group, namely pre-sterilized and aseptically packaged foods. During aseptic packaging process, a pre sterilized and sterile product is filled under sterile conditions into sterile packages in a sterile environment and then germproof sealed.

The history of aseptic packaging goes back to the early 20th century. In Denmark, prior to 1913, J. Nielson-following Orla Jensen, obtained the patent for this process, termed aseptic conservation process, in 1921. Another major development took place in 1950 when Dole brought the first commercialised aseptic filling plant in the market that used superheated steam at 210°C for sterilization. The most remarkable development in the area of aseptic packaging took place around the same time when at the end of fourties, Alpura AG, Bern and Sulzer, Winterthur, respectively in Switzerland, when subsequent to development of a UHT process for milk, they succeeded in simultaneous development of a commercially viable packaging plant for milk, i.e. the Tetra Pak system. The system remains till today the most widely used aseptic processing concept.

Although both, the aseptic can filling and aseptic carton filling systems became commercial during the late fifties and early sixties, only the latter found application in aseptic packaging of liquid foods, more particularly UHT milk. During the past few years, environmental considerations have led to the use of recyclable glass bottles instead of cartons in countries like Germany.

2.0 REQUIREMENTS OF ASEPTIC PACKAGING SYSTEMS

The major requirement of an aseptic packaging unit is to prevent recontamination of the sterilized product. The principal considerations in this regard include sterilization of the filling machine and packaging material by suitable physical and/or chemical means and maintaining aseptic barriers during filling and sealing. Besides the equipment and packaging, gas used to pressurising the filling space is one of the sources of recontamination of processed foods. Thus mechanical failures such as inadequate heating of the gas, leaks in valves and pinholes in filters may cause recontamination and must therefore be checked.

3.0 TYPES OF PACKAGING MATERIALS AND THEIR PROPERTIES

3.1 Glass: Glass bottles have been used for packaging of many liquid foods but it has not been a commercial success with aseptic filling plants. Glass as such offers protection against oxygen and light if it has been provided with anti-actinic compounds.
3.2 Cans: Aseptic canning is expensive, particularly for a low cost product like milk. Cans are not preferred for packaging of UHT processed products as the processors and marketers of the product generally want to emphasise the newness of the process whereas cans are identified with conventionally retorted products. The cans may be of tinplate or drawn aluminium: the solder in tinplate cans may have to be of higher melting point than normal to withstand the can sterilization temperatures. Cans pass along a conveyor belt within a continuous tunnel. Tunnel temperature (200-220°C) for sterilization of cans is attained by steam (at atmospheric pressure), superheated with gas flames-sterilization time being 40s, normally. Cans having passed through the sterilizing tunnel continue through the filling chamber where they are filled with the product. The can lids are sterilized, again by superheated steam, in a separate unit. The lids are applied and seamed in a chamber kept sterile by super heated steam and flue gas.

3.3 Paper board cartons: Such packaging materials are commonly used in aseptic filling systems for milk, cream, fruit juices, soups etc. The filling systems could be either of the following two types: those in which the carton is formed within the filler from a continuous reel of material; and those in which the cartons are supplied as preformed blanks, folded flat, which are assembled into cartons in the filler. The packaging material is mainly composed of printed-paper coated with aluminium foil and several plastic layers (Polyethylene-paper board-polyethylene-aluminium foil-polyethylene). The inner material side of the finished package is coated with a special layer facilitating the sealing process. Each layer has a specific function:

- The outer polyethylene layer protects the ink and enables the sealing process of the package flaps.
- The paperboard serves as a carrier of the décor and gives the package required mechanical strength.
- The laminated polyethylene binds the aluminium to the paper.
- The aluminium foil acts as a gas and light barrier.
- The inner polyethylene layer provides liquid barrier

4.0 STERILIZATION OF THE PACKAGING AND THE FILLER ENVIRONMENT

Chemical sterilization processes for the packaging film include treatment with ethylene oxide, sodium hypochlorite, peracetic acid and hydrogen peroxide (H₂O₂). Ethylene oxide is not only slow in action but its desorption requires very long time.
Hence it can be used for pre-treatment of packaging, but not for final sterilization on the packaging unit. Sodium hypochlorite and peracetic acid are very effective sterilants, but removal of their residues from the packaging necessitates a sterile-water rinse. Alcohols such as glycols require high temperature (e.g. 100°C) application for the desired sporicidal effect. Although H$_2$O$_2$ also shows poor effectiveness at ambient temperatures, its high sporicidal effect at 80°C makes it useful for packaging sterilization. It is first applied on the material and then evaporated by heating through hot air or infrared radiation. The limitations of the use of H$_2$O$_2$ are: (i) the surfactant(s) or wetting agents used for uniform deposition on the packaging film, cannot be evaporated by heat and thus may find their way into milk, (ii) the vapours of H$_2$O$_2$ must be exhausted to avoid injury to the workers, and (iii) the efficacy of its removal by evaporation must be monitored through routine testing of milk.

While steam or hot water is effective in sterilization of the milk carrying tubes, hot air (300°C) with or without filtration, is commonly used for sterilization of the air injected in the filling space. Air at 330-350°C (for 30 min) may also be used for milk tube sterilization. Sterilized air reduced to 180-200°C is used to evaporate H$_2$O$_2$ and when cooled to 50°C can be employed for pressurizing the filling chamber.

Effective use of UV radiation imposes certain stringent requirements such as perpendicular incidence of rays, dry atmosphere, smooth surface, low concentration of microorganisms, and absence of visible light to avoid reactivation of microorganisms and shields to protect the operator. Therefore, UV radiation is suitable only for a complementary treatment of already sterilized packaging. Filtration by means of depth filters (mats of compressed glass- or asbestos- fibre, or of sintered metal or ceramic) is effective in freeing air from bacteria. The filters themselves may be sterilized by fumigation, hot air or steam.

Aseptic barriers in the form of steam or circulated liquid sterilant become necessary with valves and fittings coming in contact with sterile milk. Detection of leaks by using a dye test is imperative to check recontamination of the packaged sterile milk.

5.0 ASEPTIC PACKAGING SYSTEMS

Filling of commercially sterile milk in sterilized packages/containers in a sterile environment, and hermetically sealing the same to prevent recontamination of the milk can be achieved in two major ways: (a) using presterilized preformed containers such as bottle and cans, and (b) sterilizing the packaging material, forming it into suitable containers, filling the sterile product and sealing the package on the so-called form-fill-and-seal (FFS) machines. The latter employs a multiply laminate of polyethylene, polystyrene and/or polypropylene films, paper and aluminium foil.

The Dole aseptic canning system has been used for UHT milk in the USA, but only to a limited extent. The most widely used FFS Tetra Pak systems using tetrahedron cartons, and Tetra-Briks or hexahedron cartons are characterized by continuous formation of the package below the milk level from a paper/PE/Al laminate strip which has been continuously sterilized by H$_2$O$_2$ boiled off by radiant heat in the region immediately above the milk surface thus giving a sterile atmosphere in the packaging zone as shown in figure 1 and 2. Recently, Tetra Pak has introduced the so-called 'Pillow Pak' to cut down the packaging cost of UHT milk.
Aseptic packaging of foods

Fig 1. The forming and filling process for aseptic containers

1-Control panel
2-Reel
3-Manual splicer
4-Date stamping unit
5-Strip applicator
6-H$_2$O$_2$ bath
7-Roller
8-Shaping tube
9-Filling pipe
10-Heating element
11-Longitudinal sealing
12-Tube heater
13-Product leveler
14-Top sealing element

Fig 2. Aseptic packaging unit-Tetra brik
Several other FFS systems have been developed which include Thimonnier (France) and Prepac (France) cushions or pillows. Pure-Pak (USA) and Combibloc (Germany) rectangular bricks are formed from paperboard/laminate blanks, then filled and sealed. Blow-moulded polyethylene bottles such as Rommelag’s Bottle-pack (Switzerland) and Remy’s Total Pac (France) have been used for packaging of UHT milk in the UK. Systems for aseptic filling of UHT milk in drums (No-Bac 55, USA), pails (Dole, USA) and bag-in-box (Gaulin, Scholle; USA) have also been reported. UHT milk has been filled aseptically in a sterile SS tank and successfully transported over long distances in the UK. Technical details of leading aseptic packaging systems have been provided in Table 1.

6.0 COUPLING OF ASEPTIC PACKAGING WITH THE UHT PLANT

In small processing units, a single flow-sterilizing plant can be connected with a single packaging plant of the matching capacity. But this system is inflexible because both the sterilizer and filler must operate simultaneously. If one stops for any reason, the other must be shut down, or in case of the filler stopping, the sterilized products must be recirculated for reprocessing. This problem can be solved by providing an aseptic tank at the interface between the two plants.

In large units, it is a general practice to feed two or more fillers from a single sterilizing plant whose capacity is equal to the total of filling capacity. So, if one of the fillers has to be shut down only a small portion of UHT processed products will be required to be recycled. Use of a variable speed homogenizer can altogether eliminate the need of recirculation of sterilized product in such a situation. Even with a multiple filler system, aseptic tank is very useful for smooth operation of the whole system without jeopardising the product quality. Aseptic balance tank, however, adds to the investment cost as well as cleaning and sterilization requirements. It also requires a supply of sterilized air for partial positive pressure during its use.

7.0 CONCLUSION

Aseptic packaging of liquid foods, particularly milk and fruit juices, have revolutionized marketing of such products in recent times. This is so particularly in countries where refrigerated storage facilities are still a luxury. Packaging of sterilized liquid foods has been dominated by the Tetra-Brik form-fill-seal system the world over. Recent introduction of the Pillow Pak by Tetra Pak has resulted in some cost reduction but further innovations towards this goal will have far-reaching implications in popularizing long life liquid food products particularly those processed in UHT processing systems in India. It may, however, be noted that a 2-stage HTST sterilization process (Alstom, France) for long-life milk involving first-stage UHT heating followed by second-stage in-bottle sterilization has been reported to do away with aseptic packaging and appreciably reduce the total operating cost. Furthermore, packaging of liquids and pastes loaded with particulates remain a relatively new area of application and need to be tested more thoroughly. The engineering and technological advances made in the recent past can be of considerable help in extending the ‘long life’ benefits from fluid milk to other products like concentrates, cream, desserts, pastes, puddings and many chunk in gravy type of food preparations. With this, the Indian dairy industry now engaged in product diversification, value addition and export promotion is uniquely placed to exploit these benefits.
## TABLE 1: Technical details of leading aseptic packaging systems

<table>
<thead>
<tr>
<th>MAKE</th>
<th>RAW MATERIAL</th>
<th>STERILIZING SYSTEMS</th>
<th>SEALING SYSTEM</th>
<th>BASIC PRINCIPLE</th>
<th>SHAPE OF PACK</th>
<th>COUNTRY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TETRA-PACK</strong></td>
<td>Polyethylene-paper aluminium foil laminate</td>
<td>H₂O₂ bath followed by radiant heat</td>
<td>Heat sealing below liquid level while carton is being formed</td>
<td>Form fill and seal from strip</td>
<td>Tetrahedron</td>
<td>Sweden</td>
</tr>
<tr>
<td><strong>TETRA-BRIK</strong></td>
<td>&quot;</td>
<td>&quot;</td>
<td>Heat sealing below liquid level while carton is being formed and folding and heat sealing of flaps</td>
<td>&quot;</td>
<td>Rectangular ‘flat’ top</td>
<td>Sweden</td>
</tr>
<tr>
<td><strong>PURE-PACK</strong> (ex CELL-O-NLL)</td>
<td>&quot;</td>
<td>&quot;</td>
<td>Heat sealing after filling</td>
<td>Form carton from blank then fill and seal</td>
<td>Rectangular brick with gable top or flat top</td>
<td>USA</td>
</tr>
<tr>
<td><strong>COMBIBOLOCK (PKL, PERGA)</strong></td>
<td>Cardboard plastic and aluminium foil laminate</td>
<td>Blanks sprayed with H₂O₂ after forming followed by hot air drying</td>
<td>Gas heated sterile air at 200°C</td>
<td>Form carton from centre sealed blanks then fill and top seal</td>
<td>Rectangular with flat top</td>
<td>Germany</td>
</tr>
<tr>
<td><strong>THIMM-ONIER</strong></td>
<td>“Sarane x” polyethylene PVDC laminate</td>
<td>H₂O₂ bath followed by UV irradiation</td>
<td>Heat sealing above liquid level to form pouch</td>
<td>Form fill and seal from strip</td>
<td>Cushion or pillow</td>
<td>France</td>
</tr>
<tr>
<td><strong>PREPAC</strong></td>
<td>Polyethylene polypropylene and saran laminate</td>
<td>H₂O₂ bath followed by drying with bacto filtered air</td>
<td>Heat sealing above liquid level to form pouch</td>
<td>Form fill and seal from strip</td>
<td>&quot;</td>
<td>France</td>
</tr>
<tr>
<td><strong>HAMBA</strong></td>
<td>Plastic cups (ready formed) aluminium and plastic laminate for reel caps</td>
<td>Cups and lids irradiated with UV</td>
<td>Plastic coated aluminium web caps heat sealed on to caps</td>
<td>Ready-formed plastic cups filled and closed with diaphragm caps pressed from reel</td>
<td>To custom consumers’ requirements</td>
<td>Germany/ France</td>
</tr>
</tbody>
</table>
8.0 SUGGESTED READINGS


1.0 INTRODUCTION

Packaging of foods that was considered a luxury and source of cost addition in the yesteryears has now become a necessity and source of value addition. But considerable quanta of used packaging material being non-biodegradable become a source of visible nuisance and toxic substances that are accidental byproducts of improper disposal of non-biodegradable packaging materials are a source of concern. Increasing environmental issues, awareness among the consumers and growing market of convenience foods have increased the need for development of biodegradable packaging materials.

2.0 EDIBLE PACKAGING

Edible films and coatings based on proteins, polysaccharides and/or lipids have much potential for increasing food quality and reducing food-packaging requirements. Edible films formed as coatings or placed between food components provide possibilities for improving the quality of heterogeneous foods by limiting the migration of moisture, lipids, flavours/aromas, and colours between food components. Edible coatings also have the potential for maintaining the quality of foods even after the packaging is opened. In addition, edible films formed as coatings on foods could have an impact on overall packaging requirements. Edible coatings also have the potential for carrying food ingredients and improving the mechanical integrity or handling characteristics of the food.

2.1 Advantages

- Can be consumed with packaged product.
- Can be produced exclusively from renewable edible ingredients and anticipated to degrade more readily than polymeric materials.
- Can enhance the organoleptic properties of packaged foods by providing flavour, colour and sweetness to them.
- Can supplement the nutritional value of the foods.
- Can be applied inside heterogeneous foods at the interfaces between different layers of components.
Edible, biodegradable and microwavable packaging

- Can be tailored to prevent deteriorative inter-component moisture and solute migration in foods such as pizzas, pies and candies.
- Can function as carrier for antimicrobial and antioxidant agent.
- Can control the diffusion rate of preservative substance from the surface to the interior of the food.
- Can be used for microencapsulation of food flavourings.
- Can be used in multi-layer food packaging materials together with non-edible films.

2.2 Requirements of edible films and coatings:
- Should prevent product dehydration
- Should control transmission of gases, vapors and solutes
- Should provide mechanical protection to foods
- Should restrict microbial invasion
- Should have good mechanical properties
- Should serve as a carrier for additives, viz. antioxidants, antimicrobial agents, flavours, colourings, nutrients etc.
- Composition should conform to the regulations those apply to the food product concerned

These properties depend upon the types of material used, its formation and application.

2.3 Materials for edible films:

1) **Protein:** There are different proteins like milk proteins, wheat gluten, corn proteins, soy proteins etc. that are used for film formation. Manufacture of edible films and coatings are from whey protein products, represent an effective means of increasing excess whey utilization consequently alleviating the whey disposal problem.

2) **Polysaccharide:** Polysaccharides that have been used for film forming are cellulose and cellulose derivatives, starch, some hydrocolloids like carrageenan, pectin etc. Polysaccharides films have poor moisture barrier but have good mechanical properties.

3) **Lipid:** Lipids like bee waxes, rice bran, paraffin wax, acetylated monoglycerides etc. have been used for filmmaking. Wax has been used for coating of cheese, fruit etc. Lipids are hydrophobic and therefore act as a good moisture barriers, however, their mechanical properties are inferior to protein and polysaccharide based films.

4) **Composite films:** Composite films consist of two or more components so that characteristics of the films are enhanced by individual contribution from each component, e.g. protein and polysaccharide films by themselves are fairly hydrophilic but have very good mechanical properties.
2.3.1 Wheat proteins: Wheat protein films are brittle due to extensive intermolecular forces. Plasticizers reduce these forces and increase the mobility of the biopolymer chains and thereby improve the mechanical properties of the films. However, the resulting loose structure reduces the ability of the films to act as a barrier to the diffusion of various gases and vapours. The greatest obstacle to commercial exploitation of wheat gluten film appears to be their high water permeability. Edible food packaging films and sausages castings are made from blends of collagen and gluten using filters and softening agents.

2.3.2 Corn proteins: Zein is the only protein that continues to be produced commercially. It is characterised by its ability to form tough, glossy, hard greaseproof coatings after evaporation of the aqueous alcoholic solvent. Zein coatings for pharmaceuticals tablets and candies are formed by spraying or dipping the product into aqueous ethyl alcohol or isopropyl alcohol solutions of zein. The solution also contain a FDA approved plasticizer viz. glycerin, propylene glycol or acetaldehyde glycerides. Upon evaporation of the solvent a shiny protective zein film is formed on the surface of the product.

2.3.3 Milk proteins: Casein is the major protein of milk. Highly concentrated casein solutions are firmly gelatinized using trans-glutaminase resulting in film with favourable tensile property. Transglutaminase is a calcium dependent enzyme that catalyses the formation of covalent glutamyl-lysyl cross-links. Films are insoluble in water mercaptoethanol and guanidine hydrochloride. Pure caseinate films are attractive for use in food products due to their transparent and flexible nature and solubility in water.

2.3.4 Polysaccharides: A new edible film made of natural polysaccharides has been developed for packaging foods. Polysaccharides films have high OTR and their tensile strength is not as great as that of plastics, yet they have wide applications in meat industry. Processed, smoked meats can be wrapped in such films prior to smoking to reduce moisture loss. They may also be used to extend the shelf life of fresh fruits by absorbing moisture given off by fruit. An edible composition is formed by mixing glucomannan and optionally, another natural polysaccharide with a polyhydric alcohol (glycerin) and dried into a film, which may be eaten directly or serve as shell of soft fillings.

3.0 BIODEGRADABLE PLASTICS

Biopolymers or bioplastics are intrinsically biodegradable and their use would reduce the damage inflicted to the environment by petrochemical plastics due to their extended lifetime in the environment. They are polymers utilized by bacteria as carbon and energy reserve material and accumulated by them when other essential nutrients are depleted from the medium. Plant derived starches has been used to produce biodegradable plastic articles viz. Pharmaceutical capsule by blow molding process. Further sources of biodegradable materials are poly (lactic acid), poly(malic acid), or poly (E-caprolactones), which are synthesized chemically. In contrast, poly β-hydroxy
Edible, biodegradable and microwavable packaging

alkanoates (PHAs) are produced microbially from renewable, plant-derived feedstocks. It can be processed by traditional techniques used in the plastic industry viz. Injection molding, PHA has the potential to become an important source material for biodegradable plastics. It has been predicted that in the year 2002 only 3% of the estimated annual 15 million tonnes of plastics-packaging waste will be biodegraded.

3.1 Sources of biodegradable plastics:
- Biopol Polymers: produced by Fermentation of carbohydrate by the bacterium *Alcaligenes eutrophbus*.
- Poly (L-Lactide): derived directly or indirectly from starch or sucrose.
- Starch based materials: incorporation of starch into traditional plastics.
- Cellulose-based: microbial cellulose is mixed with chitin, chitosan, CM-cellulose guar gum, collagen, dextran and gelatin.
- Pectin-based: Reaction of pectin with a polyol like glycerol, sorbitol propylene glycol and ethylene glycol.
- Pollaulan: Microbial polysaccharide is synthesized by *Aureobasidium pollulans*.
- Poly hydroxy alkanoate (PHA): bacterial polyesters.

4.0 MICROWAVABLE PACKAGES

The advent of modern urban dynamic lifestyles has created a demand for ready-to-eat foods to be met by food products manufacturers. The hurried urban middle and upper-middle class consumers have little time to cook in conventional manner. A number of such products already command substantial shelf-space in retail stores and supermarkets.

The market for domestic appliances has also witnessed tremendous growth with respect to the availability of sophisticated appliances such as the microwave oven that has now been accepted as a modern domestic appliance for food cooking and heating. So the market needs innovative food packages, which can be microwaved and hence can be used for packaging or ready-to-eat food products.

Microwavable packages are made from a special aluminium laminate that can withstand high temperature, heat-processing treatments such as sterilization and microwave heating. The material has excellent barrier properties and is available in reel form and also as pre-formed containers in various sizes and shapes, which can typically suitable for the packaging of ready-to-eat food products. For the sake of economy, deep drawn, lightweight containers are generally made. Special foils are also available which are used as lidding material for these containers. This special lidding material is easily peelable.

All types of food products can be packaged in such containers by manual, semi-automatic or automatic process. Pre-cut lids that are available can be sealed to the filled containers by using heat-sealing machine. The containers are elegant and presentable packages allowing a wide display area to the food manufacturers. Their lightweight and
regular shapes make them easy to handle in the distribution chain. The advantages of these containers are:

- Easy to open
- Excellent shelf-life property
- Wide variety of shapes
- Effective advertising
- Stackable containers (low storage volume)
- Low transport weight
- High product protection
- Optimum machinability
- Suitable for all preserving methods
- Suitable for the microwave
- Easily recyclable at low energy costs.

5.0 SUGGESTED READINGS


1.0 INTRODUCTION

Commercial food preservation is aimed at preventing undesirable changes in wholesomeness, nutritive value, and sensory quality of food, and controlled growth of microorganisms. It was Nicolas Appert’s pioneering product development work on condensed milk, which led to the science of thermal processing for preservation of foods. Retorting may be defined as a process for preserving food achieved by the application of a thermal sterilization procedure to products packed in hermetically sealed containers. Tinplate and glass were the two most preferred packaging materials because of their strength, impermeability to gases/vapours and spoilage organisms. Later developments in packaging led to the introduction of retort pouches as flexible packaging material for retort-processed foods with certain added advantages over conventional cans/glasses.

2.0 RETORTABLE FLEXIBLE PACKAGES

The concept of retort pouch which took shape in the 1940’s, was developed again in response to the military need, as the rigid cans conventionally used by the combat forces posed problems such as difficulty in opening, injurious, and the potential to be used in makeshift explosives by the enemy. The retortable flexible packages are characterized by their structural components of heat-resistant plastic layers with or without aluminium foil and their ability to be thermo processed to result in shelf-stable food product. Its cost is also less as compared to cans. An early pioneer in proving the production reliability of the retort pouch was the US Army Natick Research and Development Center. In many developed countries, most ready-to-eat foods are packaged in retort pouches. Japan has been a pioneering country in this respect. In most recent times, focus has shifted to retortable semi-rigid trays or tubs because of their added convenience in use.

3.0 RETORT POUCH MATERIAL

The materials used in making retort pouches should possess toughness and puncture resistance normally required of flexible packaging, good barrier properties for long shelf-life, and heat sealability over a wide temperature range along with the ability to processing temperatures of the order of 110-140°C. To have all of these properties,
Retort packaging for long shelf-life foods

Laminated structures or co-extruded films are used. Typical structures used for retort pouches are given in Fig. 1.

Fig. 1. Typical structures used in manufacturing retort pouches

The outer film of the composite structure is needed for strength and resistance. It should be resistant to heating temperatures, printable and be able to withstand temperatures without bursting, shrinking and delamination. The most common material used is polyethylene terephthalate (PET). It has the added advantage of being reverse printed so that ink is embossed between the outer layer and the next inner layer. In order to achieve a shelf life of one year or more, aluminium foil layer as one of the inner layers for barrier properties is essential. The thickness range of aluminium foil varies from 9 to 25 μm, though a thickness of 9-10 μm is most common. In Japan, retort pouches without aluminium foil layer are also very common as some products with a low shelf life of 3-6 months are also acceptable. Nylon is another material used as a barrier film in place of aluminium foil because of its low gas transmission rate and toughness. However, being transparent, nylon based laminates cannot provide protection from light unless covered with a carton or wrap. The current material most commonly used as innermost sealant layer is cast polypropylene, though high density polyethylene modified with isobutylene rubber has also been used.

4.0 RETORT POUCH AND DESIGN FABRICATION

The four seal flat design is always preferred to fin seal designs and gussets, since the latter ones feature multiple seal junctions and hence are apt to leakages that are sometimes difficult to detect. Pouch dimensions for a particular volume are arrived at on the basis of the thickness desired which normally ranges from 1 cm for a 200 g pouch to 3 cm for a 1 kg pouch. A seal width of 6 to 10 mm is required for good strength. Both direct printing on the pouch or on an outer carton is practiced. Prefabricated pouches or
pouches made from roll stock in line with filling and sealing are used. In the former method, speeds are slower, but there is advantage to the pouch manufacturer inspecting out poor quality. Though, cartoned pouches are predominant, polymer trays with heat sealed film lids to contain one or two retort pouches are also used to extend the shelf life of products in foil-free films and also make the package more attractive.

5.0 MANUFACTURING CONSIDERATIONS FOR RETORT PROCESSED FOODS

Basic operations connected with the conventional canning/retorting process include: preparation of the food, filling of the container, exhausting, sealing of container, thermal processing/sterilization and cooling of the cans and its contents.

5.1 Filling
The filling of containers, which is accomplished mechanically or by hand, requires to be carefully controlled. This applies not only to the gross weight of material filled, but where the product is non-uniform, as in the particulate products, to the amount of each phase filled. Correct and accurate filling is important from the economic standpoint as well as prevention of occlusion of large volumes of air inside the can/pouch, which might decrease the severity of heat treatment. Filling machines for retort pouches are of pre-formed type or of roll fed form-fill-seal type generally operating at speeds of 30-60 pouches/min. For even higher speeds, a number of such units in parallel are used.

5.2 Exhausting/air removal
An essential operation in the canning process is the removal of air from the container before it is closed. This is necessary for several reasons such as minimization of strain on the can seams or pouch seals through expansion of air during heat processing, removal of oxygen, which accelerates the internal corrosion of the container and creation of a vacuum when the container is cooled. Additional advantages which result from exhausting include prevention of oxidation and preservation of vitamin C content. In commercial practice the procedures adopted for the removal of air from the cans and flexible pouches include heat-exhaust in which can contents are heated immediately before sealing, mechanical exhaust in which air is removed mechanically and steam injection which involves injecting a blast of steam into the headspace as the lid of the can is being positioned for sealing.

5.3 Sealing of the container
Metal cans, glass bottles and flexible retortable pouches are commonly used in modern day retorts. Can closing machines operate at very high speeds. The sealing of flexible pouches relies upon the fusion of two thermoplastic materials through application of heat by means of heated pressure plates or jaws. The inner ply or fusion material is generally either polypropylene or a modified high-density polyethylene. The two most common heat sealing techniques are the hot-bar sealing and impulse sealing which result in fully reliable seals. The former, which is simply a constant-temperature, resistance heated metal bar sealing against a rubber-faced anvil, predominates as the method for
forming side and bottom pouch seals, and shares popularity with the impulse technique for closure seals.

5.4 Thermal processing/sterilization

After exhausting and closing, the containers must be heated for an accurately predetermined time and temperature in an atmosphere of saturated steam, in heated water, or in an air-steam mixture. The sterilizing action of steam depends largely upon the transfer of its latent heat of vaporization to the surface of the cans on which it condenses. Dry or superheated steam condenses less readily and is therefore less efficient than saturated steam in transferring heat. The complete elimination of air from the retort is a vitally important factor in thermal processing and, unless special provision is made to maintain a uniform steam-air mixture, serious under processing may result. Retorts should be so constructed that removal of air is facilitated. This is brought by a procedure known as 'venting', the purpose of which is to displace all air in the retort by steam before it is brought to operating temperature.

When foods are preserved by heat, the heating process serves to reduce the concentration of microorganisms in the food. It may also inactivate enzymes present. It is not a necessary requirement of the heating operation that it should eliminate all viable organisms from the food. What is required is that the resulting product should be both acceptable to the consumer and safe to eat at the end of a predetermined storage period under defined conditions. pH of the food strongly influences the nature of the heat process required to produce an acceptable product. Preserved foods range in pH from neutrality to about pH 3.0. The inhibiting effect of acids on spoilage organisms starts to become apparent at pH 5.3, while *Clostridium botulinum* and other food-poisoning organisms are inhibited at pH 4.5. The important demarcation point occurs at pH 4.5. For low-acid foods (pH > 4.5), the requirement to destroy food-poisoning organisms such as *Clostridium botulinum* leads to the use of the severest class of heat processing, a treatment above 100°C. Such processes should be designated as 'commercial sterilization', which may be defined as heat processing designed to inactivate substantially all micro-organisms and spores which, if present, would be capable of growing in the food under defined storage conditions.

Retort pouches being flexible, require special racks or pouch carriers to prevent overlapping and maintain pouch geometry, because filled pouch thickness is critical in determining process time. This also guarantees uniform exposure of the pouches to the heating medium. Indiscriminate piling in a retort basket is hazardous. Slotted racks of rectangular sheet-metal plates separated by rod-mounted spacers for horizontal loading or circular retort baskets with divider plates or specially designed individual pouch carriers for vertical loading are used.

6.0 RETORT PROCESSED FOOD PRODUCTS

The shorter process times of the retort pouch makes it possible to pack a wide variety of foods including fruits, meat, fish, vegetables, dairy products etc. along with their formulated preparations and mixtures. Generally speaking, any product currently packaged in cans or glass jars can be packaged in retort pouches. Besides, relatively
delicate products that may not withstand the long process times in tin cans are also the likely candidates for the retort pouch. There is wide versatility for retort-pouched foods and they include: sauces such as tomato, cream, meat sauces, gravies containing pieces of meat/fish/poultry, seafoods, vegetables curries, meat loaves, sausages, beefsteaks and ham slices. As a result of current R&D work done at NDRI, CFTRI and DFRL, several Indian food products such as meat biryani, meat chunks in curry, meat gravy, kheer have also been successfully processed in retort pouches.

As the thin profile of retort pouches allows rapid heat transfer to the centre-most region, it is expected to result in improved taste, colour and flavour and less nutritional losses as compared to canned products and overall a better shelf life of food products.

Fig. 2 A variety of food products processed in retortable packages

7.0 RETORTABLE SEMI-RIGID CONTAINERS

Retortable semi-rigid containers are of tray or tub type with a structural supporting body and a sealable flexible lid. The tray package is a thin-profile package that offers all the advantages of the retortable pouch with the added convenience of a serving dish. Improved techniques of thermoforming or cold impact forming and co-extrusion have recently advanced the state-of-art of this package. Thermoforming is a relatively low-cost technique, wherein the sheet is heated to an optimum temperature and it is then forced into a female cavity mould by compressed air, vacuum or a male die. Advantages of semi-rigid retortable packages include ease of filling or top-loading of
products with or without in-line forming of the container, and potential increases in line speeds due to multiple pocket forming on a wide web-style operation. Original semi-rigid packages were made of aluminium foil laminates with cast PP as sealant layer. Oriented PP was used as exterior layer. Then came the high barrier plastics as a replacement of aluminium in order to make the containers microovenable. Two resins that are being used in these are polyvinylidene chloride (PVdC or saran) and ethylene vinyl alcohol copolymer (EVOH or EVA).

8.0 CONCLUSIONS

The availability of heat-resistant flexible and semi-rigid container has made the concept of the retort pouch a reality. The three most important advantages of these packages are their low cost, better quality retention and added convenience. While lower costs result from material costs as well as savings in energy, transportation and warehousing, improved product quality is the consequence of the thin profile of the container and the increased surface area that permit rapid heat transfer and less heat damage to quality factors. From the consumer’s view point, convenience of the retort pouch food has no comparison, since it is completely shelf-stable requiring no refrigeration, simple to reheat, and easily openable. Semi-rigid retortable containers further offer the advantages of easily peelable lidding and the convenience of a serving dish. R&D efforts will be the key to newer products being processed and packaged in retortable containers.

9.0 SUGGESTED READINGS

1.0 INTRODUCTION

Changes in the way food products are produced, distributed, stored and retailed, reflecting the continuing increase in consumer demand for improved quality and extended shelf life for packaged foods, are placing greater and greater demands on the performance of food packaging. Consumers want to be assured that the packaging is fulfilling its function of protecting the quality, freshness and safety of foods. To provide this assurance and to help improve the performance of the packaging, innovative active and MAP packaging concepts are being developed. Milk is highly perishable product. It is not uniformly available round the year to the whole country due to geographical and breed variation of Indian milch animal. Milk and dairy product must be available all the year round the country, irrespective of the growing season and area. It must be presented in a way that is convenient to purchase and use, and in most instances this means that it must be packaged. The packaging technique and choice of a pack with appropriate barrier properties is designed to prevent spoilage of food by microbial or insect attack, depending upon its physical nature, and also to preserve quality and nutritive value of many foods by the exclusion of oxygen and the control of moisture loss or gain.

The preservation of dairy and food product packed in plastic film mainly depends on the maintaining of its original quality by protecting it against external deteriorative influences. This is achieved through the barrier properties of the packaging material. The required protection of the foodstuff and dairy stuffs may not be achieved with a single layer of polymer. This necessitates the use of multi-layered films including different polymers, coating and metal foils. The barrier properties, mainly originate from its permeability to gases. More harmful than moisture is oxygen for foods and dairy products. It causes lipid oxidation and provokes rancidity especially when the package allows light transmittance. The other requirements for the preservation of the qualities (physical, chemical, sanitary and organoleptic) of the food and dairy products are to prevent changes in taste, colour and odour.

2.0 MODIFIED ATMOSPHERE PACKAGING (MAP)

The technology of packaging products in modified atmosphere is the most advanced food preserving technique with many advantages. This method of packaging replaces the air headspace of package with a specific food-grade gas or mixture of gases. MAP is used to extend the product’s shelf life and to maintain the product’s initial quality for much longer period. It helps in retaining appeal to consumers and retarding the growth of mould and bacteria besides reducing the oxidative deterioration and
preventing mechanical damage to the product by adding a ‘cushion of gas around the product’.

MAP is the enclosure of food products in high barrier materials, in which gaseous environment has been modified. MAP is a process by which the shelf life of a fresh product is increased significantly by enclosing it in an atmosphere which slows down the spoilage processes particularly growth of microorganisms, whilst enhancing some beneficial action such as retaining the desirable red colour of meat (Inns, 1987). MAP extends the shelf life of meat, poultry and fresh produce by 50–400% and the quality is maintained beyond the expected shelf life inhibiting the growth of aerobic Psychrotrophs. MAP is capable of substantially extending the shelf life of many perishable foods (Hotchkiss, 1988) and has accordingly undergone developments to meet the growing consumer demand for fresh, high quality convenience foods. Generally, three types of gas mixtures (N₂, CO₂ and O₂) are used in MAP (Goodburn & Halligan, 1988). MAP slows respiration rates, reduces microbial growth, and retards enzymatic spoilage with the final effect of lengthening the shelf life of the product. MAP is the enclosure of food products in barrier materials in which the atmosphere changes as a result of dynamic interaction between atmosphere, product and environment.

In most MAP applications, it is desirable to maintain the atmosphere initially introduced into package for a long period as far as possible and to maintain the gas ratio unchanged. The use of appropriate gas mixtures for MAP offers an alternative to vacuum packaging. MAP reduces the rate of oxidation reactions and microbial growth by modifying the level of gases (CO₂, N₂ and O₂) that surround the product and improve the shelf life to a great extent (Floros et al., 2000). As per the scientific observation, CO₂ directly inhibits the growth of bacteria and mould. MAP technology has been successfully used to extend the shelf life of wide range of commodities including fish, meat, sandwiches, salad, vegetable and cheese.

3.0 POTENTIAL ADVANTAGES AND DISADVANTAGES OF MAP

Advantages

- Fresh appearance.
- Potential shelf-life increase by 50 – 400%
- Reduced economic losses
- Product distributed over long distances.
- Increased market area
- Provides a high quality product
- Easier separation of slices (vacuum vs MAP)
- Easier to open, i.e. user friendly

Disadvantages

- Visible added cost
- Temperature control necessary
Different gas formulation needed for each product type.
Special equipment and training required.

(Hotchkiss, 1988)

4.0 PRODUCT OPTIMIZATION AND CRITICAL POINTS IN A MAP SYSTEM

Product Parameters

- Organoleptic & microbiological quality of raw materials
- Temperature throughout the chain
- Packaging equipment
- Appropriate gas mixture

Critical Points

- Microbiological safety & shelf life of product
- Food chain (distribution and safety system)
- Temperature control at the point of sale.
- Consumer handling between sale & consumption

MAP packages are of two general types breathing and non-breathing types. Most of the milk and dairy products except some variety of cheese come under non-breathing types. The breathing packages allow the gaseous exchange from and into the package and the final atmosphere is result of a dynamic equilibrium which is a function of parameters such as film gas permeability, temperature, respiration rates (biological or microbial), relative humidity, surface area etc. On the other hand, non-respiring food does not involve any kind of gaseous exchange.

5.0 PACKAGING MATERIALS

The choice of packaging material is an important factor in any MAP operation. A low water vapour transmission rate together with a high gas barrier must generally be achieved. Generally, all MAP packages are based on thermoplastic polymers. The packaging materials need to have mechanical strength to withstand machine handling and subsequent storage, distribution and retailing. One of most important parameters to be considered for MAP studies is the need for proper packaging films. The most important factors influencing the antimicrobial effect of CO₂ is packaging film permeability. The success or failure of MAP for resiping and non resiping foods depends on both the O₂ and CO₂ impermeability of packaging materials in order to maintain the correct gas mixture in the package headspace. In addition, film used in gas packaging should also have low water vapour transmissions rates to prevent moisture loss or moisture gain. Since all the desired characteristics of a packaging film i.e. strength, impermeability and heat sealability are seldom found in one polymer, individual polymers are laminated to one another to produce films of desired characteristics for gas packaging of both resiping and non resiping products. The packaging of non-resiping product include nylon /PE
Modified atmosphere packaging for dairy and food industry

/nylon /PVdC /PE or Nylon / EVOH / PE. These composite structures have all the desired characteristics for gas packaging of non-respiring product specifically; strength is provided by the outer most layer of nylon, gas and moisture vapour impermeability is provided by EVOH or PVdC and heat sealability is provided by PE. (Goodburn and Halligan, 1988)

5.1 Characteristics of ideal film

The ideal film must possess the following characteristics:

- Ability to change the gas permeability properties in case of rise in temperature.
- Controllable moisture vapour transmission rate (MVTR) in order to prevent supersaturation
- Vapour accumulation and condensation problem
- Ability to warn the consumer that the quality is not at its best.
- Good thermal and ozone resistance
- Commercial suitability and ease of handling and application
- Non-reactant with produce and nontoxic
- Ease of printing for labeling purpose.

(Church, 1994; Kader et al., 1989; Smolander et al., 1997)

6.0 SAFETY ASPECT OF MAP ON MICROBIAL AND PATHOGENIC ORGANISMS

The microbial load in the packaged food has a significant effect on the quality of final product. A high microbial load and temperatures higher than recommended for particular food can reduce the shelf life of a product by 50-70%. There are ample evidences that elevated CO₂ extends the lag phase of bacterial growth and can slow the propagation of bacteria. Low O₂ is likely to favour mesophillic microbes such as Listeria and lactic acid bacteria. Elevated CO₂ may favour gram-positive bacteria over gram-negative bacteria, especially Coryneforms and lactic acid bacteria. Pathogenic bacteria have been isolated from many different commodities including fruits and vegetables (Beuchet, 1996). Pathogens such as Listeria monocytogenes and those who are able to multiply at very low levels of O₂ such as psychrotrophic Clostridium botulinum are of particular concern.

Seideman et al. (1984) studied that 20-30 % CO₂ or even 10 % CO₂ may be sufficient to retard bacterial growth. High levels of CO₂ have generally been found to have an inhibitory effect on Staphylococcus aureus, Salmonella sp. Escherichia coli, and Y. enterocolitica. The degree of inhibition increases as temperature decreases. MAP stored products at 4°C have a shelf life 2 to 3 times greater than air-packed products. The addition of CO₂ controls the growth of psychotropic bacteria in both raw and pasteurized milk at refrigeration temperatures. Dissolved CO₂ increases the lag phase and the generation time of microorganisms. Mycotoxins are secondary metabolites of fungi and their presence in any amount is undesirable.

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An important factor in determining the microbiological safety of MAP food and dairy products is whether the food is sold as ‘ready-to-eat’ or ‘raw’. The use of MAP for any raw produce that is subsequently cooked is considered less hazardous because cooking will kill all vegetative pathogens. The safety and stability of foods largely depends upon the initial microbial load. Modification of the atmosphere surrounding the food may provide one condition or hurdle that helps restrict the growth of microorganisms. Another hurdle can be provided by storage at < 4°C. The combination of chill temperature and MAP generally results in more effective and safer storage regime and longer shelf life (Leistener, 1995).

7.0 FUTURE CHALLENGES

MAP undoubtedly enhances the shelf life of products without preservatives. The future thrust should be able to maintain the quality of the packaged produce with devising films, which are cost effective and viable. The success of MAP depends on many factors including good initial product quality, good hygiene from reception of milk to the correct packaging material selection, the appropriate gas mixture of the product, reliable packaging equipment, and maintenance of controlled temperatures. It is important to realize that storage not only improves the quality but also delays the rate of spoilage. However, as we become more aware of the economic advantage of MAP technology, it will slowly emerge as the preservation cum packaging technology of future, propelling the food industry into a new era of food products, distribution and marketing. Overall, MAP can prove to be useful supplement in the effort to maintain good quality, appearance, texture, and flavour retention of nutritive value and pathogen control of dairy & food produce throughout distribution chain.

8.0 REFERENCES
INTRODUCTION

Consumers buy various kinds of food products—the food products may include fresh products, processed foods, beverages, and minimally processed products. The basic functions of food packaging are protection, containment, information, and convenience. Most food products packaged for distribution convenience and quality management and usually opened at the point of consumption.

The packaging concept is determined by the demands of both the consumer and the product. New technological developments, environmental awareness, and changes in the consumer market force the packaging technologists to consider an increasing number of factors when designing a package (Cecilia, 2000). Packaging materials provide a sort of inert barrier that prevents interaction of food products with the external environment.

A variety of packaging technologies are being developed to provide consumers with high-quality products that have a long shelf life. Technologies such as controlled-atmosphere packaging (CAP) or modified-atmosphere packaging (MAP), use of edible coating are recent developments in the area of packaging. These developments have led to the concept of interactive packaging. It can be defined as packaging when it performs the same role in the preservation of foods other than providing an inert barrier to outside influences (Rooney, 1993). One of the best examples of interactive packaging and which fulfills the definition in all aspects is MAP. MAP has been defined as the enclosure of food product’s in a high gas barrier film in which the gaseous environment has been changed or modified to slow respiration rates, reduce microbial growth and retard enzymatic spoilage with the intent of extending shelf-life.

However, besides being providing a protective atmosphere, packaging material itself may play an active role in enhancing the shelf life of food by nullifying the rate of deteriorative reactions, by arresting the growth of spoilage/pathogenic microorganisms. This has led to the concept of active packaging and Labuza first floated the idea. Other terms coined to denote such packaging include “smart”, “functional” and freshness preservative packaging. Various kinds of active substances can now be incorporated into the packaging material to improve its functionality and give it new or extra function (Han, 2000). Such active packaging technologies are designed to extend the shelf life of foods, while maintaining their nutritional quality & safety.
2.0 ACTIVE PACKAGING - A new dimension in packaging technology

Active packaging technologies involve interactions between the food, the packaging material, and the internal gaseous atmosphere (Labuza and Breene, 1989). Active packaging senses environmental changes and respond by changing its properties (Brody, 2001). In other terms, active packaging is a group of technologies in which the package is actively involved with the food products or interacts with internal atmosphere to extend shelf life, while maintaining quality and safety (Floros et al., 2000). Diverse functions they perform include oxygen scavenging antimicrobial activity, moisture control, ethylene removal, antioxidative reactions etc. The active component may be part of the packaging material or may be an inert or attachment to the inside of the pack.

Active packaging is designed to enhance the properties of packaging material so that it could increase shelf life of product. Therefore, the forms and applications of active packaging are diverse, addressing specific situations in the protection and presentation of foods and other products.

3.0 OBJECTIVES OF ACTIVE PACKAGING

Active packaging is selected to enhance the ability of conventional packaging to preserve the quality attributes of the product throughout the distribution system. However, the Rind of system used is based on following considerations.

- Shelf-life Extension
- Less expensive packaging materials.
- Simpler processing
- Easier handling
- Uniformity of packaging material
- Presentation
- Reduced additive foods

4.0 PROBLEMS THAT CAN BE ADDRESSED BY ACTIVE PACKAGING

Although the microbial spoilage, insect-pests damage, chemical reactions, physiological reactions limit the quality and shelf-life of foods, but not all variables are of equal importance for all products. Hence, the applicability of specific problems to specific food groups is considered briefly to indicate overcoming the problems by means of active packaging.

4.1 Fruits and vegetables

Fruits and vegetables either fresh or minimally processed are vulnerable to microbial, attack and undergo unfavourable biochemical changes during storage. Though modified atmospheric packaging (MAP) is becoming more popular and has been found to increase the product life substantially. High CO₂ atmosphere slows down the respiration process, and prevents the growth of aerobic microflora, but at higher-level, anaerobic metabolism as well as growth of anaerobic microorganisms, results in development of off-flavour and poses health hazards to consumers. So active packaging systems with oxygen scavengers, CO₂ emitters, desiccants and antimicrobial compounds, may be proved beneficial. Ethylene production that accelerates the ripening and senescence, although suppressed in MAP at very high
CO₂ concentration, still addition of ethylene scrubbers with packaging material seems to be an attractive alternative.

4.2 **Meat and fish products**

Flesh foods including meat, poultry and fish are vulnerable to rapid microbial spoilage, especially by Pseudomonades and the Enterobacteriaceae. High water activity and favourable pH help in flourishing of these spoilage organisms. In absence of appropriate packaging treatments, these products have very short shelf-life even at refrigerated temperature. High fat containing products like pork and fishes often develop rancid flavour due to oxidation. Taints and off flavour in muscle foods is a common problem encountered during storage and transportation like moldy taints in fish shipment.

Even low concentration of oxygen leads to the discolouration of meat colour as it causes oxidation of pink coloured nitrosomyoglobin. Moreover, water droplets that occur in the form of tissue fluid over the surface of fish, white or red meat provide a favourable breeding place for microbes.

4.3 **Cereals and snack foods**

Cereal grains and their partially processed products such as flour, are low moisture content product and relatively more resistant to microbial as well as chemical changes. However, biological deterioration may result from insect infestations. Fluctuation in temperature and humidity enhance the rate of activity at various stages in the life cycles of insects. Worldwide opposition of chemical fumigants has left us with no other options but to look for real alternatives. Storage of grains and their minimally processed product may be benefited by recent developments in the area of active packaging. In Baked products growth of moulds, yeasts and sometimes bacteria limits their shelf life. Composition of gaseous environment and antimicrobial has much to offer in the preservation of these foods coupled with low water activity. Fried snack foods, indigenous and exotic, particularly sensitive to oxidation as well as textural defects. These products are packed under inert gas flushing, however advances in active packaging can be extended to those products as well.

4.4 **Dairy products**

Fresh milk gets spoiled due to the growth of spoilage microorganism and the flavour of the milk becomes unacceptable when bacterial count reaches to 10⁷CFU/ml. Pasteurised milk has very short shelf-life in tropical countries even at refrigerated temperature. Pasteurised milk could benefit from antimicrobial packaging treatments (Rooney, 1993). UHT processed milk has gained a wider acceptance in many developed nations; still oxidative reactions are major deteriorative factor. So, application of oxygen scavengers will be of great significance. Similar is the case of full cream milk powder. Dairy products especially cheeses owing to their higher water activity are susceptible to microbial growth. Sorbic acid impregnated cheese wraps has been in practice since long to prevent undesirable mould growth.

4.5 **Dried foods**

Dried food products such as milk powder, dried soups, nuts, dried fruits and ground coffee are very much sensitive to oxygen and moisture. Such dried foods are
of higher significance both nutritionally and convenience point of view. Their packaging requirements are also sophisticated ones and additional measures to control oxygen and water ingress, further improve their shelf life. Dried fruits often undergo Maillard reaction during storage, leading to excessively dark product. To check the browning in dried fruits SO\textsubscript{2} is lost through absorbers may solve this problem.

5.0 TYPES OF ACTIVE SUBSTANCES

Based on the nature of spoilage various kinds of substances have been identified. However, only few of them can be applied in active packaging systems. Active packaging system falls into three different categories: scavenging, releasing and “other”. Scavengers include those of oxygen, ethylene, moisture, and taint, whereas emitters include for carbon dioxide, ethanol.

5.1 Oxygen scavenger

The removal of headspace and dissolved oxygen or presence of oxygen that has been produced as a result of metabolic activities, from a wide variety of food products is of paramount importance. Small quantity of residual oxygen is detrimental from product’s quality, as it may trigger a number of oxidation reactions. It is often manifested by loss of freshness, decrease in nutritive value, development of off-flavour, discoloration etc. In the packaging of less sensitive products, much of the oxygen in air can be removed by inert gas flashing, but oxygen scavenging is still advantageous. (Rooney, et.al, 1981).

Oxygen absorbents can be defined “as a range of chemical compounds introduced into the package (not the products) to alter the atmosphere within the package”. Oxygen absorbents comprise of easily oxidizable substances usually contained in sachets is available in a variety of sizes capable of absorbing 20-2000 ml headspace oxygen. These sachets are kept inside the packaged food; they actively modify the package headspace and reduce the oxygen levels to < 0.01% within 1-4 days at room temperature.

5.1.1 Classification of oxygen scavengers: Theoretically, any material that reacts with oxygen can be used as oxygen scavengers. However, the objective of active packaging is for food preservation, the material used for this purpose must meet the following criteria:

- Must be safe and must not produce toxic substances or offensive odors/gases.
- Must be compact in size and easy to handle.
- Must absorb a large amount of oxygen and have an appropriate oxygen absorption speed.
- Must be economically priced (Harima, 1990).

5.1.1.1 On the basis of reaction style: In the self-reaction type, the oxygen scavenging reaction commences as soon as the absorbent is exposed to air. In moisture dependent types, the oxygen absorption reaction occurs only after moisture has been absorbed from the food. The later types are easier to handle, as they do not react immediately upon exposure to air. The absorbent based on reaction style is presented in Table 1.

5.1.1.2 Classification according to reaction speed: On the basis of reaction speed, these can be grouped as immediate effect, general effect and slow effects types (Harima, 1990). The average time for oxygen absorption is 0.5-1 day for the
immediate type, 1-4 days for the general type and 4-6 days for the slow reacting type. The reaction time depends on the temperature of storage and the water activity ($a_w$) of the food.

5.1.2 **Oxygen Scavenging films**: Sachet based scavengers, though easy to handle, are unsuitable for use with liquid products. Hence, several research groups and manufacturing companies have been engaged in developing oxygen-scavenging plastics. The incorporation of non-iron based oxygen removers directly into plastic package materials has gained momentum. There has been great encouragement in this front, through the development of co-extruded stretch blow moulding of polymers into a monolayer plastic structure. Some of the commercially developed oxygen scavenging films is presented in Table 2.

**TABLE 1: Classification of oxygen absorbents**

<table>
<thead>
<tr>
<th>Reactant</th>
<th>Function</th>
<th>Application</th>
<th>Absorption speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>$O_2 \downarrow$</td>
<td>Self-working type. Dry $a_w&lt;0.3$. Tea, Nuts. Medium $a_w$ ($a_w&lt;0.65$). Dried beet. High $a_w$ ($a_w&gt;0.65$). Cakes. Moisture dependent type. High $a_w$ ($a_w&gt;0.65$). Pastas.</td>
<td>4-7 days. 1-3 days. 0.5 days. 0.5 days.</td>
</tr>
<tr>
<td>Catechol</td>
<td>$O_2 \downarrow$</td>
<td>Self-working type. Medium $a_w$ ($a_w&lt;0.65$) Nuts.</td>
<td>3-8 days.</td>
</tr>
<tr>
<td>Iron+ Calcium</td>
<td>$O_2 \downarrow &amp; CO_2 \downarrow$</td>
<td>Self-working type. Roasted coffee.</td>
<td>1-4 days.</td>
</tr>
<tr>
<td>Ascorbic acid</td>
<td>$O_2 \downarrow &amp; CO_2 \uparrow$</td>
<td>Self-working type. Medium $a_w$ (0.65). Nuts.</td>
<td>1-4 days.</td>
</tr>
<tr>
<td>Ascorbic acid + Iron</td>
<td>$O_2 \downarrow &amp; CO_2 \uparrow$</td>
<td>Moisture dependent type. High $a_w$ ($a_w&gt;0.85$). Cakes.</td>
<td></td>
</tr>
<tr>
<td>Iron + Ethanol/Zeolite</td>
<td>$O_2 \downarrow &amp; Ethanol \uparrow$</td>
<td>Moisture dependent type. High $a_w$ ($a_w&gt;0.85$). Cakes.</td>
<td></td>
</tr>
</tbody>
</table>

**TABLE 2: Commercially available anti-microbial films**

<table>
<thead>
<tr>
<th>Films</th>
<th>Components</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>OXBAR</td>
<td>MXD-6 Polyamide with polyester containing a cobalt sheet.</td>
<td>Zero oxygen permeability.</td>
</tr>
<tr>
<td>Nylon</td>
<td>MXD-6 Polyamide with polyester.</td>
<td>Withstand pasteurization temperature.</td>
</tr>
<tr>
<td>Type</td>
<td>Poly butadiene with polyester.</td>
<td>Zero oxygen permeability.</td>
</tr>
<tr>
<td>Diene type</td>
<td>Ethylene vinyl alcohol and polydiene.</td>
<td>Oxygen &amp; carbon dioxide barrier with no flavour change. No off-flavour.</td>
</tr>
<tr>
<td>Laminates</td>
<td>Added Benzo acrylate polymer.</td>
<td></td>
</tr>
</tbody>
</table>

5.2 **CO$_2$ generating or scavenging**

A complementary approach to oxygen control is to incorporate a carbon dioxide generating system into a film or add it as a sachet. This approach is widely recommended practice in MAP and controlled atmospheric storage of fresh produce, where higher CO$_2$ concentration is must to retard many unfavourable biochemical reactions. Permeability of CO$_2$ through plastic films is 3-5 times higher than the oxygen. Hence, a generator is needed for some application. CO$_2$ emitters developed commercially are based on the reaction between bicarbonate, an acid together with water vapour that results in production of CO$_2$. One of the products that have been benefited most by the development in active packaging is the ground coffee. The loss
of aroma substances during aging process is the major quality deteriorative reaction. The CO₂ produced in this process has to be removed to ensure proper aroma in the product. CaOH (slacked time) is most commonly used scavenger of CO₂ and incorporated in number of formulations. The shelf life of ground fresh coffee tripled when a sachet containing iron powder and CaOH was added in flexible bags. However, controlling the level of both O₂ and CO₂ may have some adverse effect on metabolic activity of fruits and vegetables.

5.3 Ethylene absorbent

Accumulation of ethylene in headspace of packages of fruits and vegetables, not only accelerates the ripening process, but also favours the formation of certain undesirable compounds like coumarin in carrots. Removal of ethylene from the plant environment can significantly retard post harvest catabolic activities in fresh produce and complement modified atmospheric storage. Recent developments have been based, in part, on a reduction in scale and improvement in handling of the potassium permagnate reaction system. Ethylene absorbing substances or as they commonly called ‘scrubbers’ include permanganates, metal catalysts and other physical adsorbents. Potassium permanganate react with ethylene to eventually produce CO₂ and water. KMnO₄ can be absorbed onto inorganic substrate for the incorporation into gas permeable sachets to permit reaction with ethylene, is a not uncommon practice for fresh produce transport. However, to remove ethylene effectively large sized sachets are required, which are not suitable for consumer-size packages. Among the alternatives have been incorporation of activated carbon impregnated with palladium catalyst dispersed ohya stone, crystobalite, coral sand, silica gel and synthetic zeolite have been developed (Abe, 1990).

Another novel method utilizes the reaction of 3,6- dicarboxy 1,2,4,5- tetrazine some alkenes like ethylene, even at much lower concentration. However, tetrazine based systems function in homogenous solution in plastic film that are purple-coloured and which bleach as reaction occurs.

Researchers at Food Processing Division of CSIRO have developed radically different polymers, which removes ethylene at the levels found to be physiologically active. However, exact mechanism of ethylene removal by many newly developed polymers has not been clearly understood.

At DFRL Mysore, a permanganate based ethylene absorbing system has been developed and proved highly successful for storage of many tropical fruits and vegetables. Clay embedded in a film that scavenges ethylene is being developed in Japan.

5.4 Moisture scavenging

Water vapour formed during course of normal metabolism, many fresh produce create high humidity in package and allow the growth of moulds and yeasts. Many packaging films do not provide an adequate water-vapour barrier. The use of polyethylene cartons and case liners often satisfied the short term commercial moisture barrier requirement but may not provide sufficient packaging if temperature fluctuation occur during the transportation and storage (Brody et al., 2001). In the packaging of produce there are problems in retaining any specific relative humidity, so considerable research has been devoted to solve such problems (Robertson, 1991).
A desiccant film or sachet can solve this problem and such systems are frequently used for retail packs of low water activity foods.

One of the humidity buffering films developed in Japan for household application is named 'Pichit'. This consists of an alcohol, propylene glycol and a carbohydrate, both of which are humectants (Labuza, 1996). Purge absorbers that control moisture content of the fresh produce and meat products extends shelf life of cut tomatoes, melon, poultry etc. Most efficient moisture controllers are those in which the desiccants are incorporated into the plastic structure. Blending the desiccants into the plastic separates the drying agent by polymer that is usually a moisture barrier, thus restrict the absorber (Broody, 2002). The preferred polymers for absorbing water are polyacrylate, salt and graft copolymer of starch (Rooney, 1995). The desiccants like silica gel, molecular sieves, CaO, clay, salts and sugars usually serve the purpose. Some of the moisture scavenging systems is presented in table 3.

Table 3. Moisture Scavenging Systems

<table>
<thead>
<tr>
<th>System</th>
<th>Structural component</th>
<th>Food product</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tyrek®</td>
<td>Heat sealed salt in spun bonded polyfin film sachets</td>
<td>Fresh produce</td>
<td>Raw chemicals</td>
</tr>
<tr>
<td>CHEFKIN</td>
<td>Duplex sheets, liquid glucose embedded in between an exterior water barrier and an inner water-vapour permeable film.</td>
<td>Fish and fresh dry fruits and vegetables</td>
<td>Chefkin, Japan</td>
</tr>
<tr>
<td>Crisper F</td>
<td>Sheet made of aluminium metallized film with non woven fabric on the reverse side</td>
<td>Meat, fish, fresh fruits and vegetables</td>
<td>Kagaka kogyo, Japan</td>
</tr>
<tr>
<td>Drip absorbent sheets</td>
<td>Superabsorbed polymer in between two layers</td>
<td>Fish, poultry, meat and fresh produce</td>
<td>Thermarite®, Australia; Toppan™, Japan</td>
</tr>
</tbody>
</table>

5.5 Anti-microbial packaging

Anti-microbial packaging is one of the most researched areas of active packaging. The research activities have been directed at determining how the surfaces of plastic can be made not only sterile, but also capable of exerting anti-microbial effect on packaged food or beverage. Two approaches can be applied to achieve anti-microbial effect. The first consists of binding an agent to the surface of packages and this would require a molecular structure large enough to retain activity on the microbial cell wall even though bounds to the plastic. Such substances are usually enzymes or anti-microbial proteins. The second approach involves the release of anti-microbial agents into food or beverage or localized removal of food ingredient essential for microbial growth.

This application could be used for foods effectively not only in the form of films but also as containers and utensils (Han, 2000). The anti-microbial activity can be imparted to food packaging material by common anti-microbial substances, radiation or gas emission/flushing. Some of the potential anti-microbial packaging applications has been summarised in Table 4.

6.0 Migration mechanism in active packaging system

Most food packaging systems consist of packaging material, food and headspace. These can be either package/food system or package/headspace/food.
system (Han, 2000). The former includes package-contacted food products or low viscous or liquid foods without headspace. Example of this type of products includes individually wrapped cheeses, deli products; shrink-wrapped fruits and aseptic brick packages. Diffusion between packaging material/food and partitioning at the interface are the main migration mechanism in this type of food system. Inhibitory substances may be incorporated into the packaging materials initially and these get migrated through diffusion and partitioning. However, in second type of system evaporation or equilibrated distribution of a substance between the headspace, packaging material and food is the major migration mechanism. In this type of system volatile substances are of importance. In active packaging systems, the control of the release rates and migration amounts of active substances are very important issues.

7.0 EDIBLE COATINGS AS ACTIVE PACKAGING MATERIAL

Edible films and coatings are thin continuous layers of edible material formed on or placed between food components to provide a barrier. These materials function as active packaging materials by providing more than traditional passive protection against the atmospheric and physical environments. In addition to enhanced barrier properties, edible films and coating control adhesion, cohesion and durability and improve the appearance of coated foods. Active ingredients and seasoning can be incorporated into edible films coatings. They may carry antioxidants, antimicrobial agents, colourants, flavour, fortified nutrients and/or spices. Two major classes of film former are, proteins and polysaccharides, for example, whey protein coatings and films can incorporate adequate amount of edible active agents as well as plasticizers. Padgett et.al., (1998), demonstrated the antimicrobial activity of lysozyme and nisin in the soy protein isolate films and corn, zein films. These film/coatings may carry approved chemical active substances as well as natural active substances like enzymes, proteins, natural oils, fatty acids, natural antioxidants etc.

8.0 CONCLUSION

Active packaging is largely a series of innovation of the last two decades. The substantial amount of progress is still going on. The introduction of active packaging requires re-appraisal of the normal requirement that there should not be any interaction between food product and packaging substances. It will have a wider application in future where emphasis is on minimally processed and reduced additive safe food products. Suitable designing, better understanding of interactions, safety and regulation through enforcement will certainly enhance consumer’s faith in active packaging substances.
## Table 4 Anti-microbial Packaging systems

<table>
<thead>
<tr>
<th>Anti-microbial agents</th>
<th>Mechanism</th>
<th>Current status</th>
</tr>
</thead>
</table>
| **Radiation** (Radioactive materials, laser excited materials, UV-exposed films, far infra red emitting ceramic powders) | • Sterilization of packaging materials & equipments.  
• Creation of anti-microbial peptides on polyamide | Radiation sterilization not yet approved |
| **Gases**  
Sulphur dioxide flushing  
Chlorine dioxide  
Hydrogen peroxide  
Ozone | • Prevents growth of moulds  
• Incorporation of Sodium chlorite in packaging films and gas is generated upon reaction with oxygen  
• May be applied on the surfaces of wraps and sheets | • Used for preservation of fresh grapes and berries  
• Effective, but chances of secondary effects on foods  
• Approved by regulatory authorities as surface sterilizants |
| **Volatile substances**  
Allylisothiocynate  
Horseradish extract  
Eugenol | • Again may be used for surface sterilization of packaging material or incorporated into packaging material  
• Being natural can be a component of edible coatings | • Not compatible with a majority of food products, as they impart undesirable flavour  
• Being natural have potential to get regulatory approval |
| **Ethanol vapours** | • Ethanol emitters absorbed in silica pads and embedded in sachets made from ethylene vinyl acetate copolymer. Migrate to headspace in packaging material and prevent growth of moulds and yeast | • Commercially available sachets (Ethicap) is available and is in use for cakes, bread and cheeses  
• Also act as anti-staling agent in baked products during refrigerated storage |
| **Fungicides**  
Benomyl  
Imazalil | • Covalently coupled to an inomeric plastic films named surlyn  
• As part of shrink wrapping films  
• Imazalil impregnated films | • Found effective against mycotoxigenic fungi at experimental level and have potential for future application in minimizing post harvest losses of fruits and vegetables. |
| **Silver salts** | • Loaded on carrier materials like zeolite which is added to plastic films and sheets | • Require regulatory approval |
| **Organic acid and their derivates**  
Potassium sorbate. Sorbic acid anhydride. Benzoic acid. Sodium benzoate | • Added in LDPE, Wax coating of cheeses. Anhydride of acids are more effective than salts. | • Approved food preservatives.  
Mechanism of migration has been thoroughly investigated. |
| **Others**  
Lysozyme  
Nisin  
Triclosan (diphenylether) | • Added with edible coatings. | • Experimental level |
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1.0 INTRODUCTION

Water is recognized as being an important factor in numerous phenomena connected with the quality of food. For instance, it plays a part in the textural properties of several commodities. Moreover, water is an essential parameter determining the behaviour of food products in the course of many processing operations: on water, will depend the amount of energy necessary for freezing or dehydration of the product; water will strongly influence the evolution of physical, chemical and biochemical phenomena taking place in the product during processing operations such as heating, drying, etc. Water will also influence the same reactions, as well as the activity of microorganisms, during the storage of food products under various conditions. As a result, all aspects of quality—sensory, nutritional and hygienic properties of the food will be affected.

In all these circumstances, the water content of a product is obviously an important factor, but equally important may be the physical properties of water, such as its thermodynamic activity and its mobility. Actually, the concept of water activity (a_w) is now widely used by the food industry and in the legislation of several countries.

2.0 WATER ACTIVITY

The water activity of food can be conveniently expressed as the equilibrium water vapour pressure (P_w) over the food system divided by the vapour pressure of pure water (P^0_w) at the same temperature and atmospheric pressure:

\[ a_w = \frac{P_w}{P^0_w} = \frac{ERH \%}{100} \]

The water activity is correlated to the moisture content of foods. This relationship is known as water sorption isotherm. The water sorption isotherm for most of the food products is sigmoid in shape. It can be divided into segments representing the a_w ranges in which the three principal types of water binding predominates (Brunauer et al., 1938). The region lying between a_w value of 0 and 0.25 is believed to be dominated by water bound by ionic groups such as NH_3 associated with proteins and -COO^- groups associated with proteins, pectins and other polyuronic acids. The moisture in this region is tightly bound (known as monolayer moisture), which is generally not available for either chemical or microbiological activities. The region lying between a_w values of 0.25 and
0.75 appears to be related primarily to covalently bound water, such as amide groups in proteins and -OH groups in proteins and carbohydrate polymers such as pectins, starch, hemicellulose and cellulose. In this region, water is bound sufficiently tightly that it is unavailable to most of the microorganisms but available for chemical activity. The region lying between $a_w$ values of 0.75 and 1.0 is believed to represent water multilayers on protein and carbohydrate polymers, in addition to water in which the vapour pressure is reduced by dissolved solutes, such as free amino-acids, sugars, and/or capillary attraction in the microstructure. The water in this region is loosely bound and is available for chemical and microbial activities. The water activity of various dairy products is presented in Table 1.

**Table 1. Approximate $a_w$ levels of some dairy products**

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>$a_w$ at 25°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dried Milk Products</td>
<td>0.1-0.3</td>
</tr>
<tr>
<td>Butter, Unsalted</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>Salted</td>
<td>0.91-0.93</td>
</tr>
<tr>
<td>Sweetened Condensed Milk</td>
<td>0.77-0.85</td>
</tr>
<tr>
<td>Cheese, Hard</td>
<td>0.86-0.97</td>
</tr>
<tr>
<td>Soft</td>
<td>0.96-0.98</td>
</tr>
<tr>
<td>Fresh</td>
<td>0.98-0.99</td>
</tr>
<tr>
<td>Cream</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>Frozen Desserts</td>
<td>0.98-0.99</td>
</tr>
<tr>
<td>Fermented Milk Products</td>
<td>0.97-0.99</td>
</tr>
<tr>
<td>Milk And Whey</td>
<td>1</td>
</tr>
<tr>
<td>Khoa</td>
<td>0.96</td>
</tr>
<tr>
<td>Paneer</td>
<td>&gt;0.99</td>
</tr>
<tr>
<td>Fried Paneer</td>
<td>0.97</td>
</tr>
</tbody>
</table>

### 3.0 MEASUREMENT OF WATER ACTIVITY

Analytical instruments or methods for $a_w$ value determination are abundant. We shall, however, limit our discussion to instrument, which are commonly used.

#### 3.1 Hair Hygrometry:

Measurements is based on the magnitude of longitudinal change in length of water-sorbing fibre in the same container at equilibrium. This measurement is based on the principle that the keratinaceous proteins in hair strands stretch under tension, when they absorb moisture. If the hair strand is fixed at one end and attached to an indicating lever arm at the other end, the relative humidity within an enclosure can be read directly. The hair hygrometer is a dial-type polyamide thread hygrometer. This type of hygrometer is relatively inexpensive. Its accuracy is comparable to others (i.e. ±0.02 upto 0.01).
3.2 Isopiestic Methods:

This method provides the measurement of equilibrium relative humidity of any aqueous systems in a closed container at a specified temperature. This is based on a principle that most food substances are consistently adjusting their moisture content through absorption or desorption processes depending upon the moisture condition and temperature of the environment until the food substances approach equilibrium. In other words, the equilibrium vapour pressure of the reference salt slush will be identical to the vapour pressure of the sample at equilibrium condition. In this method, multiple samples must be measured at different equilibrium conditions using different salt slushes in desiccators. Upon equilibrium the sorption isotherm is drawn and the $a_w$ is measured against moisture content of the food.

3.3 Electronic Hygrometers:

This type of instrument features the use of calibrated aluminium oxide or lithium chloride humidity sensors. Recalibration or standardization of sensor response is by a set of reference salt slushes. Water activity measurement is carried out by connecting the appropriate sensor to an airtight food sample container and equilibrated at a specified temperature. Since the sensor is sealed in a small container, it usually takes less than 2 hr for a sample to approach equilibrium conditions. These instruments provide a better and convenient means of $a_w$ measurement with adequate accuracy and precision. However, they are susceptible to contaminants such as SO$_2$, H$_2$S, Chlorine and oil vapours. Temporary contaminants include ammonia, acetic acid, alcohols, glycol, glycerols, etc. depending upon the sensor material used. Foods usually contain these contaminants, thereby reducing the useful life of the sensors.

4.0 INFLUENCE OF WATER ACTIVITY ON FOOD QUALITY

Water may influence chemical reactivity in different ways. It may act as a reactant, such as in case of sucrose hydrolysis. As a solvent, water may exert a dilution effect on the substrates, thereby decreasing the reaction rates. Water may also change the mobility of the reactants by affecting the viscosity of the food systems. Water may form hydrogen bonds or complexes with reacting species. For example lipid oxidation rate may be affected by hydration of trace metal catalysts or hydrogen bonding of peroxides with water. Structure of solid matrix may change substantially with changes in moisture content, thus indirectly influencing reaction rates. In addition, water influences protein conformation and transition of amorphous-crystalline status of sugar and starch.

A very important practical aspect of $a_w$ is, therefore, to control undesirable chemical and enzymatic reactions that reduce shelf life of foods. It is well known generally that rates of changes in food properties can be minimized or accelerated over widely different values of $a_w$. Small differences in it can result in large differences in $a_w$ reaction rates (Labuza, 1975; Kinsella and Fox, 1987).
4.1 Non-enzymatic Browning:

Most foods have slow browning rates at low $a_w$ (due to lower mobility of reactions), increasing to maximum points in the range of intermediate moisture foods. The browning rate decreases again as the water activity is increased, the major reason is that at this point the maximum amount of reactants that can be dissolved are in solution, the problem is no longer of diffusion, but rather that as water content increases the reactants are diluted. Since, by the law of mass action, the rate of reaction is proportional to concentration, a decrease in concentration by dilution with water will decrease the rate.

4.2 Lipid Oxidation:

At $a_w$ below the monolayer value, oxidation rate decreases with increasing $a_w$. The rate reaches a minimum around the monolayer value and increases with a further increase in $a_w$. The "antioxidant effect" of water at low $a_w$ has been attributed to bonding of hydro-peroxides and hydration of metal catalyst, whereas "Pro-oxidant effect" of water at higher $a_w$ is due to the increased mobility of reactants.

4.3 Vitamin Degradation:

The reaction rates of vitamin A, B$_1$, B$_2$ and C degradation increase with increasing $a_w$. The B vitamins are more stable than vitamins A and C at various $a_w$ levels. The degradation of tocopherol (Vit. E) in model system containing no fat has also been shown to increase with increasing $a_w$ (0.10 to 0.65).

4.4 Enzyme Activity (Lipolysis):

With almost no exception, enzyme activity increases with increasing $a_w$ or increased substrate mobility (Karel, 1975).

4.5 Protein Denaturation:

The water activity of stored protein powders can also affect protein stability. Thus, denaturation and insolubilization may occur during storage (Okamato and Matsura, 1974), i.e. there are critical moisture levels which may permit conformational changes and the subsequent formation of irreversible intra- and inter peptide interactions via electrostatic, hydrophobic and Vander Waal’s interactions and possibly via thiol oxidation. These, together with chemical changes, e.g. browning result in caking and insolubilization of proteins during storage and may adversely affect subsequent dispersibility, solubility and mouthfeel of the product. The denaturation temperature decreases sharply with increasing water content to about 0.9 gm water/gm protein, and gradually levels off with further addition of water.

It has been suggested that at low moisture content, or low $a_w$, there is insufficient water in the vicinity of the protein to bring about the thermal transition.
4.6 Growth of Microorganisms:

Microbial spoilage, food poisoning and fermentation take place if the $a_w$ of the substrate is favourable for the multiplication and metabolic activity of the microorganisms involved. The $a_w$ influences lag phase, the stationary phase as well as death rate of a culture. Most organisms associated with foods grow best at a relatively high $a_w$, only a few require a low $a_w$ for growth. Hence, if $a_w$ decreases, then fewer genera of M.O. are able to multiply in a food. Table 2 gives minimum $a_w$ required for growth of number of genera of bacteria, yeasts and molds recovered from foods.

Table 2. Minimal $a_w$ for multiplication of microorganisms.

<table>
<thead>
<tr>
<th>$a_w$</th>
<th>Bacteria</th>
<th>Yeasts</th>
<th>Moulds</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.98</td>
<td>Clostridium botulinum (C), Pseudomonas</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0.97</td>
<td>Clostridium botulinum (E), Pseudomonas</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0.96</td>
<td>Lactobacillus, Proteus, Pseudomonas Flavobacterium, Klebsiella, Shigella</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0.95</td>
<td>C. perfringens, C. botulinum (A&amp;B), Vibrio, Alcaligenes, Bacillus, Citrobacter, Proteus, Enterobacter, Escherichia, Serratia, Propionibacterium, Pseudomonas, Salmonella</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0.94</td>
<td>Bacillus, C. botulinum (B), Lactobacillus, Microbacterium, Pediococcus, Vibrio, Streptococcus</td>
<td>-</td>
<td>Stachybotrys</td>
</tr>
<tr>
<td>0.93</td>
<td>B. stearothermophilus, Micrococcus, Lactobacillus, Streptococcus</td>
<td>-</td>
<td>Botrytis, Mucor Rhizopus</td>
</tr>
<tr>
<td>0.92</td>
<td>-</td>
<td>Pichia, Saccharomyces</td>
<td>-</td>
</tr>
<tr>
<td>0.91</td>
<td>Corynebacterium, Streptococcus</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0.90</td>
<td>B. subtilis, Lactobacillus, Micrococcus, Staph. aureus (anaerobic), Vibrio</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>0.88</td>
<td>-</td>
<td>Candida, Torulopsis</td>
<td>Cladosporium</td>
</tr>
<tr>
<td>0.87</td>
<td>-</td>
<td>Debaryomyces</td>
<td>-</td>
</tr>
<tr>
<td>0.86</td>
<td>Micrococcus, S. aureus (aerobic), Vibrio</td>
<td>Hansenula, Saccharomyces</td>
<td>-</td>
</tr>
<tr>
<td>0.84</td>
<td>-</td>
<td>-</td>
<td>Alternaria, Aspergillus</td>
</tr>
<tr>
<td>0.83</td>
<td>Staphylococcus</td>
<td>Debaryomyces</td>
<td>Penicillium</td>
</tr>
<tr>
<td>0.81</td>
<td>-</td>
<td>Saccharomyces</td>
<td>Penicillium</td>
</tr>
<tr>
<td>0.79</td>
<td>-</td>
<td>-</td>
<td>Penicillium</td>
</tr>
<tr>
<td>0.78</td>
<td>-</td>
<td>-</td>
<td>Aspergillus</td>
</tr>
<tr>
<td>0.75</td>
<td>Halobacterium, Halococcus</td>
<td>-</td>
<td>Aspergillus</td>
</tr>
<tr>
<td>0.70</td>
<td>-</td>
<td>-</td>
<td>Aspergillus Chrysosporium</td>
</tr>
<tr>
<td>0.62</td>
<td>-</td>
<td>Saccharomyces</td>
<td>Eurotium</td>
</tr>
<tr>
<td>0.61</td>
<td>-</td>
<td>-</td>
<td>Monascus</td>
</tr>
</tbody>
</table>
5.0 PRACTICAL APPLICATIONS OF WATER ACTIVITY

Information on water binding is helpful in determining the energy requirements and conditions for drying of specific materials; controlling the growth of microorganisms to minimize quality deterioration; ensure safety, and selecting the appropriate microflora in certain foods, e.g. ripening cheese; for evaluation of water uptake, porosity, sorption/desorption enthalpies; estimation of specific surface area, crystalline state of components (lactose), and facilitating control of several chemical, physical and quality attributes of stored foods in addition to ensuring microbial stability.

Besides determinant role, played by $a_w$ in influencing the stability of quality parameters, $a_w$ has many other practical applications such as prediction of packaged product moisture gain/loss and prediction of shelf-life of packed food.

5.1 Packaged Product Moisture Gain/loss

The moisture transfer resulting in packaged moisture gain or loss is an important quality control and legal issue in foods. Generally the quality shelf-life of a food packaged in a non-hermetically sealed container is dependent upon the rate of exchanges of moisture through the package to the storage atmosphere plus the rate of change in $a_w$ of food towards critical upper or lower limits with respect of bacteria, fungi, texture, flavour, appearance, eating qualities, aroma, nutritional qualities, cooking qualities and regulatory issues. The moisture gain or loss in foods packaged in nonhermetic containers is dependent upon:

a) Storage relative humidity
b) Sorption properties of the product
c) The water activity gradient into or out of the product relative to storage atmosphere
d) The permeability of package material to water vapour

5.2 Predicting Packaged Food Stability:

An equation has been developed by combining sorption isotherm with Fink's low of diffusion to accomplish three main objectives:

1. Predict the storage time based on a critical $a_w$ of the product for a particular package system under assumed storage conditions.
2. Predict packaging system specifications for obtaining acceptable shelf-life with respect to moisture exchange.
3. Estimate packaging cost

Typically, the prediction method involves three steps:

i) Obtain the isotherm of the product
ii) Identify the critical $a_w$ for a product attribute, such as texture.

iii) Solve the prediction equation:

$$Q_c = \text{Days to } MC = \frac{\ln \left(\frac{M_c - M_i}{M_i - M_c}\right)}{(K/X)(A/W_0)(P_0/B)}$$

Where,

$M_e =$ equilibrium product moisture if left in contact with the atmosphere

$M_c =$ Critical product moisture level

$M_i =$ Initial product moisture

$K/x =$ Permeability of package to moisture vapour

$A =$ Surface area of the package

$P_0 =$ Vapour pressures in mm Hg at storage temperature

$W_0 =$ Grams of dry solids of product in the package

$B =$ Slope of product isotherm [Assumed linear] over the range between $M_i$ and $M_c$

$Q_c =$ Days it takes for product in the package to go from initial to critical moisture level

6.0 REFERENCES


1.0 INTRODUCTION

One of the major objectives of packaging of food is to protect it against spoilage or deterioration attributable to physical damage, chemical changes or microbial growth. Whether processed or raw, foodstuffs may be placed into two main categories with regard to shelf life: i) Fresh or perishable products and ii) shelf-stable or semi-perishable products. Fresh products have a shelf life ranging from a few hours to several days depending upon storage conditions in terms of temperatures etc. These products include refrigerated products e.g. pasteurized milk. Shelf stable products, on the other hand, keep well for up to several weeks or months at ambient temperatures. In either case packaging has an important role to play in the product’s shelf life.

Besides the temperature of storage, the product’s environment within the package is often crucial to its storage stability. The latter is the basis of active packaging as well as modified atmosphere packaging, which are discussed elsewhere. Gas permeation properties are critical not only to MAP of foodstuffs such as fruit and vegetables, but also to long life products obtained through in-package thermal processing, or aseptic packaging following sterilization treatment. Even intermediate moisture foods rendered shelf stable by water activity manipulation rely heavily on packaging for the desired shelf life.

Irrespective of the shelf-life limiting changes i.e., whether the product is subject to microbial spoilage or physico-chemical deterioration, package characteristics in terms of barrier properties, coupled with storage conditions especially with regard to temperature are the major determinants of shelf life. Thus the shelf life of a packaged food is a function of the temperature of storage and properties of packaging material. Kinetic models provide a useful tool for predicting shelf life. In the following sections, therefore, an attempt has been made to present a brief account of the shelf life prediction models and indicators meant for monitoring of the quality of packaged foods during storage.

2.0 KINETIC MODELS FOR SHELF-LIFE PREDICTION

Reactions leading to shelf-life limiting physico-chemical changes in a packaged product can be characterized in terms of reaction rates and their dependence on temperature and other storage conditions. Therefore, kinetic models usually incorporate parameters such as time, concentrations of key components, temperature, and moisture and oxygen concentrations. More complex models may involve many more parameters. However the basic steps involved in development of kinetic models are: (i) Establishing the index of deterioration (or index of quality); (ii) identifying the parameters influencing
the index; (iii) determining the time dependence of the index in terms of rate constant; (iv) working out the dependence of the rate constant on relevant parameters such as temperature, water activity, oxygen concentration etc., and (v) integrating time dependence and temperature (and other parameters) relationships into a comprehensive mathematical expression that would serve as the simulation model for the quality of the stored product.

2.1 Index of quality

Quantitative analysis of quality losses in a product during storage is based on the assumption that chemical or physical properties identified as an index of quality is indeed relevant to the product quality and that storage-induced changes in it can be reproducibly measured. Sometimes a single property of the product may not adequately describe the product quality, which may necessitate considering more than one characteristic variables and take a weighted set of measurements as the index of quality. This would entail assigning an arbitrary value to each property. Since the product quality is primarily perceived in terms of sensory attributes, it is necessary that the index of sensory is quantitatively related to the latter. Quantification of sensory attributes on one hand and their functional relationship with the measured property on the other would enable developing a comprehensive kinetic model incorporating all parameters identified as independent variables affecting the quality index.

2.2 Time dependence and the order of reaction

The time dependence of the reaction is obtained in terms of the rate of the reaction based on the changes in the reactant concentration (or intensity of the measured property) as a function of time. If the quality loss is related to a reaction in which compound A changes into B, i.e. A → B

Then the rate of changes of A and B can be expressed as

\[-dC_A / dt = dC_B / dt = k \cdot A^n\]  

where \(C_A\) = concentration of A

\(C_B\) = concentration of B

\(k\) = molecular rate constant

and \(n\) = order of reaction

Either \(C_A\) or \(C_B\) alone may be monitored and indicated simply by C. If the measured quantity increases during storage, \(k\) will be positive, and if it decreases, \(k\) will be negative. The order of reaction determines the degree to which the reactant concentration \(C\) influences the reaction rate. When reaction rate is independent of the reaction concentration, \(n=0\) and the change is a zero order reaction, and Eq. 1 becomes

\[-dC / dt = k\]  

Integration of Eq.1 between concentration \(C\) at time \(t\) and \(C_0\) at time zero \((t_0)\) results in :

\(C-C_0=-k(t-t_0)\)
Thus the rate constants $k$ can be obtained from the slope of this equation, which represents a linear plot of concentration vs. time of storage.

Non enzymatic browning in many foods viz. fruit products, vegetables, dry milk condensed milk, whey powder etc., as also ascorbic acid degradation in fish and pigment loss in pomegranate juice has been found to follow a zero order reaction.

A first order reaction (where $n=1$) is the one in which the reaction rate is directly proportional to the reactant concentration $C$, i.e.

$$-\frac{dC}{dt} = kC \quad (4)$$

which can be integrated to yield

$$C = C_0 \exp[-k(t-t_0)] \quad (5)$$

or

$$\ln \left(\frac{C}{C_0}\right) = -k(t-t_0) \quad (6)$$

The rate constant can be obtained from the slope of the linearized plot of $\ln \left(\frac{C}{C_0}\right)$ vs. $t$.

Ascorbic acid loss, colour loss and enzyme inactivation in many food systems follow a first order reaction.

Loss of thiamine and lysine in certain heat processed food products such as milk has been characterized by a second order reaction ($n=2$):

$$\frac{1}{C} - \frac{1}{C_0} = -k(t-t_0) \quad (7)$$

Depending on the foodstuff and the quality factor involved, different reaction orders may be observed. Certain changes in foods such as lipid oxidation and $\beta$-carotene degradation have been reported to follow mixed order reaction. However for relatively small degree of quantity loss in terms of a chemical or physical attribute, the reaction order may not be critical. The loss in zero order and first order reaction, for example, is essentially the same up to 50% loss.

2.3 Temperature dependence of the chemical changes

The temperature of storage is crucial to the loss of product quality. The dependence of the loss on temperature is generally given by the Arrhenius relationship, considered to be the most reliable approach to modeling temperature dependence in reaction kinetics:

$$k = k_0 \exp \left(\frac{-E_a}{RT}\right) \quad (8)$$

or

$$\ln \left(\frac{k}{k_0}\right) = \frac{E_a}{RT} \quad (9)$$

where $k =$ rate constant

$k_0 =$ constant independent of temperature (or pre-exponential, frequency factor or collision factor)

$E_a =$ activation energy

$R =$ ideal gas constants ($= 8.314 \text{ Jmol}^{-1}\text{K}^{-1}$)
T= absolute temperature

The activation energy is obtained from the slope of the plot \( \ln k \) vs \( 1/T \). It depends on compositional factors such as water activity, moisture content and pH. Also when the reaction mechanism changes with temperature, \( E_a \) may vary considerably. Table 1 showes typical values of \( E_a \) for some of the common reactions in foods.

The temperature dependence of the rate constants may alternatively be expressed in terms of the \( Q_{10} \) value given by

\[
Q_{10} = \frac{\ln (k_{\theta+10})}{\ln k_{\theta}} \quad (10)
\]

where \( k_{\theta} \) = rate constant at temperature \( \theta \)

\( k_{\theta+10} \) = rate constant at temperature \( \theta + 10 \)

Thus \( Q_{10} \) value indicates as to how much faster the reaction takes place when the temperature is increased by 10°C.

**TABLE 1. Activation energies (\( E_a \)) for selected reactions**

<table>
<thead>
<tr>
<th>Reaction</th>
<th>( E_a ) (J/mol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lipid oxidation</td>
<td>40-105</td>
</tr>
<tr>
<td>Vitamin loss</td>
<td>80-130</td>
</tr>
<tr>
<td>Millard browning</td>
<td>105-210</td>
</tr>
<tr>
<td>Enzyme inactivation</td>
<td>50-420</td>
</tr>
<tr>
<td>Inactivation of vegetative cells</td>
<td>210-630</td>
</tr>
<tr>
<td>Spore inactivation</td>
<td>220-350</td>
</tr>
<tr>
<td>Denaturation of protein</td>
<td>335-500</td>
</tr>
</tbody>
</table>

**2.4 Effect of environmental factors other than temperature**

The reaction rate constant (k) may depend on other environmental factors such as moisture (or water activity), oxygen tension, etc. With regard to moisture, a simplified relation with wide validity has been given as:

\[
\ln k = a + bm \quad (11)
\]

where \( m \) = moisture content

\( a, b = \) constants

Similarly,

\[
\ln k = c + d a_w \quad (12)
\]

where \( a_w = \) water activity

\( c, d = \) constants
In food systems with a low moisture content the rate constant for oxidative changes has been shown to be related to $m$ as follows:

$$k = \frac{b}{m^n} \quad (13)$$

where $b = \text{constant}$

$n = \text{exponent (usually } \approx 1.0)\)

Oxygen concentration is often an important determinant of the rate of oxidative reaction:

$$R = f \times \frac{O_2}{a + [O_2]^b} \quad (14)$$

where $R = \text{rate of oxidation}$

$f = \text{function relating rate dependence}$

$[O_2] = \text{oxygen concentration}$

$a, b = \text{constants}$

2.5 Constituting the kinetic model

The reaction rate equation (vide Sec. 2.2) can be combined with the Arrhenius equation giving temperature dependence (Sec. 2.3) in order to obtained a mathematical expression useful for predicting the index of quality as a function of storage time. Thus for a zero order change, Eq. 3 and Eq. 8 would yield

$$C - C_0 = k_0 \exp\left(-\frac{E_a}{RT}\right) (t - t_0) \quad (15)$$

or

$$C = C_0 + k_0 \exp\left(-\frac{E_a}{RT}\right) (t - t_0) \quad (16)$$

Thus the value of $C$ as index of quality can be predicted for known value of initial concentration, storage temperature and storage time for a particular product. Complex models have been developed which include more than one environmental factor such as moisture and temperature. The temperature as a quality-determining factor for single constant value as in the case of static (isothermal) modeling or varying value as in dynamic (non-isothermal) modeling. Fluctuating storage temperature may be converted to a weighted mean temperature so as to yield effective isothermal storage temperature for the prediction purpose. Quality loss during fluctuating temperature storage is greater than that predicted under constant condition of the arithmetic mean temperature. When changes in the environment of a packaged food (e.g. moisture, oxygen content) are expected during storage due to the package properties such as permeability relationships, the latter can be incorporated into complex shelf life simulation models. Dynamic stress conditions in terms of temperature and moisture content have been used, for instance, for modeling of the shelf life of moisture-sensitive foods.
If the index of quality can be mathematically related to the relevant sensory attribute, Eq.15 can be combined with such a functional relationship to derive a model which predict the sensory status of the product as a function of storage time, temperature, etc. Such models have been reported for several products e.g. sweetened condensed milk, UHT treated milk and soy beverages.

While such models have considerable usefulness under practical condition, it should be noted that most of these model are product specific and cannot be applied universally primarily because of the complex nature of food systems which represent widely varying sets of environmental conditions affecting the deteriorative changes. Complexities of chemical reactions in the foods, with different mechanisms, often lead to different kinetic conditions, which necessitate product wise shelf life modeling.

3.0 SHELF LIFE MODELING OF FOODS SPOILED BY MICROORGANISMS

In perishable and semi-perishable foods where microbial growth represents the major shelf-life limiting factor, modeling of growth of microorganisms becomes necessary. Shelf life models based on microbial growth allow prediction of the fate of the food stored under specific conditions of temperature, pH, gaseous environment etc. These models are mainly of the two types: (a) Probability models which predict the probability of occurring of an event, and (b) kinetic models which predict the change in microbial numbers.

As many chemical kinetic studies are based on model food systems, most work done in relation to microbiological models pertains to microbiological media as they are of consistent composition and can be easily and reproducibly adjusted to the conditions required for study. However, homogeneous foods such as milk lend themselves to developing simple kinetic models. Plate counts often constitute the major variable monitored, but optical density and other measures have been used.

Microbiological models involving four or more factors have been developed. Gompertz-polynomial type and Belhadek type (square root models) are among the important models applicable to growth of microorganisms. Newer modeling techniques developed to predict growth and non-thermal inactivation of microbes promise to offer wider applicability.

4.0 TIME–TEMPERATURE INDICATORS AS SHELF LIFE SENSORS

From the foregoing discussion, it is evident that temperature dependence of shelf life is one of the most important factors for packaged foods of both perishable and shelf stable types. Since the storage temperature may not necessarily be constant, monitoring of temperature as a function of storage time becomes imperative to know the quality status of the product. Sensors as temperature history indicators for packaged foods have been extensively studied. These indicators are of different types (i) Critical temperature indicators, (ii) partial history indicators and (iii) full history indicators.

4.1 Critical temperature indicators

Critical temperature indicators give response only when the temperature either goes above or below a certain preselected value. It does not provide the time-temperature history. Such indicators are useful to indicate if a certain temperature was reached during storage. Thus, it is possible to know if a freeze sensitive product was exposed to freezing.
temperature. This type of information is useful if quality attributes of the product are sensitive to some critical temperature. The Monitor Mark Freeze indicator (manufactured by Packaging division/3M, USA) is an example of critical temperature indicators.

4.2 Partial history indicators

A response from these indicators is elicited only when the temperature exceeds (or is below) a certain predetermined value. An example is the Monitor Mark Extended Response Indicator, which contains a pad saturated with a chemical mixture. The chemical diffuses along a porous wick after the pad is brought into contact with the wick and only when the temperature exceeds the melting point of the chemical. Since the diffusion process is temperature dependent, for temperatures greater than the melting point of the selected chemical, one obtains a time-temperature integrated response from this type of indicator. Different chemicals with their corresponding melting points can be used for needed applications.

4.3 Stress – time indicators

An integrated time-temperature response is continuously obtained using these indicators. Examples of such full history time-temperature indicators include LifeLines Freshness Monitor (LifeLines Technologies, USA) and IPOINT Time/Temperature Monitor (IPOINT Biotechnologies A.B., Sweden). The IPOINT Monitor involves two pouches, one containing a lipolytic enzyme and other containing a lipid substrate. Breaking the seal between the two pouches and mixing their contents activates the indicator. An enzymatic hydrolysis of a lipid substrate results in a decrease in pH with a consequent change in colour. Different indicator response times can be obtained by changing the concentration of the enzyme substrates. The activation energies of these indicators can be made to vary from 15 to 35 kcal/mole, which covers a broad range suitable for many quality degradation reactions during food storage and distribution. The LifeLines Fresh-Scan indicator uses a temperature-dependent polymerization reaction. In this type of indicator disubstituted diacetylene crystals are allowed to polymerize. As the polymer is formed, there is a distinct change in colour. A specially designed optical reader is used to measure the reflectance of the polymer. The indicator is in active state upon manufacturing therefore it requires special care during shipment prior to its attachment to a food package. The range of activation energy is 20 – 24 kcal/mole, useful for many food storage applications.

The usefulness of these sensors in monitoring quality depends on how well they can mimic changes in quality. Development of coconut flavour in UHT milk was found to be strongly correlated with the response of LifeLines Freshness indicator. Published studies on correction of time temperature indicator response with quality attributes in various foods include hamburger, tomatoes, lettuce, UHT milk, fruit cake, pasteurized whole milk, ice cream, refrigerated ready-to-eat salads, refrigerated orange juice, pasteurized cream, and cottage cheese.

Kinetic models are useful to describe changes in food quality along with the response of time temperature indicators. The indicator response at a constant reference temperature and its activation energy can be used to predict a constant temperature equivalent of the indicator response change for any interval between successive indicator inspections. The constant temperature equivalent can be then used to predict, with the
help of kinetic model the change in a food quality attribute expected during the same interval. The advantage of using the equivalent temperature approach is that it does not require the food quality to be observed experimentally or predicted theoretically based on temperature history recorded by a data acquisition system. The time-temperature indicators have proven to be useful aids in monitoring the quality of packaged foods during storage and distribution. It is important to note that time-temperature indicators provide a history of temperature changes in the immediate vicinity of the indicator. Mathematical models have been proposed to extend this local temperature history to the entire unit package used for a food with known thermal properties.

5.0 CONCLUSION

Shelf life of packaged perishable and semi-perishable or long-life foods depends primarily on the environmental conditions, which include temperature, water activity, carbon dioxide concentration, pH etc. The packaging material may have a significant role on shelf life not only by preventing microbial contamination but also by altering the product environment depending upon its permeability characteristics. Quality loss in a packaged product during storage can be monitored in terms of a physical, chemical, or microbiological parameters identified as an index of quality or deterioration. Kinetic models relating the index of deterioration to the storage conditions provide a useful tool for shelf-life prediction. Many successful practical applications of these models have been reported for a variety of products. Their usefulness notwithstanding, shelf life models are usually product-specific mainly because of the complexities of chemical reactions and heterogeneity of food systems. Food environment factors affecting microbial growth are so varied that microbiological prediction models are also highly product specific.

Since temperature is one of the most important parameters, a range of time-temperature indicators have been developed and applied to monitor shelf life of packaged foods. Full history time-temperature indicators have been found to closely mimic a given quality attribute. Response of such an indicator together with the relevant kinetic model could be used to predict a packaged product’s quality during storage. Such indicators could be placed on the food package so that the quality status of the product can be known at any stage during storage. Application of various sensors available commercially in Europe and America have been successfully tested.

6.0 SUGGESTED READINGS


1.0 INTRODUCTION

The materials widely used for food packaging or in food contact applications include paper and coated-paper products, cellulose products, cellophane, metals such as tinplate, aluminum, stainless steel, ceramics, glass, rubber, plastics, and miscellaneous materials such as wood, fabric, etc. Most of these materials have been in use for many years and have given rise to very few problems. Plastics, in contrast, while offering many advantages as a new range of packaging materials at the same time involve contact between food and a whole new range of chemical components not previously used in the food industry and for which no previous experience was available. Migration of additives used in their manufacture causes the greatest concern relating to food safety issues.

All plastics, in addition to the basic polymer derived from the petroleum industry, contain a number of other substances added either deliberately during manufacturing and processing or, unavoidably, as residues from polymerization reactions. Polymers themselves, being of very high molecular weight, inert, and of limited solubility in aqueous and fatty systems, are unlikely to be transferred into food to any significant extent (Crosby, 1981). Even if fragments were accidentally swallowed, they would not react with body fluids present in the digestive system.

2.0 SOURCES OF CONTAMINATION

Packaging contaminants from plastics primarily arise from two sources:

i) Polymerization residues including monomers, oligomers (with a molecular weight of up to 200), catalysts (mainly metallic salts and organic peroxides), solvents, emulsifiers and wetting agents, raw material impurities, plant contaminants, inhibitors, decomposition and side reaction products

ii) Processing aids such as antioxidants, anti blocking agents, antistatic agents, heat and light stabilizers, plasticizers, lubricants and slip agents, pigments, fillers, mould release agents, and fungicides. The more volatile gaseous monomers, e.g. ethylene, propylene, vinyl chloride, usually decrease in concentration with time, but very low levels may persist in the finished product almost indefinitely (Crompton, 1979; Crosby, 1981). Styrene and acrylonitrile residues are generally the most difficult to remove.

Since compounds of the first group are present inadvertently, not much can be done to remove them. However, the efforts made by the industry to reduce vinyl chloride monomer levels in particular illustrate the effects of optimum manufacturing processes.
3.0 Toxicological Aspects
The toxicological aspects of some monomers to humans are:

3.1 Vinyl Chloride: IARC (1973) has reviewed the relevant biological data and epidemiological studies on humans on the safety of vinyl chloride. Rats, mice, and hamsters have all been exposed to varying levels of vinyl chloride monomer (VCM), either by inhalation or by oral administration. Maltoni et al. (1974) showed that inhalation of levels of VCM in the range of 50–10,000 ppm in air for 4 hours a day, 5 days in a week for 12 months resulted in the production of a number of tumors at different sites, including angiosarcomas of the liver. Oral administration of doses as low as 3.33 mg/kg body weight were also shown to be carcinogenic. VCM has also been shown to be mutagenic in Ames test, and metabolic studies provide some evidence of alkylolation of nucleic acids (Crosby, 1981). The principal products formed during metabolism are chloroethylene oxide and chloroacetaldehyde.

In the IARC (1973) study, the principal toxic effects of VCM in humans included lesions of the bones in the terminal joints of the fingers and toes as well as histopathological changes in the liver and spleen. Long-term exposure gave rise to a rare form of liver cancer (angiosarcoma). VCM also has a long latent period for tumor development, requiring as many as 20 years for the symptoms to appear. The IARC (1973) study concluded that VCM causes angiosarcomas of the liver as well as tumors of the brain, lung, and hematolymphopoietic systems in humans.

3.2 Acrylonitrile: Acrylonitrile (AN) is considerably more toxic than the chlorinated monomers and has LD 50 values of 80-90 mg/kg body weight in rats and 27 mg/kg in mice (Crosby, 1981). It converts to a mutagen after metabolic activation by the liver enzymes. In animals, AN is metabolized to cyanide, which is subsequently converted to thiocyanate and excreted in the urine. There is also some evidence of carcinogenicity in animals and possibly humans (IARC, 1973).

3.3 Vinylidene Chloride: Little toxicological information is available regarding the safety of vinylidene chloride. The LD 50 values for rats and mice are around 1500 and 200 mg/kg body weight, respectively (Crosby, 1981). It affects the activity of several rat liver enzymes and decreases the store of glutathione. Some tumors have been observed after prolonged exposure but no teratogenic effects were seen in rats or rabbits. The main pathway of excretion is via the lungs, with other metabolites being discharged by the kidneys.

3.4 Styrene: Liebman (1975) has extensively reviewed the biological properties of styrene. The LD 50 value for rats is 5 g/kg body weight. It is metabolized to styrene oxide, which is a potent mutagen in a number of test systems. Both styrene and its oxide have been shown to produce chromosomal aberrations under certain conditions. Although little is known about the toxicity and carcinogenicity of monomers used in the production on the purity of the final product. In contrast, chemicals added deliberately during formulation to alter the processing, mechanical, or other properties of the polymer are likely to be present in greater amounts than polymerization residues and should be subject to strict quality control. Additives in the second group listed above are normally restricted to compounds appearing on an approved list for food contact use (Deshpande and Salunkhe, 1996).
of food-grade plastics, there is clear evidence of the need for concern in the case of VCM and AN. Further studies are required to elucidate the interactions of various monomers with body components, their bio transformation and metabolism in the humans (Steinhart and Doyle, 1995).

4.0 MIGRATION TESTING

The concentration of a food contact substance (FCS) in the daily diet may be determined from measured levels in food or in food simulants, or estimated using information on formulation or residual levels of the substance in the food contact article and the assumption of 100% migration of the FCS to food. Although FDA has always accepted reliable analyses of FCS in real foods, in practice, many analytes are difficult to measure in food. As an alternative, migration data obtained with food simulants that can reproduce the nature and amount of migration of the FCS into food must be collected. Because a FCS may be used in contact with many foods with different processing conditions and shelf lives, the collected migration data should reflect the most severe temperature/time conditions to which the food-contact article containing the FCS will be exposed.

Before undertaking migration studies, the potential uses of the FCS should be carefully considered. If for example, use at temperatures no higher than room temperature is anticipated; it makes little sense to conduct migration experiments that simulate high temperature food contact. Such experiments would lead to elevated levels of the FCS in the food simulants that might require a more extensive toxicological data package to support the exaggerated exposure. In some cases where the use level of the FCS is low, it may be possible to dispense with migration studies altogether by assuming 100% migration of the FCS to food. The following example illustrates this approach:

Consider an adjuvant added prior to the sheet-forming operation in the manufacture of paper. If analysis or calculation shows that the final adjuvant concentration in paper cannot exceed 1 ppm and the basis weight of the finished paper is 50 pounds/3000 ft$^2$, or 50 mg/in$^2$, then the maximum weight of adjuvant per unit area of paper is $1 \times 10^{-6}$ g adjuvant/g paper $\times$ 50 mg/in$^2$ 10.000050 mg/in$^2$. If all the adjuvant migrates into food and 10 grams of food contacts 1 square inch of paper (FDA’s default assumption), the maximum concentration in food would be 5 parts per billion (ppb). It may be expected that this low concentration in food would lead to commensurately low estimated daily intake (EDI) of the FCS. Therefore, migration studies which could result in further lowering of the estimate of daily intake might be unnecessary.

5.0 DESIGN OF THE MIGRATION EXPERIMENT

5.1 Migration Cell

For general use or when the package surface area does not produce sufficient extractives for adequate characterization, a migration cell should be used in which a specimen of known surface area is extracted by a known volume of solvent. The two-sided migration cell described by Snyder and Breder (1985) is recommended. Although this specific cell may not be universally applicable, two of its essential features are recommended for incorporation in modified designs. These are:

i) Polymer plaques of known surface area and thickness (for further discussion) are separated by inert spacers (such as glass beads) so that solvent flows freely around each
plaque. Exposure to the solvent is two-sided.

ii) The headspace is minimized, and gas-tight and liquid-tight seals are maintained. (Minimum headspace and gas tightness are of lesser importance if the migrant of interest is non-volatile).

Additionally, and importantly, the cell is subjected to mild agitation to minimize any localized solubility limitation that might result in mass-transfer resistance in the simulant phase.

5.2 Considerations for Test Sample

i) Formulation: The highest proposed concentration of the FCS in the food-contact article in preparing samples for migration testing should be used. If the formulation is plasticized, the most highly plasticized formulation should be used for testing.

ii) Sample Thickness & Surface Area: Both the thickness and surface area of the sample tested should be reported. If a sample is tested by immersion and is of sufficient thickness to ensure that the initial FCS concentration at its center is unaltered by migration that occurs from both sides during the test period, the surface area of both sides can be used to calculate migration (units of mg/in$^2$).

Migration may be considered to be independent from both sides of the sample if the sample thickness is at least 0.05 cm (20 mil or 0.020 in) and not more than 25 percent of the FCS has migrated by the end of the experiment. If these conditions are not met, the surface area of only one side should be used in the calculation.

iii) Polymer Properties: If the FCS is a polymer adjuvant, notifiers should perform migration testing on the polymer with the lowest average molecular weight should be performed. If the FCS is a new polymer, test the polymer that would be expected to give the highest levels of extractives, i.e., the polymer with the lowest average molecular weight, percent crystallinity, and degree of cross-linking.

5.3 Volume of Test Solvent

The volume should ideally reflect the volume to specimen surface area ratio expected to be encountered in actual food packaging.

5.4 Food Simulating Solvents

Previous test protocols (prior to year 1988) recommended the use of water and 3% acetic acid as food simulants for aqueous and acidic foods, respectively. However, water and 3% acetic acid have been shown, in a number of instances, to underestimate migration into aqueous foods. Therefore, 10% ethanol is now recommended as an aqueous food simulant. Use this solvent for evaluating migration to aqueous, acidic, and low-alcohol foods, except when the acidity of the food can be expected to lead to significantly higher levels of migration than with 10% ethanol or, in certain instances, if the polymer or adjuvant is acid-sensitive, or if trans-esterification occurs in ethanol solutions. In those instances, separate extractions in water and 3% acetic acid should be conducted. 10% Ethanol is intermediate in alcohol concentration between wine and beer. Migration levels to wine and beer are not expected to be very different from 10% ethanol values. Therefore, test results developed with 10% ethanol can be used to evaluate exposures and support clearances for alcoholic beverages with up to 15-volume %
ethanol.

Unsaturated food oils (like corn and olive oils) can at times be difficult matrices for the analysis of a migrant because these oils are susceptible to oxidation at high temperature. Studies by the Chemistry Methods Branch (CMB) have indicated that Miglyol 812™, a fractionated coconut oil having an estimated boiling point range of 240 to 270°C and composed of saturated C16 (50-65%) and C10 (30-45%) triglycerides, is an acceptable alternative fatty-food simulant for migration testing. HB307, a mixture of synthetic triglycerides, primarily C10, C12, and C14, is also useful as a fatty-food simulant.

5.5 Temperatures and Time of Test

Conduct migration testing under the most severe conditions of temperature and time for which a regulation is requested. If the intended application of the packaging material involves contact with food at temperatures higher than room temperature, conduct tests at the highest use temperature for the maximum time period. In many instances, short time periods of elevated temperature-food contact are immediately followed by extended periods of storage at ambient temperatures. For such applications, the migration protocols call for short-term accelerated testing intended to simulate additive migration that may occur during the entire food-contact scenario.

For room-temperature applications, a test temperature of 49°C (120°F) for 10 days has been previously recommended. This accelerated testing protocol was based on studies showing that migration-levers were roughly equivalent to levels after extended time periods (6-12 months) at 20°C (68°F). Recent studies by CMB, however, have shown little difference in migration levels at 49°C and 40°C (104°F). Furthermore, the differences in migration levels between 49°C and 40°C are of even less significance for migration studies requiring elevated temperatures (e.g., 100°C or 121°F) for the first two hours.

Up to 80% of the total migration observed over the 10 day period is usually completed within this two-hour period at the higher temperature. Therefore, 40°C is now regarded as acceptable for migration studies for room-temperature applications and for the portion of the migration test for elevated-temperature applications intended to reflect long term ambient storage. For refrigerated or frozen food applications, the test temperature is 20°C. For polymers, such as polyolefins, which are used with food at temperatures above their glass transition temperatures, the highest migration values are used to calculate the concentration of migrants in food.

For polymers, such as polyethylene terephthalate (PET) that are used with food at temperatures below their glass transition temperatures, a change in temperature generally produces a smaller change in migration rate than when they are used above the glass transition temperature. Therefore, migration data obtained over ten days at 40°C should be extrapolated to 30 days in order to obtain better approximate migration levels expected after extended time periods at 20°C. For restricted uses where the maximum shelf life and food-contact temperature of an article are known, it is possible to carry out migration studies for the maximum shelf life under temperature conditions approximating expected use intervals.
5.6 Data Reporting

Perform migration studies in triplicate and analyze the test solutions for the migrants. Report results in terms of milligrams of substance extracted per square inch, (mg/in\(^2\)) of surface area. Although migration amounts are often expressed in terms of mg/dm\(^2\), the mixed unit mg/in\(^2\) to facilitate conversion to concentration in food is preferred. If ten grams of food are in contact with one square inch of packaging surface, migration of 0.01 mg/in\(^2\) corresponds to a concentration in food of 1 ppm. For specialized food-contact applications where an assumed ratio of 10 g food per -in\(^2\) is not appropriate, such as in dual-ovenable trays and microwave heat-susceptor applications, use the lowest ratio from the actual food-contact applications and provide justification for the ratio selected.

6.0 REGULATORY ASPECTS

Although the majority of packaging contaminants are nontoxic in the small amounts in which they are present, food/package and package/process compatibility are food safety issues from FDA’s viewpoint. The packaging materials are thus legally considered to be food additives, requiring pre market safety evaluation by the FDA. FDA (food & drug administration) requirements include conducting extraction tests to measure the amount of migration and providing appropriate toxicological data for the migrants by the manufacturers and processors (FDA, 1976). Adjuvant use level of migration (or the lack thereof) under various conditions of use for foods, and consumption of these foods in the diet must be evaluated with regard to safety.

7.0 CONCLUSION:

While no specific harm has been verified for any specific packaged food, at least three cases involving the additive polychlorinated biphenyl (PCB) and the monomers acrylonitrile and vinyl chloride have been of major economic consequence. The PCB situation was primarily from contamination in recycled paper, while the acrylonitrile case has resulted in multimillion-dollar losses in the beverage container market (FDA, 1977). The vinyl chloride problem threatened to ban the usage of PVC for food packaging, but the ability of the industry to reduce the residues of vinyl chloride to the low ppm range has delayed the proposed ban.

8.0 REFERENCES


1.0 INTRODUCTION

It has been estimated that approximately one-fourth of all harvested perishable produce (fruits & vegetables) are spoiled before consumption and processing. Spoilage of fresh fruits and vegetables usually occurs during storage and transport and while waiting to be processed. As soon as fruits and vegetables are gathered into boxes, bags, or trucks during harvesting they are subject to contamination with spoilage organisms from each other and from containers, unless these have been adequately sanitized. During transportation to market or the processing plant, the mechanical damage may increase significantly leading to decay and growth of microorganisms may take place during processing, packaging and storage. However, sorting and pre-cooling of the product and refrigeration during transportation will have positive effect on slow growth of spoilage organisms. Adopting an appropriate technique in the processing and preservation of foods can certainly control microbiological spoilage in food products during packaging and storage. In the recent years many innovative methods have been developed to increase the shelf life of many perishable food products by using controlled hygienic conditions, aseptic packaging, preservatives and controlled atmospheric environments during storage. These preservative measures help to stop microbial growth and chemical reaction that cause the destruction of flavor, color, texture and nutritive value in the finished food products.

2.0 MICROBIAL FOOD SPOILAGES

The main purpose of food preservation is to prevent food spoilage. Spoilage in the packed food in particular may be due to one or more of the following reasons:

1. Growth and activity of microorganisms
2. Action of enzyme of the plant or animal food
3. Purely chemical reaction, i.e. those not catalyzed by enzymes of tissues or of microorganisms
4. Physical changes such as those caused by freezing, burning, drying pressure etc.

Microbial food spoilage is mainly caused by bacteria, yeast and moulds. The major requirement of microbial growth are the availability of nutrients as well as favourable living conditions such as temperature, water activity, presence or absence of oxygen, redox potential and pH value. A list of common spoilage organisms in food items is given in Table I.
Control of microbiological spoilage in food products during packaging and storage

TABLE 1:

<table>
<thead>
<tr>
<th>Food items</th>
<th>Name of the organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk and Milk</td>
<td>Streptococci, Lactobacilli, Microbacterium, Achromobacter, Pseudomonas and Flavobacterium Bacilli.</td>
</tr>
<tr>
<td>Products</td>
<td></td>
</tr>
<tr>
<td>Fresh meat</td>
<td>Achromobacter, Pseudomonas and Flavobacterium, Micrococi, Cladosporium, Thaminidium</td>
</tr>
<tr>
<td>Poultry</td>
<td>Achromobacter, Pseudomonas and Flavobacterium, Micrococi, Penicillium</td>
</tr>
<tr>
<td>Shellfish</td>
<td>Achromobacter, Pseudomonas and Flavobacterium, Micrococi</td>
</tr>
<tr>
<td>Eggs</td>
<td>Pseudomonas, Cladosporium, Penicillium, Sporotrichum</td>
</tr>
<tr>
<td>Vegetables</td>
<td>Penicillium, Rhizopus, Torulopsis, Achromobacter, Pseudomonas and Flavobacterium</td>
</tr>
<tr>
<td>Fruits and juices</td>
<td>Saccharomyces, Coreopsis, Botrytis, Penicillium, Rhizopus, Acetobacter, Lactobacilli</td>
</tr>
</tbody>
</table>

Food spoilage is manifested by a reduction in aroma, flavor, texture and nutritional value of foods. In extreme cases the foodstuff becomes totally unpalatable. In addition, some microorganisms are known to release toxins that may cause damage to health. The deadliest type of food poisoning is Botulism, which is caused by a toxin produced by Clostridium botulinum in canned foods. The toxin can be destroyed by six minutes of boiling. Mostly it occurs in improperly processed canned foods. The presence of Clostridium is often marked by a slight bulge in a sealed can followed by a sour smell upon opening.

3.0 CLASSIFICATION OF FOODS ON THE BASIS OF SPOILAGES

On the basis of ease of spoilage, foods can be placed in three groups:

- **Stable or nonperishable foods.** These foods, which do not spoil unless handled carelessly, include such products as sugar, flour, and dry beans.
- **Semi perishable foods.** If these foods are properly handled and stored, they will remain unspoiled for a fairly long period, e.g. potatoes, some varieties of apples, and nutmeats.
- **Perishable foods.** This group includes most important daily foods that spoil readily unless special preservative methods are used. Meats, fish, poultry, fruits and vegetables, eggs, and milk.

4.0 FACTORS AFFECTING KINDS AND NUMBER OF MICROORGANISMS IN FOODS

The spoilage of foods by microorganisms will depend on kind and extent of contamination, previous opportunities for the growth of certain kinds of organisms and pre-treatment, which the food has received as illustrated the following:

a) Contamination may increase number of microorganisms in the food and may even introduce new kinds. Thus wash water may incorporate surface-taint bacteria in butter;
plant equipments may add spoilage organisms to foods during processing; washing machines may add them to eggs; and dirty boats may add them to fish. The increased "bioburden" of microorganisms, especially those which cause spoilage, makes preservation more difficult; i.e. spoilage is more likely and more rapid and perhaps takes a different form from that which would have appeared without contamination.

b) Growth of microorganisms in or on the food obviously will increase numbers or the bioburden of microorganisms in most foods which will bring about an increase in the organisms and likely to be involved in spoilage. The heavier bioburden will add to the difficulty of preventing spoilage of the food and may influence the kind of spoilage to be anticipated.

c) Pretreatments of foods may remove or destroy some kinds of microorganisms, add organisms, or change the preparations of those present or inactivate part or all of the food enzymes and thus limit the number of spoilage agents and hence the possible types of spoilage. Washing, for example, may remove organisms, from the surface or may add some from that wash water. If washing is by means of an antiseptic or germicidal solution, numbers or organisms may be greatly reduced and some kinds may be eliminated. Treatment with rays, ozone, sulfur dioxide, or germicidal vapors will reduce numbers of contaminants. High temperatures will kill more and more organisms and leave fewer and fewer kinds as the heat treatment is increased. Storage under various conditions may either increase or decrease kinds and numbers of organisms.

5.0 METHODS OF PREVENTING SPOILAGES DURING PACKAGING AND STORAGE

5.1 Prevention of chemical and physical changes

Oxidation phenomenon is responsible for chemical and physical changes in foods and it can be restricted by withholding or inactivating the oxygen that is in contact with the food material. And this can be achieved by using oxygen impermeable packaging material. The air contained in the packets can be replaced by inert gas or removed by vacuum packaging. Another method is to use antioxidants that scavenge free radicals produced during oxidation process. Finally, oxygen can be eliminated using palladium with hydrogen or glucose oxidase. Addition of emulsifiers and thickeners in foods checks the physical changes. Such preventive measures will also have control on secondary spoilage which is caused by microbial growth in the finished product.

5.2 Methods of food preservations

There are various methods of food preservation, which have been adopted by food processing industries to curb microbiological spoilage and to enhance shelf life of finished products. These are thermal processing, freezing dehydration, chemical preservatives and irradiation. Especially important in food preservation (i.e. prevention of spoilage) is the lengthening as much as possible of lag phase and phase of positive acceleration of microorganisms. This can be accomplished in different ways by adopting the following precautions:

1. By reducing the amount of contamination; the fewer the organisms are present, the longer the lag phase will be.
2. By avoiding the addition of actively growing organisms (from the logarithmic phase of growth). Such organisms might be growing on unclean containers, equipments, or utensils that come in contact with foods.

3. By one or more unfavourable environmental conditions; unfavourable food, moisture, temperature, pH, or OR potential, or presence of inhibitors. The more unfavourable the conditions, the longer the delay of the initiation of growth.

4. By actual damage to organisms by processing methods such as heating or irradiation. Thus, for example, bacteria or their spores subjected to sub lethal heat treatments have been found to require a better culture medium for growth than do the unheated organisms. Often a combination of methods for delaying the initiation of growth is enough to give a food the desired storage life.

5.3 Asepsis technique to control microbial contamination:

In the food industries an increasing amount of attention is being given to the prevention of the contamination of foods, from the raw material to the finished product. The food technologist is concerned with the “bioburden” of microorganisms on or in a food and considers both kinds and numbers of organisms present. The kinds are important in that they may include spoilage organisms, those desirable in food fermentation, or even pathogenic microorganisms. The numbers of microorganisms are important because the more spoilage organisms, the more likely food spoilage will be, and more difficult will be the preservation of food. The "bioburden" may be the result of contamination, growth of organisms, or both. The quality of many kinds of foods is judged partly by the numbers of microorganisms present. The following are some examples of the importance of aseptic methods in food industries.

Packaging of foods is a widely used application of asepsis. The covering may range from a loose carton or wrapping, which prevents primarily contamination during handling, to the hermetically sealed container of canned foods, which, if tight, protects the processed contents from contamination by microorganisms. In the canning industry the bioburden or load, of microorganisms determines the heat process necessary for the preservation of a food, especially if the contamination introduces heat-resistant spoilage organisms, such as spore forming thermophiles that may come from equipments; and the sealed can prevents recontamination after the heat treatment.

5.4 Thermal Processing

Heat thermal processing includes heating, holding and cooking required to eliminate the potential of food borne illness. The use of heat finds wide applications. The simple act of cooking, frying, boiling or simply heating food prior to consumption are forms of food preservation. Cooked food itself can be held for several days provided it is protected from recontamination. Various methods in thermal processing include blanching, pasteurization and sterilization, which are recommended to enhance keeping quality of foods.

5.4.1 Blanching: Blanching process typically utilizes temperatures around 75-95 °C for about 1 to 10 min, depending on the product requirements. It is a necessary pretreatment
D. N. Gandhi

for many vegetables in order to achieve satisfactory quality in dehydrated, canned and frozen products. A blanching process may be needed if there is a likelihood of delay in reaching enzyme-inactivating temperatures. The process should ensure the required reduction in enzyme activity that otherwise might cause undesirable changes in odor, flavour, colour, texture and nutritive value during storage by freezing. Another major effect is the removal of intercellular gases. This reduces the potential for oxidative changes in food and allows the achievement of suitable headspace. Blanching may result in some reduction in the microbial load and the texture may be improved.

5.4.2 Sterilization: Sterilization involves the use of heat to bring about total destruction of all microorganisms and their spores. This requires a treatment of at least 121 °C of wet heat for 15 min or its equivalent. The sterilized food must be placed in a container to prevent the entry of further spoilage organisms.

5.4.3 Canning process: The first and foremost operation is to clean and remove all inedible parts from the food. Food is graded, washed and blanched. Blanching not only inactivates enzymes which affects the stability of foods but also help to drive out air bubbles trapped within the foods, thus allowing a better "fill", if too much air remains in the cans the desired temperature may not achieved during sterilization. The next step is "filling and exhausting". The washed cans are filled automatically with weighed amount of foods. For vegetables, fruits and some other foods, cans are topped up with liquor. The liquor is normally in the case of vegetables and sugar syrup in case of fruits. After filling, the cans are passed to an exhaust box in which they are exposed to hot water or steam so that when the lid is sealed on a partial vaccum will fall in the cans and then passed to an automatic sealing machine which bends the edges of the lid and flange on the can body into the roll. The roll is then flattened forming a hermetic (i.e. airtight seal), then sterilization is carried out.

The amount of heat required for sterilization depends on the size of the can, nature of its contents and the pH of the food. Heat takes longer to penetrate into a large can and it is faster in convection packs such as soups, the conduction packs such as corned beef. The main purpose of sterilization is to eliminate Clostridium botulinum and its spores, since this is the most dangerous and heat resistant microorganism present in canned foods. Depending on pH of the food, the amount of heat treatment required to eliminate this microorganism differs. Therefore, foods have been classified into different groups viz. high, medium and low acid foods.

5.4.4 Controlled atmosphere storage and food irradiation: To increase the shelf life of packed foods, controlled atmosphere storage is also practiced whenever food is sealed in a package under vacuum, nitrogen or carbon dioxide. Perishable foods such as meat, fish, fresh fruits and vegetables can be sealed in packages in which air has been replaced by some mixture of gases, which extend the shelf life. Food irradiation is a treatment of food either packed or in bulk to control amount of ionizing radiation for a specific time to achieve objective to control microbial spoilage. This process is gaining more and more attention around the world in the recent years.

6.0 CONCLUSION:
Microorganisms invariably are responsible to cause spoilages of fresh and finished food products and contributing off flavour by means of breakdown of a product or synthesis of new compounds, which leads to a great loss to food processing industries. In addition, consumption of deteriorated food products are also responsible to cause public health hazards. To prevent such microbiological spoilage, it is essential to minimize the contact between microorganisms during food processing, packaging and storage by maintaining strict hygienic conditions and by adopting appropriate preservation techniques according to the nature of the food items.

7.0 SUGGESTED READING


James M. Jay. 1996., Modern Food Microbiology, CBS Publisher & Distributor New Delhi.


1.0 INTRODUCTION

It is estimated that nearly half of the total milk production in India is utilized for the manufacture of a range of traditional milk products viz., fat rich (Ghee), heat desiccated (Khoa and Khoa based sweets, Rabri, Basundi, etc.), acid coagulated (Paneer, Channa and Channa based sweets), fermented (Dahi, Misti Dahi, Chakka and Shrikhand) cereal based (Kheer, Payasam etc.) and frozen (Kulfi) products. Most of these products, except 10-15% of total ghee production, are produced by private traders (Halwais) using labour and energy intensive batch processes, resulting into large variations in their qualities. The shelf life of traditional dairy products is generally low and does not commensurate with the principles involved in their manufacture. One of the reasons for poor shelf life is either no packaging or inadequate packaging of traditional dairy products. The other reasons for poor shelf life being microbial contamination of these products mainly post-manufacturing; due to unhygienic conditions in production, packaging and storage areas. Though lot of R&D efforts have been made for mechanization and upgradation of these methods of manufacturing traditional milk products, due attention has not been paid for designing and developing new packaging materials and systems for these products. On the contrary, very fast developments are taking place in western countries where most of the dairy products are being inline packaged in flexible packages like paper cartons, plastic pouches, laminates moulded containers etc. using continuous packaging systems and machinery.

In recent years the popularity for traditional products like Ghee, Paneer, Rasogolla, Burfi, etc. have increased in European countries and lot of export potentials exist for these products. Hence, there is an urgent need to extend the shelf life of these products adopting not only good manufacturing practices but by packaging them in very cheap and attractive materials having excellent barrier, printable and consumer friendly properties. An attempt has been made to describe the present status of packaging some commercially important traditional milk products and the future scope in this regard.

2.0 GHEE

Ghee (anhydrous butter-fat) is defined as pure butterfat obtained by heat clarification of cream or butter. Approximately 28% of total milk production is converted into ghee, which is next to the liquid milk consumption; hence it has great economical significance in our country. Since butterfat is most expensive constituent of milk, utmost care is taken in its processing (into ghee), packaging and preservation. The role of packaging material in transportation and preservation from tampering and
spoilage of ghee is unsurmountable. With a view to select suitable packages for ghee, it is essential to know the method of handling, nature of spoilage, storage conditions and consumers’ requirements/choices. Ghee is prepared at a temperature of around 110°C at which most of the microorganisms and enzyme (lipase) are eliminated and moisture content is left less than 0.5%; hence there is no microbial spoilage of ghee during storage. However, upon prolonged storage, ghee undergoes lipid deterioration resulting into either hydrolytic rancidity or oxidative rancidity defects. Contamination of ghee with lipase activating/producing microorganisms and presence of higher moisture are responsible for hydrolytic rancidity. Oxidative rancidity in ghee is more common and develops due to interactions of fat with oxygen content in ghee/package and accelerated by the presence of copper, iron and also by exposure to sunlight. The selection of right type of packaging material can play a vital role in delaying the onset of these defects in ghee. The packaging materials being used for ghee or have great potential are discussed here:

2.1 Tin Plate Container:

Majority of dairies in public as well as private sector are using lacquered or even unlaquered tin cans of different sizes (250 g, to 15 kg.) for packaging of ghee. Some dairies sell loose ghee to local consumers through their sale depots or stores, where the possibilities of adulteration are fairly high. The advantages of using tin cans are manifold. They protect the product against tampering and being sturdy, can be transported to distant places without much damage and wastage during transport. The oxygen content in ghee can be reduced in case of tin cans by either hot filling or minimizing the headspace thereby preventing/delaying the oxidized flavour defect. It is very essential that tin cans be properly lacquered because rusted cans are liable to accelerate the lipid deterioration. Proper granulation in ghee is a highly desirable attribute from consumers’ point of view, and ghee packaged in tin cans normally has better developed grains. The only drawback of tin cans is their high cost and involvement of foreign exchange. BIS specifications for different sizes of tin plate containers are available for packaging of ghee.

2.2 Glass Bottles:

Though glass bottles provide excellent protection, they do not react with the food material and can be used for high-speed operations; but are not in much use for packaging of ghee because of their fragility and high weight.

2.3 Semi Rigid Containers:

Of late, semi-rigid plastic containers are replacing tin plate containers. These are mainly made from HDPE. The advantages of using these containers are that they provide a moderately long shelf life (not as long as tin cans), are lightweight, economical and transport-worthy. These are of several types viz., blow moulded HDPE, PET (polyethylene terephthalate) bottles, PVC (poly vinyl chloride) bottles, and recently introduced bag-in-box systems, lined cartons and tetrapacks. Blow moulded HDPE are, available in form of bottles (200, 400 g), jars (1 kg and 2 kg.), and jerry cans (2 kg, 5 kg, and 15 kg). PET bottles have excellent clarity are odour free and have gas barrier
properties (Dordi, 1998). All these semi-rigid containers have good scope for packaging of ghee.

2.3 Flexible Films/Pouches:

Flexible pouch may be made from laminates or multilayer films of different composition. The pouch may be in the form of pillow pouch or as stand-up pouches. Limited quantities of ghee are today packed in flexible pouches of less than 1 kg. The most attractive feature of packaging ghee in flexible pouches is that they are most economical than any other packaging system. The selection of a laminate or a multilayer film is governed primarily by the compatibility of the contact layer, heat sealability and heat-seal strength and shelf life required. While deciding a flexible film/pouch for ghee, the other properties that need to be considered are water vapour barrier and oxygen and light transmission rates which should be lowest. The aroma and grease barrier properties are also important considerations for flexible material for packaging ghee. The indigenously available flexible materials which have very low values for the above mentioned properties are HDPE, PP, Al foil, Nylon 6, PVC, Saran, Polyester and numerous laminates of flexible films (Dordi, 1998, Goyal and Rajorhia, 1991). Sachets made from a laminate of PVdC/Al foil/PP is suitable for long term storage of anhydrous milk fat or ghee (Dhar, 2002)

3.0 PANEER

Paneer, a popular traditional Indian dairy product, is obtained by acid and heat coagulation of hot milk. Paneer has a short shelf life of about 7 days at refrigeration storage and less than 24 hours at room temperature. A high moisture content (about 55%), post-manufacturing contamination and improper packaging are some of the major contributors for such a limited shelf life. The spoilage in paneer occurs due to the surface growth of microorganisms. A greenish yellow slime forms on the surface and the discolouration is accompanied by an off-flavour. Hence, it is invariably the surface that gets spoiled early while the interior remains good for a longer time at refrigeration storage. Use of an appropriate packaging material and creating air free environment, therefore, may contribute greatly in increasing the shelf life of Paneer.

Sachdeva et al.(1991) vacuum packaged paneer blocks of 10x4x6 cm size in cryovac polyethylene bags using a Roscher metric vacuum packaging machine. No deterioration was observed upto 30 days at 6 ±1°C in vacuum packaged paneer samples. The body and texture of paneer also improved on vacuum packaging as it became more compact and better sliceable. Punjrath et.al. (1997) reported that vacuum packaging of paneer in specific film (EVA/EVA/PVDC/EVA) followed by heat treatment at 90°C for one minute could help extending the shelf life upto 90 days at refrigeration temperature.

4.0 KHOA

Khoa is a partially heat desiccated milk product obtained by continuous boiling of cow, buffalo or mixed milk or concentrated milk till desired flavour, texture and consistency is achieved. Normally, it contains 65-70% TS and the level of individual milk constituent in Khoa depends on the initial values in milk and the degree of
concentration which is 4 - 5 times depending on the type of milk. The fat content should be more than 30% of dry matter as stipulated by PFA. When khoa comes out from the processing kettle/continuous Khoa making machine, the temperature is more than 90°C and it is invariably free from microorganisms. It is only the subsequent poor handling, packaging and storage conditions that are responsible for heavy microbial contamination in Khoa resulting into limited shelf life of about 5 days at room temperature. Though three types of khoa, viz. Pindi, Dhap and Danedar are produced in the country, only Pindi variety is marketed to large and metropolitan cities. One kg blocks of spherical or hemispherical shape are packed in a bamboo basket lined with green leaves or newspaper and covered with a gunny, cloth for transportation. Packaging of khoa in this manner is improper and unsuitable from hygienic and shelf life point of view.

The most common defects occurring in khoa during storage are hardening/drying of the product, fat oxidation, yeast and mould growth, staleness etc. Selection of proper packaging system may, therefore, minimize these defects and extend the shelf life of khoa to a substantial longer period. According to Goyal and Rajorhia (1991) hot filling (80-90°C) of khoa in tin cans increases its shelf life to 14 days at 37°C, while the use of 3-ply laminate made of paper/aluminium foil/LDPE or 2-ply laminate of MST cellulose/LDPE keeps khoa in good condition for 10 days at 37°C and for 60 days under refrigerated storage. Hot filling of khoa at such a high temperature though helps extending the shelf life, it imparts undesirable browning in Khoa making it unsuitable for sweets making. Recently, high barrier structures/laminates based on polyester/ethylene vinyl alcohol (EVOH)/polythene are being developed for products like Khoa and milk desserts (Punjrath, 1995). Such laminates can be used for bulk packaging of khoa in cold stores for longer duration. Tin cans and rigid plastic containers of 15 kg cap can also be advantageously used for bulk packaging of khoa under vacuum and storage at room temperature.

5.0 MILK SWEETS

5.1 Burfi and Peda

Amongst the several khoa-based sweets, burfi and peda occupy most dominating place in terms of popularity and market demand. About 30% sugar (W/W basis) is blended vigorously with hot khoa for making these sweets, but the shape, body and texture and chemical composition (particularly moisture content) of burfi and peda are slightly different from each other. Currently, these sweets are largely prepared by private sector (Halwai’s) on small scale and mostly packaged in paper cartons or duplex board boxes with or without butter paper lining. The traditional packages do not provide sufficient protection to milk sweets from atmospheric contamination and unhygienic handling and thus susceptible to become dry, hard and mouldy and develops off flavours. Only recently, some of the reputed manufacturers of these sweets have started packaging burfi and peda in HDPE/polypropylene boxes and cartons of 500g and 1 kg size, particularly on festivals. Palit and Pal (2000) investigated the influence of different packaging materials on the shelf life of burfi. Burfi was hot filled in pre-sterilized polyester tubs of 250 g capacity and subsequently vacuum packaged in multilayer co-extruded nylon high barrier pouches. They observed the shelf life of 52 days at 30 °C
in vacuum packaged samples against 16 days without vacuum packaging. No mould growth was observed in vacuum packaged samples.

Kumar *et al.* (1997) packed peda under modified atmospheric packaging (MAP) (80% nitrogen and 20% CO₂) in bags made from high barrier multilayer (EVA/EVA/PVdC/EVA) film and also at normal atmospheric conditions in barrier bags containing oxygen scavenger pouch placed in barrier bags along with indicator tablet. Control samples were in cardboard boxes. Mould growth was observed in control samples after 7 days of storage. Samples with MAP showed shelf life of 15 days at 37°C and 30 days at 20°C. Packaging of peda with oxygen scavenger extended the shelf life up to 2 months at 37°C, 5 months at ambient temperature (30°C) and 6 months at 20°C.

5.2 Gulabjaman and Rasogolla

Gulabjaman is a khoa based sweet while rasogolla is prepared from channa. The similarity between the two is based on their shape, texture and method of storage. Both are spherical in shape, spongy (rasogolla more spongy than gulabjaman), porous and kept in sugar syrup. Their shape and porosity attributes are very critical and have to be maintained till product reaches to the consumer. On an average, they contain about 40% moisture and 50% sugar (including lactose and carbohydrates). Fat content in gulabjaman is more than rasogolla. Yeast and mould growth is a more common problem associated with yeasty/fruity flavour defects during storage in both the sweets.

Since the body and texture of rasogolla is very delicate and it has to be preserved in sugar syrup, it is invariably packaged in lacquered tin cans of 500 g and 1 kg capacity. The proportion of rasogolla and syrup is kept 40:60 and product stays in good condition for more than 6 months at ambient conditions, because hot filling (at about 90°C) technique is adopted. Gulabjaman is largely packaged without syrup in paper cartons or polyester boxes like burfi and peda. Though lacquered tin can is the most suitable packaging material for rosogalla and gulabjaman, it is very expensive. Hence, Goyal and Rajorhia (1991) suggested the need to develop plastic can similar to “Letpak” commonly used in European countries. “Letpak” is extruded and laminated with a PP-Al foil material. The foil provides the necessary water vapour barrier property, smooth curved corners and good printing surface for multi-colour designs. The ends are injection moulded and lined with same type of laminate as used for the body. The size and the dimensions can be adopted to suit the distribution systems and consumers’ needs. The material is heat resistant and thus hot packaging of syrup and products is possible.

6.0 FERMENTED PRODUCTS

Dahi, Misti dahi and Shrikhand are the popular indigenous fermented products. Now, their production is not restricted to household and Halwais level but many organized dairies have started their commercial manufacturing. Dahi and Misti dahi are sold in earthen pots which, provide firm body and texture but are heavy in weight, breakable, expensive, cannot be covered properly and above all shrinkage of product takes place during storage because of moisture seepage through the porous body of pot.
Polystyrene (PS) and polypropylene (PP) cups of 100, 200 and 500 g size are used for the packaging of shrikhand, dahi and Misti dahi by the organized dairies. PS & PP cups are free from all the problems associated with earthen pots. The drawbacks with them are that wheying off of the product, particularly of dahi, is rather fast and they are not eco-friendly.

7.0 FUTURE PROSPECTS

Revolutionary changes are taking place at a very fast speed in packaging. New concepts, materials, designs, machinery, printing and labelling and computers software are revolutionising the packaging sector. Preformed PS or PP containers with improved lids are available for packaging of traditional milk products. The paper/polyester heat seal lidding, and more recently metallized polyester peelable film laminate gives an even peel without tearing when lid is removed from a container (Punjrath, 1995). There is also a switch from thermoformed (multivac) packaging using nylon/polyester laminate to flow pack type of system incorporating polypropylene or polyester barriers often incorporating gas flushing in cheese packaging which can also be attempted in paneer and milk sweets. Ethylene vinyl alcohol (EVOH) has excellent gas barrier properties in dry conditions and should be suitable for packaging of milk sweets such as burfi and peda under vacuum or MAP. Poly vinylidene chloride (PVdC) also has high barrier properties and being increasingly used particularly in retort pouches in food industry. Recently, a complementary polymer, metaxylene diamine and adipic acid polycondensate (MXD6), has been developed with better flexibility and barrier properties.

Other barrier materials that may have great use in packaging of traditional milk products are HNR (High nitrile resins) and amorphous nylon Selar PA. In view of the increasing environmental concerns about the disposal of flexible films and laminates, the concept of edible and biodegradable packaging materials is being conceived seriously.

Many innovations have taken place in packaging systems in the past, such as, modified atmospheric packaging (MAP), vacuum packaging, aseptic inline packaging and oxygen absorbers/scavengers. These synergistic effects, along with appropriately chosen packaging material, on the shelf life, and could have great prospects in the packaging of traditional Indian dairy products. Software packages are now available which automate the process of designing a food package on the basis of composition, cost and film requirements in terms of barriers properties.

8.0 REFERENCES


1.0 INTRODUCTION

Milk has been packaged in different types of containers throughout the world. The changes in its packaging system have been very fast in recent years, and the industry is in confusion and difficulty in keeping pace with the fast changes in milk packaging systems. Although for protecting milk from environmental standpoint, it would be desirable to use secure rigid packs, but mostly for economical and convenience reasons, their use is fast decreasing. It has become possible because alternate plastics materials with more or less the same desired functional properties have been evolved. Presently, in many Western countries, milk is sold in flexible packages like cartons, bags, pouches, plastic bottles and jars etc. The pasteurized plastic pouch (PPP) has been a major packaging medium for liquid milk in developing countries. The lack of a continuous cold chain, along with the prohibitive costs of having, result in a broken cold chain for the PPP in most developing countries (Krishna, 2002).

The unique advantages offered by the plastic packages are: they have good barrier properties, permit visibility of the contents, are light in weight (thus reducing the cost of transportation), can be used for single-service, are easy to carry home, are more economical and can be made more attractive. The use of plastic containers eliminates noise in the milk bottling plants and during delivery, and also reduces water pollution caused by milk residues and detergents used in the bottle washing process.

2.0 PACKAGING OF LIQUID MILK

Of the total milk packed, flexible pouches dominate with 92%, glass bottles 7% and aseptic packaging 1%. Glass Bottle is a multi trip package for milk and, on an average each bottle performs as many as 90 trips to the consumer before it goes out of circulation. Bottles are cleaned in a bottle washer, filled on automatic filling machine and are capped with aluminum foil. Weight of empty bottle is high and requires higher freight cost.

Plastic pouches are fast replacing milk bottles. Flexible pouches have proved to be a safe, quick and cost effective packaging method with a wide distribution network, providing ease of packaging and handling. A good consumer response to milk pouches paved the way for the technological changes. In the form-fill-seal (ffs) system, the plastic film is formed into a tube, sealed along its length, sealed at the bottom to form a pouch, filled with milk and then sealed at the top. Butane LLDPE or C-4 and Octane LLDPE or C-8 is widely used because of their excellent cold storage properties.
Aseptic packaging using flexible materials is employed where extended shelf life is required. Aseptic packaging is a technology wherein the product and package are separately sterilized, and the product is then filled into the package and the package sealed in an sterile environment. The product is commercially sterile (meaning that any pathogenic or other spoilage microorganisms have been destroyed) and shelf stable (does not require refrigeration or freezing). Economic saving is realized in many cases by the use of lighter weight packaging materials such as polymer/foil/paper laminations or co-extruded container constructions. Many aseptic packaging systems are based on form-fill-seal technologies that eliminate the need to ship preformed containers to the processor.

Plastic materials used in aseptic packaging of milk products are polyethylene, polypropylene, polystyrene as tubes, bottles or plastic film laminates with paper board or aluminum in the form of cartons. High-pressure steam is used to sterilize product lines and hydrogen peroxide with heat of UV radiation for container materials. The popular commercial systems available for aseptic packaging of milk are Tetra pak, Tetra brick, Brick pack, Combi block, Pure pak, Hind pak, etc. Tetra pak/Tetra brick packs are used to pack UHT treated milk into pre-sterilized package in aseptic conditions. Tetra-pak uses paperboard laminated with 10µ LDPE from outside and 70-75µ LDPE from inside. The Tetra-brick uses aluminum foil of 7-9µ in addition to above laminates. The machinery needed for this system is more capital intensive. TFA launched by Tetra pak keeps the milk fresh without refrigeration for about 15 days.

Doy pack system provides a shelf-life of almost 90 days. Kaushik (1998) reported Fino aseptic packaging for UHT treated milk. Fino package is a multi-layered laminate of paper, aluminum foil and PE and is a temper proof aseptic pack with its shape similar to a plastic pouch.

3.0 ECONOMY OF PACKAGING OF MILK

From the cost point of view, it has been established that sachet is the only economic non-returnable pack, effecting a substantial saving in freight costs. The distribution costs were found to be lower with PE sachets than the bottles by Chaudhary and Patel (1980) also, being 22.4 and 30.4 paise/litre of milk, respectively.

The relative cost of packaging milk in some packages is given in Table 1. Punjrath (1995) reported the packaging cost of liquid milk in pouches as Rs 0.50 per litre, which is around 5% of the consumer price of the package. Mathur (1998) reported the cost of one litre pouch of film thickness 60-65 µ of LDPE + BUTENE LLDPE in a blend ratio 1:4 as Rs. 0.52 and LDPE + OCTANE LLDPE in a blend ratio 1:1 as Rs. 0.37. The use of a package film blend of 50% each of octane LLDPE and LDPE provides the least cost option to dairies as it reduces leaks from existing 5-7% to below 1%, cuts down loss of expensive milk and affects a saving of about 30% in their packaging cost.

Joshi (1987) reported cost of 500 ml TetraPak and TetraBrik around Rs 0.40. Kaushik (1998) reported that Fino aseptic packaging provides a cost effective method in distribution of UHT treated milk.
### Table 1: Relative cost of packaging of milk

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Packaging material</th>
<th>Package size</th>
<th>Cost of Packaging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid Milk</td>
<td>Glass Bottle</td>
<td>0.5 litre</td>
<td>Rs. 0.55 per litre</td>
</tr>
<tr>
<td></td>
<td>Flexible Pouches</td>
<td>0.5, 1.0 litre</td>
<td>Rs. 0.45 to 0.5 per litre</td>
</tr>
<tr>
<td></td>
<td>LDPE</td>
<td></td>
<td>Rs. 0.30 per litre</td>
</tr>
<tr>
<td></td>
<td>LDPE + BUTENE</td>
<td></td>
<td>Rs. 0.50 per litre</td>
</tr>
<tr>
<td></td>
<td>LLDPE (1:1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LDPE + BUTENE</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LLDPE (1:4)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 4.0 PACKAGING TRENDS

#### 4.1 Status in India

The per capita availability of milk in India is about 218 g. Though India has a tradition of milk drinking, its per capita per annum milk consumption is just over 33 kg. Ireland is the biggest milk guzzler with a whopping 189 litres per capita per annum for the year 2000 (Vyas, 2002). Of the total milk produced in India, only 10% is marketed by the organized sector, whereas 55% is handled by traditional Dudhias / Halwais (Roy, 2002). The rest is retained by milk producing households for in-house consumption and local sale. Low-fat and skimmed milk are replacing whole milk.

Approximately 46% of the total milk production in the country is consumed as fluid milk (Dhar, 2002 and Chennegowda, 2002). Only 15% of milk is packed (Dhar, 2002). Of this, the flexible pouch accounts for approximately 94% (Chennegowda, 2002). 89% of the households in India consume loose milk whereas only 9% households use packaged milk. Packed milk is concentrated in 40-50 major cities. Of 3700 cities and towns, only about 778 are served by an organized milk distribution network. The penetration of packaged milk is high amongst towns having a population of more than 10 lakh.

About 15-20 years ago, milk was home delivered by a milkman. Later, bottled milk came into existence as the organized sector became involved in milk distribution activities to maintain quality and hygiene. The retail sale of pasteurized milk by organised dairies was mainly through two methods: either it was distributed to consumers from the cans to individual containers or is bottled. The different types of pasteurized milk like standardized, toned, double toned, cow's milk, buffalo's milk and skim milk, were distinguished by the adoption of aluminium caps of different colours/designs on the bottles. Of late, recognising the disadvantages of bottling of milk viz., high initial and operational costs, breakage of bottles during handling and transportation, need for cleaning and sterilization of bottles, heavier loads during transportation etc., and in addition, the need of aluminium foils for caps, many selected dairy organisations of this country started packaging of milk in plastic pouches generally made of low density polyethylene (PE).

#### 4.2 Packaging Trends Abroad

The glass bottle for milk was introduced in USA in 1884 and plastic containers, i.e. single-service high-density blow-molded PE containers were
introduced in 1964. Since then, especially in recent years, there has been a noticeable swing towards the use of plastic combinations in the dairy industry of western countries. The consumers in Canada welcomed milk packaging in plastic sachets. Multipacks, i.e. bags containing 3 sachets, each with 1.13 litre milk are commonly used (Halonen, 1971).

The pasteurized milk packed in plastic jars remained good for more than ten days under the normal conditions of handling the jar each day and keeping it in refrigerator (Goyal, 1986). The milk is also sold in LDPE pouches, but they are not popular for the reason of their handling, mainly at the consumers' end right from purchasing to pouring of milk. Due to significant loss in popularity of paperboard containers for milk, the paperboard industry in USA, has flooded the US market with a new twin pack comprising two-half gallon containers, joined by a handle with the help of hot melt, with the idea to regain the confidence of the people in paperboard milk packs (Goyal, 1986). In German Federal Republic, with a view to differentiate between varieties of pasteurized milk, the same are packaged in pure-pack gable-top cartons, with prominent decoration.

In UK, quart plastic bottle weighing 23 g and of conventional shape was made from a 50/50 blend of high and low density PE. Liquid milk for loose sale in Berlin has been contained in 15-1 plastic bags placed in returnable plastic crates. The bags are made from single-ply blue PE film, 670 mm long and 365 mm width with three seams. The bags are filled automatically at the rate of 200 or 300 bags/h. Emptying of bag is done by cutting off a corner (Muller, 1971). Another plastic package for milk consisted of a heat-sealable material which had a tear-strip opening device built into the welding seams, and a pouring spout, the shape of which could be adjusted.

The Rhineland Milk Supply of Germany marketed pasteurized milk in Tetra King one litre packs of PS-foam laminate produced on a Tetra Pak machine with a capacity of 7200 units/h. The new package was named 'milk cooler' because of its heat insulation properties (temperature increase at 25°C room temp. 1.5°C/h as compared to about 6°C for conventional carton packages). The new package was welcomed by the consumers (Heiber, 1979). Another package for liquid products comprising paper or cardboard with an impervious plastic coating has been reported (Reil, 1979). The package had a closure formed by two strips and provided with outwardly extended superimposed tear strips, which could be pulled apart to separate the two closure strips to form a pouring spout. The package could have a flat or gable top.

5.0 PACKAGING OF CREAM

Cream contains a high percentage of butterfat, so it is very susceptible to spoilage. In addition, it must be protected from water loss. The shelf life of refrigerated creams ranges between 1-2 days without proper protection. Packaging consists of units similar to those used for milk, i.e. PE coated paperboards. Since cream is used in smaller amounts, sizes sold are 500 g and smaller. In India, cream is packaged in 250 ml glass bottles or sold in consumer’s own container. Whipped creams and synthetic formulations are sold in AEROSOL cans and PE tubs with snap-on lid. Imitation cream made from soybeans and vegetable oils is often marketed in wax-coated paperboard cartons.
Newer concepts include portion-control thermoformed packs made from linear PE, PS or PP. These may be closed with a peelable lid or snap-on cover. Tin plate containers have also been used for larger sizes.

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1.0 INTRODUCTION

The keeping quality of dried milk products during storage in the warehouse, in the retail store, or on the kitchen shelf is of great importance to consumer acceptance. To maintain the high quality of the product during storage and transportation, it is necessary to prevent chemical reactions causing the formation of various compounds that impart a more or less undesirable flavour to the reconstituted milk. Packaging of dried milk products, therefore assumes greater significance.

2.0 CATEGORIES OF DRIED FOODS BASED ON MOISTURE AND PACKAGING REQUIREMENTS

Dried milk products and other foods fall readily into categories based upon moisture content and these tend to define the packaging requirement for each group.

Group 1: Instant beverages such as coffee, freeze-dried and vacuum dried foods that contain very low levels of moisture in the range of 1-3 %.

Group II: Most dehydrated milk products together with breakfast cereals and some biscuits contain moisture in the range of 2-8 %.

Group III: Dried fruits, nuts, cereals, nuts and some baked products have moisture levels in the range of 6-30%.

Of special interest are the products falling in Group I and II categories as most dairy products including instant products fall in these two categories. Dried foods which contain only 1-3 % moisture have equilibrium relative humidity (ERH) values, which are below 20% and may even be below 10%. As the humidity of ambient air is rarely in this low range, such foods absorb water vapour freely from the air surrounding them. These foods often have a porous nature and a high surface-to weight ratio, thereby increasing the hygroscopicity. Uptake of water vapour may be so rapid that packaging is done in an air-conditioned room in which low RH is maintained. Some very low moisture dried foods are very sensitive to oxidative deterioration, so they must be packaged in containers, which are impermeable to water vapour and to oxygen.
Hermetically sealed glass jars, lever lid cans and heat-sealable multi-wall laminates with a foil layer are generally used. They are often packed initially under vacuum or in an inert gas. Many, like ‘instant coffee’ must be packaged in resealable containers. These products are relatively expensive and can tolerate more expensive packaging. If they are inadequately packaged, they will cake and will not reconstitute, and also can lose much of their volatile flavouring components. In-package desiccants, or oxygen scavengers are sometimes sealed in with dried foods, which are susceptible to deterioration caused by minor changes in moisture or oxygen level. The packages for these scavengers must transmit gases and vapours but be sift-proof to avoid contaminating the food.

Dried foods in 2-8% moisture range have ERH values in the 10-30% region. Their packaging requirements are not as exacting as those for foods included in Group I. In bulk, they are frequently stored and transported in lever-lid containers of 20-25 litre capacity, or in open-top drums of upto 200-litre capacity, which can be hermetically sealed. At retail level, they are generally packaged in triple laminates consisting of polyethylene, aluminium foil and paper. In a few instances, a flexible film with very low water vapour transmission rate (WVTR) may be used. Most dried foods in this category are better packed in an inert gas, but this is not commercially common. Some dried foods such as onion, garlic and flavouring materials are powdered and packaged in plastic-shaker dispensers. In this finely divided form, they are very hygroscopic, and the dispenser, once opened, cannot be perfectly sealed again. Anti-caking agents, such as silicates, may be mixed with the powdered foods up to 5% by weight. Packaging is often done in air-conditioned premises. Dried soups require thorough protection from oxygen and moisture as well as from loss of volatile flavourings. Most of the small retail packs for this type of material are made from heat-sealable laminates containing a layer or layers of aluminium foil. In-package desiccation is not practical for these packs, but inert gas packing is practiced.

Dried milk powder is generally produced either by roller or spray process. The creamy colour, granular and almost crystalline form and tallowy or oxidized-fat odour are characteristics of roller powder. A milder heat treatment is used to produce spray powder, which is fine white powder with a smaller particle size and which reconstitutes more easily. Roller dried powder has better bacteriological quality due to the more rigorous heat treatment. The packaging of dried milk therefore must take account of its sensitivity to moisture, oxidation and microorganisms. Even though, bacteria such as *Streptococcus thermophilus* may be completely destroyed by the heat treatment, their chemical products such as lactic acid will remain undestroyed. If the moisture content is below 3%, bacterial growth may be ignored and the only serious deterioration may be due to slow oxidation of the fat, which may be delayed by holding in an oxygen-free atmosphere, by coating with an impermeable material or gas packing or the addition of antioxidants.

Protection of fat rich and vitamin-containing foods against oxygen is more difficult to achieve in flexible packages than is protection against moisture vapour. This
is because the quantity of oxygen, which can cause spoilage, is usually very small, and it is therefore essential that the package is absolutely free from small pinholes. However, flushing with an inert gas such as nitrogen can afford some protection against oxidation. Where flexible packages are required for products such as cheese, dried fruit, coffee etc. and the shelf-life is relatively short, laminates of plastics films without aluminium foil may be used e.g. moisture-proof coated cellulose film laminated to polyethylene, where the gas barrier is provided by the cellulose and the polyethylene layer provides a positive heat seal and enhances moisture resistance.

3.0  PACKAGING OF NON FAT DRY MILK (NFDM)

A suitable container for dry milk should be impervious to moisture, light, gases and insects; should be durable for handling, resistant to corrosions, of low cost; and be relatively easy to fill, seal, handle and empty. The retail package should have a reclosable opening. Non fat dry milk for industrial use and storage may be packaged in barrels, drums and bags or for retail purposes in metal cans, glass jars, or cartons. NFDM in domestic commercial trade is commonly packaged in polyethylene bags inside a 4-ply Kraft paper bag. The outside layer is usually plain, but a crinkled type is available. Freezing, high temperature, and low humidity during storage of bags cause them to become brittle and thus damage more readily in handling. Manual filling of the bags is most commonly completed by means of a simple device attached to the sifter. Automatic dispensing machines are readily available to dispense to correct weight of powder in one bag before shifting the product flow into the next bag. Bags are sewn 3 to 3.5 stitches per inch automatically or by a manually operated sewing machine suspended and counterbalanced within easy reach of the filling area. After closing, the bags are usually stacked on pallets.

3.1  Bulk bins

Portable bulk bins may be used to hold NFDM a few days prior to usage in the plant. These bins are often used as a container for shipment to industrial users. The bins are fabricated from different metals or alloys including stainless steel. Aluminium is most often used by the dry milk industry, costing about one-half as much and being lighter than those made from stainless steel. The advantages are mainly in reduction of labour and bag costs with possibly a reduction in dust problem. Automatic conveying equipment is available to fill a group of these bins, each in succession when properly positioned. They are airtight and can be stacked. The bins are emptied into a hopper by elevating and tilting the product flow, or by inversion to allow the product to flow through an iris-type outlet valve.

3.2  Retail carton

Cartons of fiberboard, foil and plastics have largely supplanted glass and metal as retail containers. Because of hygroscopic nature of dried milk, the packaging materials must provide a good vapour barrier. Of several types in use, one is a fibreboard carton with an over wrap of foil laminate to paper. Another consists of a fibreboard carton with
an inner liner of foil laminated to paper. A polyethylene bag inside the fibreboard carton is also used. Other combinations of layers of polyethylene, foil, and paper either in liner or over wrap are available for packaging.

4.0 PACKAGING OF WHOLE MILK POWDER (WMP)

The average production conditions and normal market periods for export and retail sales necessitate gas packaging of dry whole milk to delay oxidative changes. Its rapid flavour deterioration due to oxidation necessitates inhibitory measures. One of these consists of packaging the product with low oxygen content. The general procedure is to immediately remove oxygen by subjecting the product to 28” of vacuum within 24 hours of drying with final packaging within a few days. The specific procedure selected for gas packaging is governed by final oxygen limit desired in the package, and by the equipment-filling rate in relation to oxygen evacuation rate. Oxygen desorption of WMP is slow, principally due to entrapped air in the lactose. The amount of entrapped air is influenced by content in the concentrate, spraying pressure, orifice size, and temperature and treatment of concentrate. Less than 2% final oxygen in the headspace gas of the package is considered satisfactory for most storage conditions. Good quality WMP with a low oxygen content can be expected to withstand room temperature storage for 6 months or more without an oxidized off-flavour.

To obtain a low level of headspace oxygen in WMP, a double gassing technique is applied. The customary procedure is the collection of filled cans on trays to be conveyed into the vacuum chamber. The air is removed rapidly (60 seconds) with the gauge indicator decreasing to 29” of vacuum. After a 2 to 5 min hold, the pressure is restored with nitrogen to 0.5 to 1.0 psi above atmospheric pressure. Nitrogen may be replaced with a mixture of nitrogen and CO2, the latter being restricted to 5 to 20%. After removal from the chamber, the containers are sealed by soldering 1 to 2 mm hole in the lid or crimping on the lid. The containers are held for oxygen desorption. When an oxygen equilibrium has been attained in the head-space, usually within a week but at the most ten days, the cans are punctured and the vacuum treatment, pressure restored with nitrogen, and sealing steps are repeated.

Gas packaging of WMP should not be delayed after drying. Otherwise quality deteriorates during the holding period. Warm powder directly from the drier tends to have a more rapid rate of oxygen desorption under vacuum.

5.0 CONCLUSIONS

Chemical changes in dehydrated milk products cause staleness, oxidized flavour, hydrolytic rancidity, and insolvibility to an extent influenced by the processing treatments, moisture content, free oxygen levels within the container, and storage temperature. The exact causes and chemical reactions involved in powder deterioration are complex and partly obscure. However, the keeping quality of dried milk products can be enhanced to a great extent by proper packaging. The type of packaging material used will depend on its cost, barrier properties and convenience, besides functionality.
5.0 REFERENCES

ROLE OF SENSORY EVALUATION IN SELECTION OF PACKAGING MATERIALS FOR DAIRY PRODUCTS

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1.0 INTRODUCTION

The choice of packaging materials depends on properties, such as water vapour transmission rate, oxygen transmission rate, reliability and heat processing compatibilities that eventually influence the microbiological, biochemical and sensory changes in the product during storage. Sensory quality of foods not only includes taste and aroma, but also the aesthetics and appeal. The shelf life of the food though influenced by many factors like quality of raw materials, processing, packaging, distribution / storage, climatic conditions and nature of product, good packaging in present competitiveness of world has emerged as a corporate priority and a resource for organisational image and profit contributor.

An array of spectacular range of packaging materials and systems are available for a variety of food / dairy products. Newer packaging systems such as aseptic and retort packaging, vacuum packaging, bag-in-box and lined carton systems, MAP / CAP, shrink wrapping and stretch wrapping etc are gaining popularity. Often the cost of modern packaging materials and the systems is very high, sometimes even greater than the cost of food product itself, and also all of these materials and systems are not suitable for all range of products. Hence sensory evaluation is used as an important tool to select the cheap and most appropriate packaging for a food commodity.

2.0 CHANGES IN PACKAGED FOOD PRODUCTS DURING STORAGE

Food products during storage normally may undergo the following changes:

- Loss of aesthetics and appeal of the package/container (label, instructions, etc)
- Leakage and spillage of product
- Spoilage by bacterial / enzymatic / biochemical action
- Loss of sensory properties (flavour, colour, texture, appearance etc)
- Physicals changes such as loss or gain of moisture, resulting into surface hardening, caking etc
- Permeation of oxygen resulting into lipid oxidation, oxidation of pigments leading to flavour and texture changes
- Invasion of insects to the packaged food.
- Absorption of foreign flavour by the food from storage environment
- Interaction of packaging material with food product resulting into undesirable flavour
- Staling of product
- Deformation of shape and design of package, and body texture of product.
The use of sensory evaluation techniques is indispensable in detecting all these changes, even though the instrumentation and chemical tests are used for determining some of these problems. Sensory evaluation is one of the simplest analytical tools for monitoring changes in package itself and the food quality at all stages starting from procurement, processing and packaging till it reaches the consumer.

3.0 ROLE OF SENSORY EVALUATION

The sensory evaluation is defined as a scientific discipline used to evoke, measure, analyse and interpret the results of those characteristics of foods and materials as they are perceived by the senses of sight smell, taste, touch and hearing. The first consideration in purchasing a food starts with examining the type of package in terms of its tamper proofness, reliability (no leaks/spillages etc), cleanliness, attractiveness (colour combination), and printability (proper labeling for manufacture and expiry dates, contents, using directions etc) which are made through sight check. Detection of defective package before filling product into it is very important so that they may not reach the production line and could be achieved through sight. The colour of the food product is no less important than flavour and texture as far as consumer’s preference is concerned and the quickest method to examine it in relation to effect of packaging is by sensory technique. Similarly, all other attributes of a food product influenced by the type of package are evaluated adopting sensory methods. The advantages of sensory evaluation over the other methods, viz. physical, chemical and instrumental as suggested by Nakayama and Wessman (1979) are as given below:

- It identifies the presence or absence of perceptible differences.
- The important sensory characteristics are measured in a fast and quantifiable manner.
- It quickly identifies a particular problem that cannot be detected by other analytical procedures.

The sensory evaluation procedures have been studied in considerable detail with the result that this scientific discipline has come to be recognized as fairly objective in nature (Lamond, 1987). Various workers have used this analytical tool with great significance for selection of packaging materials for dairy/food products (Kumar and Srinivasan, 1982; Rajorhia and Pal, 1989).

The inherent variability of sensory evaluation by human subjects, who act as analytical tool/instrument, can be greatly overcome through appropriate selection and training procedures, coupled with application of statistical methods so as to take full advantage of the high sensitivity of human sense organs that even today surpass the most sophisticated instrumental means for flavour, texture and colour examination.

4.0 SENSORY EVALUATION PROCEDURES FOR SELECTING PACKAGING MATERIALS

A successful implementation of sensory evaluation programme for any purpose requires trained sensory panels, proper laboratory facilities and pre-use sensory methods. Pal et al. (1997; 1998) have reviewed these requirements for sensory evaluation of foods. The most important aspect of this R&D activity is to properly screen and select sensory panel members and train them rigorously for the job so that they can detect even the
The smallest difference/defect in the samples and can provide reproducible results. Most investigations have suggested specific tests based on:

- Discriminating differences between solutions or substances of known chemical composition
- Ability to recognize flavours and odours
- Performance in comparison with other panel members and
- Ability to discriminate differences in samples packaged in different types of the packaging materials.

The selected members are also trained in identification and/or quantification of desirable and undesirable attributes of the product and also the changes taking place in the food product, particularly during storage. While selecting suitable flexible package for a particular food product special attention is given to identify that the colour, taste and odour of the food are not affected by interaction between packaging material and food constituents. An inert packaging material such as glass bottles can be used for comparison and discrimination with the flexible films/pouches by packaging food product in them and examining the different sensory attributes.

A large number of sensory tests are available and new methods continue to develop. Stone and Sidel (1993) classified these tests into three categories viz., discriminative, descriptive and affective (acceptance/preference). Discriminative testing is the most useful and these tests not only discriminates between the samples but also indicate the direction and intensity of different attributes. Within the discriminative class of testing are a variety of specific method e.g. paired comparison, duo-trio, triangle, multiple sample and dual standard tests. A descriptive test involves relatively few subjects whose training is primarily focused on development of descriptive language, and some of the frequently used tests for food analysis under this category are: flavour profile, texture profile, QDA, scoring, etc. Affective and acceptance testing refers to measuring liking or preference of a product, and can measure directly by comparison of two or more product with each other, keeping in view their potential consumers.

5.0 REFERENCES
1.0 INTRODUCTION

India produces a wide range of tropical, sub-tropical and temperate horticultural crops by virtue of its varied agro-climatic conditions. The total annual production of fruits and vegetables is 144.0 million tonnes. India is the second largest producer of fruits and vegetables in the world. Fruits and vegetables are a major source of important valuable vitamins and minerals. They have got the status of protective foods. Being highly perishable, a sizeable amount of these crops go waste due to improper infrastructure in post harvest management. Therefore, they have to be preserved and processed during market glut season or from extra seasonal produce of kitchen garden for later use.

2.0 MAJOR CAUSES OF SPOILAGE OF FRUITS AND VEGETABLES

1. Microbiological
2. Enzymatic
3. Chemical
4. Others (Insects, rodents etc.)

2.1 Importance of Preservation

- To prevent or delay microbial decomposition and self decomposition
- To make the preserved products more palatable
- To process into various products having innovative and pragmatic approach
- To increase their storage life and shelf life
- To check contamination

2.2 Commercial Methods of Preservation

The modern methods of preservation of fruits and vegetables can be classified into four main type (Table1), which are as follows:
1. Physical methods
2. Chemical methods
3. Fermentation
4. Other methods
TABLE 1: Methods of preservation for fruits and vegetables

<table>
<thead>
<tr>
<th>Physical Methods</th>
<th>Chemical Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal processing</td>
<td>Pasteurization, Sterilization, Aseptic processing and packaging</td>
</tr>
<tr>
<td>Storage at low temperatures</td>
<td>Refrigeration, Freezing dehydrofreezing</td>
</tr>
<tr>
<td>Removal of water (evaporation or dehydration)</td>
<td>Sun-drying dehydration, Freeze-drying, concentration</td>
</tr>
<tr>
<td>Irradiation</td>
<td>Application of U.V. or ionizing radiation</td>
</tr>
<tr>
<td>Other means</td>
<td>Carbonation, High pressure, etc.</td>
</tr>
</tbody>
</table>

**Physical Methods**

| Thermal processing | Pasteurization, Sterilization, Aseptic processing and packaging |
| Storage at low temperatures | Refrigeration, Freezing dehydrofreezing |
| Removal of water (evaporation or dehydration) | Sun-drying dehydration, Freeze-drying, concentration |
| Irradiation | Application of U.V. or ionizing radiation |
| Other means | Carbonation, High pressure, etc. |

**Chemical Methods**

| Addition of acid | Pickled vegetables |
| Salting or brining | Vegetable/fruit pickles, lactic acid fermentation |
| Addition of sugar and acid | Fruit preservation, jam, jellies, marmalades, candies, etc. |
| Addition of chemical preservatives | Sodium benzoate (benzoic acid), Potassium metabisulphite (Sulphur dioxide) |

**Fermentation**

| Alcohol and acetic fermentation-fruits wines, apple cider, vinegar, etc. |

**Other Methods**

A judicious combination of one or more than one methods mentioned above for synergistic preservation

The non-thermal methods for preservation of fruits and vegetables and their packaging are.

1) Refrigerated storage
2) Controlled atmosphere storage (CA)
3) Freezing by various means
4) Irradiation
5) Fermentation
6) Chemical preservation
7) Pickling

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8) Carbonation  
9) High pressure  
10) Preservation by high concentration of sugar and acid  
11) Pulsed light processing and  
12) Minimal processing.

3.0 FOOD PACKAGING

Packaging can be defined as a mean of providing protection to the product, in order to ensure safe delivery from the place of production to the point of sale to the consumer. The main functions of packaging are protection of the content from physical, chemical and biological damage during processing, storage, distribution and display. It can also play a role in promoting sale. In our country nationwide outburst of processed foods is necessitating improved and dependable packaging that can withstand wide variations in climatic conditions. This is also a medium of communication as it provides identity and information of the product and motivates the consumer to buy. In India, the last decade has seen considerable developments within the country relating to packaging materials and packaging of different food products. The demand for convenience, the need of the ready-to-cook and ready to eat packaged foods is constantly rising. At the same time the consumer is showing greater awareness towards food packaging, for quality and quantitative assurance and also for hygienic environment for the food products.

3.1 Packaging of Processed Foods

For preserved fruits and vegetables, metal cans, laminate pouches, glass bottles, plastic containers and jars for consumer packs and paper-board for boxes and cartons for outer packing and for transportation, the wooden pellets are used. For packaging of processed and preserved foods, the industry offers a wide range of packaging materials for different types of products. Many factors must be considered while choosing the packaging, such as shelf life, type of processed products, period of storage, mechanical strength of package, machine energy consumption and raw material availability. For consumer packs the choice between metal cans and glass jars is another consideration.

Different materials used in food packaging are:

1. Plastics: Low density polyethylene (LDPE), High density polyethylene (HDPE), Polypropylene (PP), Poly vinyl chloride (PVC), Polyvinylidene chloride (PVdC or cryovac), Polyester (PET), Laminates, Coextruded films  
2. Tinplate Can  
3. Tin free Steel Can (TFS)  
4. Aluminium Can  
5. Glass Containers  
6. Retortable Pouches  
7. Aseptic Packaging
TABLE 2: Film properties of common RTE food packaging materials

A. Barrier Properties of Various Materials.

<table>
<thead>
<tr>
<th>Stock (1 mm)</th>
<th>MVTR</th>
<th>OTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyethylene (PE)</td>
<td>1.2</td>
<td>250-840.0</td>
</tr>
<tr>
<td>Cellophane</td>
<td>0.5</td>
<td>2.0</td>
</tr>
<tr>
<td>Oriented Polypropylene (OPP)</td>
<td>0.4</td>
<td>150.0</td>
</tr>
<tr>
<td>Polyester (PET)</td>
<td>1.3</td>
<td>5.0</td>
</tr>
<tr>
<td>Nylon</td>
<td>25.0</td>
<td>2.6</td>
</tr>
<tr>
<td>Foil</td>
<td>0.007</td>
<td>0.004</td>
</tr>
</tbody>
</table>

B. Effect of Lamination onto 1 mm OPP

<table>
<thead>
<tr>
<th>Laminate</th>
<th>MVTR</th>
<th>OTR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base OPP</td>
<td>0.4</td>
<td>150.0</td>
</tr>
<tr>
<td>+Saran</td>
<td>0.35</td>
<td>2.0</td>
</tr>
<tr>
<td>+Polyvinyl alcohol (PVA)</td>
<td>0.38</td>
<td>0.1</td>
</tr>
<tr>
<td>+Polyvinylidene chloride (PVdC)</td>
<td>0.18</td>
<td>0.3</td>
</tr>
<tr>
<td>+Metalized</td>
<td>0.1</td>
<td>3.0</td>
</tr>
</tbody>
</table>

MVTR: Moisture vapour transmission rate as the number of grams of water transferred across a piece of film (100 in² area) at 38º C.

OTR: Oxygen transmission rate that measures the volume in cubic centimeters (CC) of oxygen transferred at across a piece of liner (100 in² area) at 24º C.

4.0 SUGGESTED READINGS


1.0 INTRODUCTION

The last two decades of the twentieth century have seen a tremendous growth in the field of Food Packaging globally. Similar kind of growth started in India almost at the same time. The population of our country has made the demand steeper. The packaging of food demands a valuable contribution and responsibility from all the partners involved in the packaging industry to reach the safely packed food to such a large population. The mixed economy of the country on one hand makes it essential that the cost of the package should be economical, otherwise the packed food items shall never reach the larger section of our society, which is still below the poverty line, and on the other hand Health and Safety criteria are of top most priority. Even the printing inks are an essential part of any package. Let us work over a safer, hygienic and better packet of food to the present as well as our next generation.

2.0 PACKAGING FOR DRIED FRUITS AND VEGETABLES

Packaging is an integral part of processing. It provides a barrier between the food and the environment. It controls light transmission, the transfer of heat, moisture and gas, and movement of microorganisms or insects. The shelf life of a dehydrated product is influenced to a large extent by the packaging, which must conform to certain special criteria. These are:

- Protection of the dehydrated product against moisture, light, air, dust microflora, foreign odour rodent etc.
- Strength and stability to maintain original container properties through storage, handling and marketing.
- Size, shape, appearance to promote stability of the product.
- Composition of the container must be approved for use in contact with foods.
- Cost must be acceptable.
3.0 TYPES OF CONTAINER

3.1 Retail containers (Consumer unit): They protect and advertise the food in convenient quantities for retail sale and domestic storage. They may be in form of small pouch of LDPE, HDPE, bottles etc.

3.2 Shipping containers: They contain and protect the retail containers during transport and distribution. These includes (i) Wooden boxes; (ii) Metal cans; (iii) Fibre board boxes; (iv) Plastic crates; (v) Barrels; (vi) Drums; (vii) Sacks etc.

4.0 PACKAGING MATERIALS FOR PROCESSING INDUSTRY

A large variety of packaging material that is generally used by modern food processing industries can be classified into following groups.

i. Textiles and wooden boxes.
ii. Metal cans
iii. Glass containers/bottles/jars
iv. Paper and fibre board
v. Flexible films

4.1 Single films: Cellulose, polypropylene, polyester, polyethylene, polyvinylidene chloride, polystyrene, etc.

4.2 Coated films: These films are coated with other polymers or aluminum to improve the barrier properties or to impart heat sealability.

4.3 Laminated films: Lamination of 2 or more films improves the appearance, barrier properties or mechanical strength.

4.4 Co-extruded films: Simultaneous extrusion of 2 or more layers of different films.

4.5 Rigid and semi-rigid materials: Such as trays, bottles and jars, are made from single or co-extruded polymers. They have greater corrosion resistance, less weight more tough, unbreakable and lower cost as compared to glass or metal.

5.0 PRECAUTIONS BEFORE PACKAGING

5.1 Protection against moisture pick up: The low moisture products must be packaged as soon as possible after removal from the dehydrator. Each product has its individual need with regard to moisture uptake. Dehydrated apricots, figs, raisins, prunes etc. require very little protection than others, if the product is packed in a flexible package having high resistance to moisture. Smaller sized packs of dehydrated vegetables are packed in heat sealable laminates consisting of polyethylene, aluminium foil and paper. Large sized packs of dehydrated vegetable are packed with calcium oxide or silica gel as an “in package desiccant”. The in-package desiccant has high absorption capacity at very low moisture levels. Hence allows sufficient space in the pouch containing the desiccants.
for the expansion of the desiccant, as otherwise, the pouch may burst and contaminate the product.

5.1.1 In-package desiccation: In-package desiccation has been used successfully for many dried fruit products, particularly powders. The desiccant compound is placed in the container inside a small envelop made out of a moisture permeable material which does not allow the contamination of the product with desiccant. Calcium oxide or silica gel are usually used for this purpose. When in package desiccant is used, the dried product can be stored at higher moisture content without caking than in the absence of a desiccant.

5.2 Anticaking agents: To ensure the free flowing property of fruit powders, particularly those high in sugar content such as figs, dates and apple powders, anticaking agents are mixed with the low moisture product usually during the milling operation. Calcium stearate is the most commonly used anticaking agent in dehydrated products. It is mixed with the fruit powders at a rate of approximately 0.25-0.50%.

6.0 SELECTION OF PACKAGING MATERIALS

Dehydrated fruits and vegetables are hygroscopic and absorption of a small amount of water decreases the shelf life considerably. Hence, the permeability of the package towards water vapour is the most important property to be considered for such products. When retention of low moisture content is the limiting factor of the shelf life of the product, the tests required to be made for determining the shelf life are: determination of

- the normal moisture content of the product
- the moisture contact of the product at which the product becomes unacceptable to the consumer and
- the R.H. and temperature of the surrounding atmosphere at which the equilibrium moisture content is maintained in the product.

The critical moisture content at which the product becomes unacceptable and the equilibrium moisture content established from the sorption isotherm of the product is calculated. From the sorption isotherm, the amount of water vapour that would have to pass through the walls of the package to change the moisture content from the initial level to the level of unacceptability is calculated. From this data along with requirement for gas permeability etc. and the published data for different packaging material, the suitable packing material is selected. The product is packed in the selected packaging material stored under controlled conditions of temperature and R.H. and examined periodically for moisture uptake and acceptability.
Table  Water vapour and gas transmissions x 10^2 of various material in CC (NATP cm^2/ sec/cm Hg at 25°C)

<table>
<thead>
<tr>
<th>Material</th>
<th>Water Vapour</th>
<th>CO₂</th>
<th>O₂</th>
<th>N₂</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Polyethylene (density 0.922)</td>
<td>420</td>
<td>210</td>
<td>140</td>
<td>55</td>
</tr>
<tr>
<td>Polyethylene (density 0.954)</td>
<td>60</td>
<td>30</td>
<td>20</td>
<td>13</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>160</td>
<td>80</td>
<td>53</td>
<td>12</td>
</tr>
<tr>
<td>PVC</td>
<td>630</td>
<td>320</td>
<td>210</td>
<td>0.4</td>
</tr>
<tr>
<td>Polystyrene</td>
<td>4700</td>
<td>2400</td>
<td>1600</td>
<td>2778</td>
</tr>
<tr>
<td>Polyester</td>
<td>510</td>
<td>260</td>
<td>170</td>
<td>0.5</td>
</tr>
</tbody>
</table>

7.0 SUGGESTED READINGS

CIFT 1999. Proceedings of the seminar on food packaging and environmental protection; Consumer choice, Background paper. Confederation of Indian Food Trade & Industry, Federation House, Tansen Marg New Delhi


1.0 INTRODUCTION:
A package intended for sugar and chocolate confectionery has to perform several functions during distribution, storage and sales. Essentially, the package has to preserve the quality attributes of the product and afford protection against chemical and microbiological deteriorative reactions. For sugar confectionery items and chocolates, the major functional packaging requirements include protection from:

a) Dust, dirt and other contaminating agents
b) Moisture/water vapour pickup or loss resulting in sugar and fat bloom, stickiness, hardening and desiccation.
c) Rancidity due to interaction with moisture and oxygen.
d) Colour and aroma loss and tainting.
e) Physical damages like dusting, breakage and loss of shape.

In addition to the above, the packaging material should be amenable to run well on machines, should be hygienic and do not cause any health problem. Currently the major addressable problem is that it should be eco-friendly and easy to use and dispose-off.

2.0 PACKAGE FORMS:

Consumer unit packages: Flexible packages
                   Semi-rigid packages
                   Rigid containers.

Shipping/bulk containers: Conventional bags, sacks and boxes.
                   Corrugated fibreboard boxes.

2.1 Consumer Unit Packages
2.1.1 Flexible packages:

The basic styles of flexible pouch/bag used to contain sugar confections and chocolates are – flat and pillow type, satchel bottom, gusseted and stand-up types. The materials of construction comprise functional papers, plastics, aluminium foils, metallised films and composites of these materials.

Although conventionally, different kinds of papers such as Poster, grease-proof and glassine, vegetable parchment and even sometimes news-paper are used for making bags, newer materials include polyolefins, polyethylene terephthalate (PET or polyester), polyamide (Nylon), aluminium metallised plastic films and co-extruded structures are being increasingly used.
Since polyester, polyamide and metallised films (PET, PP and PA) films possess very good barrier properties towards oxygen and aromas, but unsupported, do not provide good heat-seals. They are generally combined with polyethylene and its modifications to provide sealability and inertness.

Recent developments in the flexible packaging field is the availability of co-extruded structures. A most common combination suitable for sugar confectioneries is an outer polyethylene – Low-density or linear low density (LDPE or LLDPE), core or middle layer of polyamide (Nylon-6) or ethylene-vinyl alcohol (EVOH) copolymer and inner or contact layer of Ionomer or Ethylene-Acrylic Acid (EAA) copolymer film. The properties of EVOH films that are relevant to packaging are indicated in Table 1.

To enhance the shelf life of the products, either vacuum or gas packaging can be resorted to. The former technique is suitable for packing sweets having rigid structure such as sohan papdi and Mysore pak, while gas packaging is better suited for softer confections. For these applications, materials such as plain and metallised PET with PE, or copolymer of HD-LDPE, Nylon and EVOH based co-extruded films and polyvinylide chloride (PVdC) copolymer, coated PP would be the better choice.

2.1.2. Semi-rigid containers:

These comprise folding cartons, set-up boxes, lined-folding cartons and thermoformed containers.

Collapsible folding cartons of tray-type with coated or laminated paperboard base are extensively used to package dairy food-based sugar confections. These cartons with outer embellishments are best suited for gift and display applications. The liner material may be PE-wax-EVA blends or PVC or PET films. Set-up boxes of either half or full-telescopic type having inner glassine liner are economical and provide good physical and mechanical protection.

Lined folding cartons system is of bag-in-box type where an inner pouch is lined (fixed) to the outer paperboard carton. The selection of the material of the pouch is decided by the functions required, economics and marketing requirements. Materials such as paper/PE, PET/PE, paper/Al-foil/PE and the almost ultimate choice, PET/Al-foil/PE are used in LPC’s. Provisions for reclosing, reduction of headspace volume and such features can be incorporated.

Thermoformed containers include blister packs, single and multi-cavity trays, thin-walled containers with lids etc. These are produced by the process of thermoforming by vacuum, pressure or matched techniques. For packing sweets, thermoformed tray type containers are better suited. For multi-coating trays, the number, shape and size of cavities is determined by the product to be packed. Such trays are useful when a number of similar or assorted items are packed.

2.1.3 Eco-friendly packages:

Bio-containers or eco-friendly packages based on natural materials such as leaves of banana, Butea and Bauhinia as well as Areca spathe can also be used to contain and distribute sugar-based confectioneries. The processes developed by CFTRI to manufacture these involve only heat-treatment without recourse to any additional adhesive or chemical treatments.

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15th CAS Course on “Advances in Packaging of Dairy and Food Products” (13th Feb to 5th Mar 2003) NDRI, Karnal
2.1.4 Rigid packaging systems:

Among the metal containers, the conventional OTS cans of A 2½ size are being used to process rasagolla and gulab jamun in syrup. Tinplate cans are available in various standard sizes. For flat sweets, 3-oz dingley-type cans are preferred. For gas flushing applications, formed cans with aluminium taggu top are used. Newer metal containers include differentially coated cans, chromium coated (Tin-free-steel) cans. The provision of ring-pull ends (Easy-open-end; EOE) facilitates easy opening for consumers.

Aluminium containers are made by different techniques. These are available in circular, oval, rectangular or any fancy shapes and can be decorated in an unlimited range of design and colour variations. EOE ends with reclosable polyethylene lids are finding greater applications for sugar and dairy products.

2.1.5 Composite containers: These are made of paperboard body and metal or plastic ends. The container body may either be spirally or convolutely wound with fibreboard lined with aluminium foil and/or plasters. Composite can having a body material of 25 μm PE/Paper-board/0.009 mm aluminium foil/37 μm LDPE with a water vapour transmission rate in the range of 0.003 g/24 h at 38°C/90% RH are well suited to package sweet meats.

2.2 Shipping containers:

Corrugated fibreboard boxes (CFB) are being employed as exterior containers for packing unit packs both for inland and export markets. They can be used up to a maximum weight of contents of 75 kg. The BIS specifies, depending on the maxima of mass of contents:

a) Maximum combined internal dimensions (LxWxD),
b) Minimum bursting strength of the boards
c) Combined liner grammage
d) Moisture absorptiveness value (Cobb value).

The style of the box is decided by the contents, protection required and marketing destinations.

3.0 PACKAGING AND STORAGE STUDIES:

For designing packages, the primary requisite is the knowledge of relationship between moisture content and equilibrium relative humidity (ERH) (and hence water activity) denoted through moisture sorption isotherm. This is indicated in Figure 1 for the 3 main categories of sugar confections. Also indicated for comparison, is the moisture adsorption characteristic of crystalline and amorphous sucrose. The (ERH) a_w of different types of confections are given in Table 2.

Packaging and storage studies carried out on sugar foods are indicated in Chart No. 1.
Developments in the packaging of sugar and chocolate confectionery

3.1 Sohan papdi: This confection which normally has a shelf-life of about 12 days with critical moisture content of 3% corresponding to 0.3 water activity at 27°C. Chemical and sensory analysis carried out on BHA-treated packed product has indicated that the product could be stored well for 20 days in PET/PE, 120 days in HDPE and 225 days in paper/foil/PE pouches and rigid metal container.

3.2 Sohan halwa: This product with permissible moisture pick up of 1.7 percent and stored at normal environmental conditions has revealed storage life of 30 days in LDPE, 120 days in HDPE and 180 days in foil-laminate pouches. The shelf life has also been determined in package of tagger-top tinplate containers.

3.3 Milk pedha: Studies on buffalo milk pedha with preservative at two concentrations were carried out. Sample containing 0.002% sorbic acid extended the storage up to 9 days at 30°C/70% RH and 37 days at 7°C/90% RH conditions. Sorbic acid added at 0.05% was effective against chemical and microbiological deterioration up to 50 days at 7°C. Milk pedha, having 0.84 water activity or 14.0% moisture packed in laminates pouches of PET/PE and PET/foil/PE and co-extruded LLDPE/PA/EAA has indicated that ambient-air packaging did not extend the shelf-life. Usage of free-oxygen absorber sachets extended the life up to 42 days.

Extensive studies have been carried out on hard-boiled sweets, toffees and chocolates on moisture sorption characteristics. Packaging and storage studies have revealed that sucrose in amorphous state in hard boilings have critical moisture content in the region of 1.2 to 1.5%. Modified and plain toffees had higher critical values, which was in the region of 4-6%. Plain and milk chocolates having moisture contents of 0.7% and 1.33% respectively, equilibrating to 0.64 water activity was found to be critical with respect to maintenance of good colour, aroma and texture, as shown in chart No. 2.
Table 1: Properties of Ethylene-vinyl alcohol film grades

<table>
<thead>
<tr>
<th>Property</th>
<th>Unit</th>
<th>EVAL Grade</th>
<th>BOPA</th>
<th>PVDC/BOPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
<td>Mm</td>
<td>15/15/20</td>
<td>15/22.5</td>
<td></td>
</tr>
<tr>
<td>Tensile strength</td>
<td>kPa</td>
<td>204.6/195.0/79.9/52.0</td>
<td>215.6/161.6</td>
<td>214.9/165.4</td>
</tr>
<tr>
<td>Elongation</td>
<td>%</td>
<td>100/100/260/180</td>
<td>90/140</td>
<td>90/140</td>
</tr>
<tr>
<td>Tear strength</td>
<td></td>
<td>260/330</td>
<td>380/300</td>
<td>460/440</td>
</tr>
<tr>
<td>WVTR</td>
<td>g/m².24h@40°C/90%RH</td>
<td>40.3/100.7/65.6</td>
<td>260/4.6</td>
<td></td>
</tr>
<tr>
<td>OTR at</td>
<td>ml/m².24h atm @20°C</td>
<td>0.15/0.62/35.65</td>
<td>0.31/1.24/15.50</td>
<td>1.24/2.64/8.06</td>
</tr>
</tbody>
</table>

CHART No. 2 - MOISTURE SORPTION ISOTHERMS OF SUGAR CONFECTIONS
Table 2: Equilibrium Relative Humidity of Sugar Confectionery:

<table>
<thead>
<tr>
<th>Type of confection</th>
<th>Type of deterioration</th>
<th>ERH(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiled sweets, Toffees</td>
<td>Stickiness, graining</td>
<td>&lt;30</td>
</tr>
<tr>
<td>Gums and pastilles</td>
<td>Stickiness, microbial growth</td>
<td>65</td>
</tr>
<tr>
<td>Liquorice paste goods</td>
<td>Stickiness, microbial growth</td>
<td>55-65</td>
</tr>
<tr>
<td>Turkish delight</td>
<td>Stickiness, microbial growth</td>
<td>60-70</td>
</tr>
<tr>
<td>Marzipan</td>
<td>Drying out, microbial growth</td>
<td>70-85</td>
</tr>
<tr>
<td>Fondant cream and jam</td>
<td>Drying out, microbial growth</td>
<td>75-85</td>
</tr>
<tr>
<td>Milk chocolate</td>
<td>Sugar bloom, syrup formation</td>
<td>~ 80</td>
</tr>
<tr>
<td>Plain chocolate</td>
<td>Sugar bloom, syrup formation</td>
<td>~ 85</td>
</tr>
<tr>
<td>Traditional confections (Sohan</td>
<td>Rancidification, microbial growth</td>
<td>15-20</td>
</tr>
<tr>
<td>papri, Mysore pak)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk products (Khoa, pedha)</td>
<td>Sugar bloom, browning, mould growth</td>
<td>80-85</td>
</tr>
</tbody>
</table>

4.0 REFERENCES:


K. R. Kumar


1.0 INTRODUCTION

Consumer preferences and new technological innovations have always been the major forces that herd change in the food industry. In the past century particularly, the increase in population, urbanization, education, life spans and communication drove the food industry to be large-scale and health-conscious, with safety, attractiveness and convenience of foods being the forerunner of technological transformations. Along with the concept of eating healthy foods to balance the declining medical system, there emerged a need for convenience foods that nourish, heal and fortify. Shifting consumer preferences toward ready-to-cook meals, specialty foods, and convenience foods have placed new demands on the food packaging industry. Food processors look for longer shelf life, attractive packaging, and new materials for novel preparation methods such as microwaving, ohmic heating, aseptic processing for particulates, high-pressure processing and high-pressure extrusion. At the same time, increasing emphasis is being placed on reducing the amount of packaging used, a response to the public’s environmental concerns and government regulations that have targeted a 50 per cent staged reduction in packaging waste by the year 2005. These changes translate into a wide range of business opportunities for innovative approaches and solutions in the design and manufacture of packaging, processing and labeling equipment, and for new materials.

2.0 CONVENIENCE FOODS: DEFINITION

Convenience foods may be defined as foods, which are referred to as second-generation foods, either because of preparation, packaging, or a combination of both. The foods are fully prepared by a food processor before packaging, distribution and sales, and are ready-to-heat or ready-to-eat either cold or at room temperature. They may be a whole new food idea like a frozen stuffed sandwich, or a familiar canned item like sliced fruit but in a small plastic cup or aluminum can with easy open lid. The prepared foods of interest include quick cooking frozen, chilled/refrigerated shelf-stable foods in a variety of packages that require different cooking methods, as well as these three food types marketed in microwave-only packages. Further definitions for consumer cooking methods include packages that require foods to be removed before microwave or conventional cooking, dual ovenable packages for microwave and conventional ovens, cook able packages for microwave and stovetop cooking, packages for microwave cooking, or packages that require no heating/cooking for foods.
3.0 PERSPECTIVES ON PACKAGING OF CONVENIENCE FOODS

Snacks and convenience foods have a relatively high packaging to product cost ratio and may be high value, premium products with opportunities for innovation and added value. Packages should have convenient features that make food preparation and serving easier, yet respect the environment by having fewer materials added to the waste stream. They should be recyclable or reusable. Along with these demands are the usual expectations that packages preserve food quality and resist any elements that could affect food safety.

Changes in packages have been made possible by improvements in food processing, package materials, and configurations. New food processing methods have produced the need for packages to become more heat-resistant, extend shelf life with little or no chemical preservatives, and improve the quality of foods. Improvements in package materials have enabled suppliers to develop packages that are Microwavable, cook-in/eat-in, stronger, lighter, simpler and safer to use, and more environmentally friendly. Moreover, material improvements have alleviated some problems created by the use of certain materials, such as off-flavors, off-aromas, and migration of chemicals, as well as deficits of microwave oven cooking. Improvements in package configurations allow the development of convenience features, such as lids that are easy to open, close, reclose, and reseal, single-serve packages for portion control, and lightweight packages for easy portability for consumption outside the home.

The prepared food packaging industry is composed of material suppliers and package converters of preformed packages. The packaging materials of concern are plastic, paperboard, glass, steel, and aluminum cans. For some packages, food processors can choose between buying preformed packages or buying the materials and forming the package on-site at the food plant. This industry is a highly fragmented segment of the packaging industry, and is very competitive with many companies vying for their material or configuration to be the favored, generic choice of the majority of food processors. Most companies confine themselves to supplying just one type of material that can be used for one or more food types.

4.0 PACKAGING TRENDS

Convenience foods encompass a wide range of products from snacks to complete meals and from salads to dairy products. Packaging in this sector is now no longer simply a means of providing damage protection or sales promotion but must provide functionality and product enhancement. Packaging functionality is becoming a point of differentiation in product choice with easy open and reclose features expanding in popularity. Pasta, rice and sugar are now equipped with reseal labels and developments in form/fill/seal machinery that allow for in-line inclusion of zip closures within the bag structure. Convenience in the produce sector has boomed with the growth of pre-prepared salads, vegetables and fruit. Modified atmosphere packaging has provided a means of shelf life extension for a range of washed and
chopped salads and vegetables ready to eat. Inclusion of portion sized sachets of dressing with salads is now commonplace and recent research has shown that shelf life can be further extended by use of high oxygen and novel gas mixtures. In the search for natural alternatives that can lengthen shelf life without compromising a product’s quality, addition of alpha-tocopherol (vitamin E) during the production of plastic is a novel example. Although the present legislation does not permit its use, positive results will usher in changes in the right direction.

Ready meals are now experiencing a boom in the chilled sector where fresh, home prepared and ethnic varieties are offered in a range of ovenable and microwaveable containers. Complete meal packages have been designed to compete directly with take-away options equipped with snack, main meal and beverage. Combination packs combining meat and cook-in sauces are targeted at those who still like a degree of preparation, following the development of hot fill polypropylene bottles. Ready prepared sauces are also seeing growth with new cooking and cuisine options lining the shelves. Shrink labeled glass bottles are popular in this area, enabling dual product offerings. Growth continues in frozen microwaveable meals with new designs and susceptor technology providing improved levels of crispness to items such as pies and pizzas. Single portion packs have been extended to those designed for school lunch packs. The multipacks of individually packed items such as cakes, biscuits and snacks are now being extended into non-traditional areas such as yoghurt and cheese. Flow-wrapped packs containing crackers, dips and drink are also offered.

Providing authenticity to foods, particularly to ready meals is one of the most important requirements of a packaging system. In this direction, a patented ‘Steamer Tray’ includes a perforated grille, with the liquid portion contained below the grille and the solid portion of the meal above. The steam and the microwave energy gently heat up the meal and preserve the high quality of the food. Another system (‘Dream Steam’) has a valve built into the film that seals the tray. When the heat in the tray generates a particular pressure, the valve opens and releases steam, maintaining the ideal pressure and heat inside the tray. This way of preparing food ensures improved and uniform quality, because of constant reheat conditions.

Convenience plays a dominant role in the lifestyles of children, as more mothers go out for work. The millions of such children between the ages of 6 and 11 in crèches and with baby-sitters greatly influence the way families eat and the way food is marketed. Convenience stores are also becoming a common alternative to the grocery store. Families are more often stopping at convenience stores to make quick food purchases rather than waiting in line at the supermarkets. During these stops, parents may give children the opportunity to purchase snacks. The convenience store has also become and after school hangout in which children spend their own money on food without the guidance of an adult. As a result, food is being marketed to children, with packaging designed especially for children, such as smaller containers and shatterproof materials.
4.1 Convenience vs. Safety

Increasing number of consumers want their foods to appear as minimally processed as possible owing to the negative connotation ‘processing’ has in relation to nutrients. Thus, convenience foods often seem like a recipe for disaster, being multiple-component, minimally processed low-acid products, placed in modified-atmosphere, reduced-oxygen packaging and shipped through a distribution chain that might not closely watch temperatures. Despite this, no major food-borne illness outbreak has been attributed to refrigerated-prepared foods (the convenience products of the 1990s) barring a few occasional, isolated incidents. Much of the credit is attributed to the efficient packaging systems of these foods. However, that is no reason for becoming complacent and quests to develop perfect processing systems should not be aborted.

The better food safety conditions may be owing to the more sophisticated means for detecting food pathogens. Biosensors that detect the presence of Salmonella, E. coli and other food-borne pathogens have sealed the safety environments more securely. The U.S. Food and Drug Administration recently approved pulsed-light as a food-pasteurization process. This technique kills surface microorganisms, but does not penetrate into the food. Consumer resistance to another approved process, irradiation, has continued to subside.

Besides these, there are Hazardous Analysis Critical Control Point (HACCP) programs, mandatory for meat and poultry and soon to be required for seafood. Processors of many other product categories should be following similar voluntary programs. For example, HACCP should be mandated for all chilled modified atmosphere packaging (MAP) foods.

5.0 SYNERGY BETWEEN FOOD PROCESSING AND PACKAGING

Since developing a 100% safe food processing technology is impossible, the R&D sector also can continue to rely on systems of hurdles, or barriers, to deter microbial growth and pathogenic production. Hurdles include such elements as temperature, water activity, presence of other inhibitors such as pH or salt, pasteurization and sterilization and packaging. When combined, these various elements frequently function in synergy, enhancing their overall effect.

The increasing popularity of modified atmosphere packaging underscores the importance of temperature. The use of modified atmosphere, which is effectively the reduction of oxygen concentration and, to some degree, the elevation of carbon dioxide, is intended to retard aerobic growth as well as maintain quality for longer periods of time. It is probably the best way to retard quality losses from prepared foods. However, as modified atmosphere will work only at reduced temperatures (greatest effect at −1.7°C and ineffective above 4.5°C) care must be taken to maintain such temperatures. If the temperature rises out of control, there are greater chances for Clostridium botulinum spores to grow under the anaerobic conditions provided. Also of concern are Listeria and Salmonella species that grow at temperatures as low as 0°C. Thus, centrally prepared, low-acid, ideal-for-microbial-growth food products...
such as mushroom soup and cheese sauce may be saved if packaged well and distributed at –0.6°C. Pouches are filled with pumpable food at 87.8°C, placed in tanks of ice water to drop the temperature in less than 30 minutes to 1.1°C, taken out and chilled to –0.6°C. With such processes, no food safety-related incidents have been reported. Thus for prepared foods to maintain their respectable safety record, controlled temperature distribution must be a priority, the responsibility being shared by the manufacturer through the warehouse officials and the truck driver to the consumer.

6.0 CONSUMER RESPONSES TO PACKAGING

According to a consumer research carried out in the US, consumers are tired of packs that make demands on their time and attention. Some packaging criteria that they expect are portability, product protection before and after opening, easy opening, product visibility, value for money, legibility, use-by dating, easy storability, environmental acceptability and waste reduction. Unnecessary packaging was a common complaint.

Research on accidents associated with packaging has highlighted many areas where improvements must be made. A particular feature of this research was the question of openability and reclosability and the special difficulties of older people, the young and the physically disadvantaged.

Consumers distrust environmental initiatives taken by retailers, believing them to be led by profit motives. This distrust leads to a lack of demand for ‘green’ goods and limits incentive for retailers to undertake environmental initiatives. Although consumers are becoming better informed about the problems of waste disposal, there is still a long way to go. Issues such as excess of recovered materials for reuse, problems of contaminated wastes, and what actually constitutes a renewable resource, are still largely misunderstood.

7.0 CONCLUSION

The whole dining experience has undergone a transformation, with the emphasis in many households shifting from cost to time as the premium asset. Foods, which meet consumers’ desire for convenience have seen enormous growth over recent years with innovation both in terms of product offering and pack design. Packaging functionality is becoming a point of differentiation in product choice. Consumer acceptance of new packaging concepts will continue to grow with the increasing pressures on eating and cooking time.

8.0 SUGGESTED READING

Modern Food Packaging. Compiled by: Dordi, M.C., Indian Institute of Packaging, E-2, MIDC Area, P.B. No.9432, Andheri (E), Mumbai – 400 093.
1.0 INTRODUCTION

Packaging of foods including meat, poultry and fish is done to protect them against contamination by dust, microorganisms, yeasts, moulds, toxic substances or those factors which influence taste, flavour and loss of moisture. Packaging should help to prevent spoilage, weight losses and enhance consumer acceptability of the product. Factors, which influence shelf life of muscle foods, may include both endogenous and exogenous factors besides sources of secondary contamination. The endogenous factors are pH, acidity and $a_w$ or moisture level, whereas the major exogenous factors include presence of atmospheric oxygen, microorganisms, temperature of storage, exposure to sunlight and evaporation or desiccation. Secondary contamination of muscle foods during slaughtering, carcass dressing, cutting and also processing cannot be avoided. Bacterial growth during storage therefore cannot be altogether prevented by mere use of packaging. However, secondary contamination of these foods from sources such as contact with dust, dirt and unclean hand can be certainly avoided to minimize or delay product deterioration.

2.0 PACKAGING MATERIALS FOR MUSCLE FOODS:

Packaging materials for meat, poultry and fish could either be monofilms or formed from two or more different films laminated together. These materials may differ in oxygen permeability, water vapour barrier, resistance to hot or cold temperature and mechanical strength. A high oxygen barrier is important in the application of films for packaging of meat and meat products. Films made of poly vinyl chloride (PVC), polyethylene (PE) or polypropylene (PP) have a relatively high oxygen permeability, whereas polyvinylidenechloride (PVDC), polyester (PETP), poly amide (PA) and cellulose film (ZG) are less or almost non-permeable to oxygen. Materials of the first group are generally used as laminate with materials of the second group so as to meet special requirements viz. mechanical strength, heat sealing properties or to make packages fully impermeable to oxygen and water vapour depending upon products’ requirements. The following table 1 enlists types and characteristics of packaging films used for muscle foods.
TABLE 1: Types and characteristics of film used for packaging of muscle foods

<table>
<thead>
<tr>
<th>FILM</th>
<th>CHARACTERISTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cellophane (100 grade)</td>
<td>Printable, heat sealable, flexible, oxygen impermeable</td>
</tr>
<tr>
<td>Cellulose acetate</td>
<td>$O_2 + CO_2$ permeable, oil resistant, not heat sealable, used for fresh sausages</td>
</tr>
<tr>
<td>LDPE derived ionomers</td>
<td>High strength, oil resistant, used for vacuum packages</td>
</tr>
<tr>
<td>Metallized films</td>
<td>Light + gas resistant, printable, tough, easily laminated into retort pouches, $O_3 + H_2O$ impermeable, very strong</td>
</tr>
<tr>
<td>Nylon</td>
<td>High temperature resistant, very impermeable to $O_2 + H_2O$, easily printable, tough.</td>
</tr>
<tr>
<td>Polybutylene terephthalate (PBT)</td>
<td>Good heat, tear, abrasion, chemical resistant, needs adhesive to seal, $O_2 + H_2O$ impermeable, used for retort pouches and laminates</td>
</tr>
<tr>
<td>Polyester</td>
<td>Oxygen permeability, easily sealed, moderate strength, poor grease resistant, or heat resistant.</td>
</tr>
<tr>
<td>Polyethylene-HDPE, LOPE, LLDPE</td>
<td>Stronger than PE, more heat resistant, more grease resistant</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>Readily processed, clear, oxygen permeable, not resistant to flex</td>
</tr>
<tr>
<td>Polystyrene</td>
<td>Very strong</td>
</tr>
<tr>
<td>Polyurethane</td>
<td>Very clear, heat stable and used as vacuum + heat shrink films</td>
</tr>
<tr>
<td>Polyvinylidene Chloride</td>
<td>Easily formed, easily sealed, strong, easily coated and printed</td>
</tr>
<tr>
<td>Polyvinylidene chloride with PP-Saran</td>
<td>Extremely low $H_2O$ permeable, resistant to chemicals, heat abrasion, tearing, oil and grease frequently used as a coating</td>
</tr>
</tbody>
</table>

3.0 PACKAGING OF MEAT

In general practice carcass and joints remain wrapped during transport from slaughterhouse and wholesale market to retail processor and outlets. Usually, they are covered with soft cotton and elasticated netting. Vacuum packaging is widely used for hot boned wholesale meat.

Now a days instead of whole carcass, the meat is “cut into primal cuts” which are intermediate between quarters and retail cuts. These prime and subprime cuts may be vacuum packaged in specialized barrier bags (e.g. Saran and Cryovac). However, unwrapped meat should be stored under refrigerated conditions. Temperature fluctuations must be carefully controlled to avoid loss of surface moisture and in such condition meat is stored in a thin high-density polyethylene (HDPE), which prevents leakage and wetting of other items. In supermarkets, packaged meat is an important item of commerce and maintenance of red colour and bloom of the meat is essential. So packaging film used for this purpose must have higher permeability to oxygen as well as good appearance, sealibility and low water vapour transpiration rate, to check loss of weight.
3.1 Vacuum packaging of meat

Vacuum packaging of meat is meant to retard or completely check the oxidative reactions. The complete removal of oxygen from the packaging environment substantially inhibits the growth of microorganisms. However vacuum packaging of meat often causes discoloration as meat becomes darker and purplish. On opening the package, oxygen availability at the surface of meat reverts its original red colour. As entrapped air will be there in foods small quantity of oxygen always remains inside the packaging bag. Oxidation of food can therefore be reduced by using materials of low oxygen permeability.

Production of slime by *pseudomonas sp.* at refrigerated temperatures spoil fresh meat. High bacterial population may also result in putrid flavour development. Lactic acid bacteria flourishes rapidly in vacuum packaged meat. These growths limit the shelf life of meat stored at refrigerated temperatures, as sourness develops. Puncturing of vacuum packages favour spoilage of meat. Hence packaging materials used in vacuum packaging of meat must have high resistance for gaseous exchange and water vapour along with perfect seal and excellent mechanical strength. LDPE derived ionomers possess high strength and oil resistance and are frequently used in vacuum packaging of fresh meat. Beef meat, having pH more than 5.8 is not suitable for vacuum packaging, as there is chances of the growth of *H₂S* producing bacteria and *H₂S* reacts with myoglobin to form a green coloured compound “sulphmyoglobin”. Pork and lamb though higher fat containing products are not vacuum packaged, as not much is known about their microbiology and shelf life. Lamb is expected to have shorter shelf life than beef as it has higher pH whereas pork may have a short shelf life as it is heavily contaminated with bacteria.

4.0 PACKAGING OF POULTRY

Poultry birds are defeathered and eviscerated after slaughter and then the meat quickly cooled. Carcasses are then hung for a short duration before being weighed and graded for packaging. Like any other meats, poultry are also susceptible to microbial spoilage, particularly to *Salmonella* and *campylobacter*. Packaging has also to ensure that moisture evaporation and discoloration through oxidation are minimized besides subsequent loss of flavour.

Packaging considerations are similar to those applied for meats, only difference being the shapes and sizes. Shrink wrapping polystyrene foam trays with PVDC films or shrink wrapped low density polyethylene (LDPE) are often used. Poultry meat is also packaged in film laminates such as LDPE/Vinyl acetate copolymer (EVA).

5.0 PACKAGING OF FROZEN MEAT, POULTRY AND FISH

Freezing of meat, poultry and fish is done to extend the storage life beyond those obtained by chilling. The physical and chemical changes in meat still take place. The fat if exposed to oxygen and light may lead to rancidity whereas the red pigment (myoglobin) in the lean tissue may fade. Freeze burn is also the common defect in frozen meat caused as a result of dehydration of the meat surface. The development of PVDC copolymer film has helped overcome these problems to a great extent. The bags when shrunk form a second skin around the contours of meat cuts of birds, which are frozen.
These materials have both moisture dehydration or water absorption and have good oxygen barrier properties, which prevent rancidity. Several other materials suitable for this purpose are a range of laminated deep frozen grades of PE and other films. Table 2 lists various packaging materials used for meat/fish products.

**TABLE 2. Packaging materials used for meat/fish products**

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>PACKAGE FORM</th>
<th>MATERIAL</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fresh red meat</strong></td>
<td>Overwrap films</td>
<td>Plasticized stretch, PVC, EVA/LDPE stretch and shrink</td>
<td>Treated with antifog agents</td>
</tr>
<tr>
<td></td>
<td>Trays</td>
<td>PS or pulp</td>
<td>Foamed and clear trays</td>
</tr>
<tr>
<td></td>
<td>Drip pads</td>
<td>Polyolefin-covered cellulose</td>
<td>Polyolefin prevents sticking</td>
</tr>
<tr>
<td></td>
<td>Club (tube) packs</td>
<td>EVA/nylon/EVA with or without EVOH, EVA/PVdC, EVA</td>
<td>Ground meat, course and fine grind, heat processed pork sausages, cold processed pork sausages</td>
</tr>
<tr>
<td><strong>Fresh fish</strong></td>
<td>Trays and</td>
<td>LDPE</td>
<td>Packaging similar to red meats</td>
</tr>
<tr>
<td></td>
<td>overwrap</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fresh poultry</strong></td>
<td>Overwrap films</td>
<td>PS pulp trays, plasticized wraps</td>
<td>Packaging similar to red meats</td>
</tr>
<tr>
<td></td>
<td>Trays, bags</td>
<td>EVA/LDPE and PVC stretch/shrink</td>
<td></td>
</tr>
<tr>
<td><strong>Frozen poultry</strong></td>
<td>Shrink bags</td>
<td>EPS and pulp, LDPE</td>
<td>Often preprinted</td>
</tr>
<tr>
<td><strong>Frozen fish</strong></td>
<td>Paper cartons</td>
<td>EVA and LLDPE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>shrink films,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>overwrap</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Modified atmosphere</strong></td>
<td>Thermoformed</td>
<td>Polyolefin-coated solid bleached sulphate fiberboard, LDPE or EVA</td>
<td>Often clip tied</td>
</tr>
<tr>
<td><strong>packaged meats</strong></td>
<td>trays</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lidding stock</td>
<td>PVC/EVOH or PS/PVDC or nylon with added barrier, PET or biaxially oriented nylon with barrier layer (PVDC), ionomer heat seal layer</td>
<td>Requires good moisture resistant barrier such as PVDC or EVOH sometimes added as coextraction or laminates</td>
</tr>
<tr>
<td><strong>Processed meats</strong></td>
<td>Thermoform film</td>
<td>Nylon with ionomer or EVA seal layer, PVDC or EVOH barrier to prevent discolouration</td>
<td>EVOH or PVDC barriers. Tie layers may have antifog additives, often preprinted, Franks, luncheon meats</td>
</tr>
<tr>
<td></td>
<td>trays</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rigid plastic for</td>
<td>Hips or PET rigid base</td>
<td>PVDC or EVOH added for barrier</td>
</tr>
<tr>
<td></td>
<td>carded meats</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shrink bags</td>
<td>EVA/PVDC/EVA shrink bags</td>
<td>Polyolefin bone guards to prevent film puncture</td>
</tr>
<tr>
<td><strong>Wholesale and distribution</strong></td>
<td>Corrugated boxes</td>
<td>Kraft corrugated</td>
<td>Boxed meats</td>
</tr>
<tr>
<td><strong>meats</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6.0 MODIFIED ATMOSPHERE PACKAGING OF FRESH MEAT, POULTRY AND FISH

A relatively new concept - modified atmosphere packaging of meats is done by using CO\textsubscript{2} alone or in combination with oxygen. As formation of metmyoglobin is to be retarded, oxygen concentration could be between 60-80 %. Higher CO\textsubscript{2} concentration (40-60%) results in better preservation goal, however, it may lead to discoloration due to denaturation of meat proteins. This superiority of CO\textsubscript{2} atmosphere over vacuum packaging is attributed to more inhibition of pathogenic psychrotrophs. In modified atmosphere packaging, the headspace CO\textsubscript{2} pressure change depends upon the initial packaging/product and storage conditions viz. head space-to-meat ratio, surface area, meat volume and initial gas composition. As CO\textsubscript{2} is generally absorbed by fresh meat, package shrinkage or collapse is one of the dangers to be overcome.

MAP poultry meat results in shelf life - 2 to 3 times more than air packed meats when stored at identical refrigerated temperatures. The modified atmosphere with 70 % CO\textsubscript{2} and 30% nitrogen reportedly gives better shelf life than 30% CO\textsubscript{2} and 70 % nitrogen. The temperature of storage which shows higher inhibitory effects on the growth of enterobacteriaceae and on production of spoilage metabolites viz. free fatty acids and extract release volume is generally in the range of 2-4°C.

The shelf life of MAP fish is increased manifolds as compared to fish stored under atmospheric air. Generally, CO\textsubscript{2} is considered as effective medium for MAP of fish. MAP inhibits bacterial growth, reduces increase in the pH, trimethylamine level and total volatile bases, besides delayed changes in protein functionality. Gas mixtures with highest initial CO\textsubscript{2} concentration are very effective in extending the shelf life, however, it may sometimes lead to reduced water holding capacity of fish muscle. MAP has also been used successfully for a variety of processed meat products viz. sausages, salami, patties, nuggets etc. Depending upon product characteristics, the combination of gases tried could include CO\textsubscript{2}, nitrogen and oxygen or many times only CO\textsubscript{2} flushing.

6.1 Safety of MAP muscle foods

Although MAP results in extended shelf life of all muscle foods, FDA of US has expressed concern with regard to safety aspects of its use. It has been pointed out that low oxygen and high CO\textsubscript{2} level in modified atmosphere may induce longer log/lag phase of aerobic spoilage organisms. Besides, it may favour growth of anaerobic pathogens. Psychrotrophic non-proteolytic strains of Clostridium botulinum and Listeria monocytogenes besides several others could grow in many meat products stored under modified atmosphere at room temperature. However, if temperature abuse during storage, distribution and even consumer handling is not allowed, safety concern could be effectively addressed to.

7.0 ACTIVE PACKAGING OF MEAT, POULTRY AND FISH

Active packaging does more than simply provide a barrier to outside influences. It can control, and even react to, events taking place inside the package. Fresh muscle foods like any other fresh food are active biological systems. During metabolic processes, gasses and moisture are constantly produced inside the package leading to change in atmosphere surrounding the product. The metabolism of fresh foods continues to use up
oxygen in the headspace of a package and increases CO₂ concentration. Humidity in the package increases as moisture is released, leading to favourable atmosphere for the growth of microorganisms.

Each food has its own optimum gas composition and humidity level. With active packaging, it is possible to optimize the composition of headsapce in a package. Active packaging employs a packaging material that interacts with the internal gas environment. It continuously modifies the gas environment and may sometimes interact with the surface of the food by removing gases or even adding gasses to the headspace inside the package. Active packaging systems work on several principles as underlined below:

**TABLE 3: Active packaging systems for meat, poultry and fish**

<table>
<thead>
<tr>
<th>PROCESS</th>
<th>MATERIALS USED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygen scavenging</td>
<td>Powdered iron</td>
</tr>
<tr>
<td></td>
<td>Ferrous carbonate</td>
</tr>
<tr>
<td></td>
<td>Iron/sulphur</td>
</tr>
<tr>
<td></td>
<td>Metal catalysts</td>
</tr>
<tr>
<td></td>
<td>Glucose/ oxidase enzyme</td>
</tr>
<tr>
<td></td>
<td>Alcohol oxidase</td>
</tr>
<tr>
<td>Carbon-dioxide scavenging</td>
<td>Iron oxide powder/lime</td>
</tr>
<tr>
<td></td>
<td>Ferrous carbonate/metal halide</td>
</tr>
<tr>
<td>Release of preservative</td>
<td>BHA/BHT, sorbitol,</td>
</tr>
<tr>
<td></td>
<td>Hg compounds, zeolites</td>
</tr>
<tr>
<td>Ethanol emission</td>
<td>Alcohol spray, encapsulated ethanol</td>
</tr>
</tbody>
</table>

Carbon dioxide scavenging principles are generally applied in packaging of fresh meat, poultry and fish. However, carbon dioxide is more permeable through plastic films than oxygen and therefore CO₂ will have to be produced actively to maintain the desired atmosphere in the package. This problem still persists and search efforts continue to be pursued to over come this problem of gas diffusion.

Oxygen Scavenging systems are very effective against mould growth as moulds require oxygen to grow. Besides, oxygen absorbents have also been used to prevent oxidative rancidity in high fat foods and flavors and colour defects. It is therefore that several reports of this system being used in processed meats including cured meats are being reported. These scavengers, however, sometimes pose serious limitations as apart from requiring the free flow of air around the sachet for maximum efficiency, they may also contribute to the growth of potentially harmful anaerobic bacteria.

Active packaging systems, which release microbial inhibitors containing metal ions and salts of propionic acid, have been tested successfully in the laboratory. Specially fabricated films to absorb flavour and odours, or, conversely to release them into the package are being reported and could soon be seen in the market place.
8.0 CONCLUSION

Packaging of foods is an integral part of techniques used for extending the shelf-life. With consumers becoming more and more conscious of quality and hygiene, besides convenience there is need for adopting packages, which could maintain product quality, safety and enhance consumer appeal. Vacuum packaging (VP) and modified atmosphere packaging (MAP) have been successfully exploited in meat industry. VP can delay the growth of aerobic spoilage microorganisms and retard oxidation of lipids in fresh meats. However, deformation of cuts by tightening of packaging film, temporary discoloration and sometimes purge losses have adversely affected its’ widespread use. MAP greatly extends not only the shelf life of muscle foods but also maintains colour, texture and flavour of the product. Despite this, pathogens may grow if there are extreme temperature abuse and the spoilage organisms are low in the MAP foods which would otherwise compete with the pathogens. It is therefore that more hurdles may have to be introduced to ensure product safety. Active packaging concepts will probably dominate the future trends in food packaging. Research efforts in this area have been very active and already some packages based on this principle are available in the market.

9.0 SUGGESTED READINGS


Smith, J.P. Ramaswamy, H.S. and Simpson, B.K. 1990 Developments in food packaging technologies, part 2, Trends in food science and technologies, November:107
1.0 INTRODUCTION

Explorers and travellers throughout history have had to develop methods for preserving food and carrying enough food for their journeys. More than 20 years ago, astronaut John Glenn became the first American to orbit the Earth. Among the many tasks Glenn had to perform while in orbit were the first American space experiments in eating food in the weightless conditions of Earth orbit. Eating in space for John Glenn turned out to be an easy though not too tasty experience. Other Mercury astronauts following John Glenn were forced to endure bite-sized cubes, freeze dried foods, and semi-liquids in Aluminium Toothpaste-Type Tubes. They found the food unappetizing, had trouble rehydrating the freeze-dried foods, and disliked squeezing the tubes.

In the Gemini missions eating in space became more normal. The Aluminium Tubes of the Mercury program were replaced because the container weighed more than the food inside. Bite-sized food chucks were coated with an edible gelatin to reduce crumbling. Rehydratables were encased in an improved Plastic Container. To rehydrate food, water was injected into the pack through the nozzle of a water gun. After kneading the contents the food became a puree and was squeezed through a tube into the astronaut's mouth. A typical meal would include shrimp cocktail, chicken and vegetables, toast squares, butterscotch pudding, and apple juice. Before each flight, the astronauts themselves chose meal combinations but the menus chosen were required to provide 2,800 calories per day. Further advances in Apollo food systems came with the introduction of the "Spoon-Bowl" Package for rehydratable foods and Retort Pouches for thermostabilized foods. Following rehydration of the contents in the spoon-bowl, a pressure type, plastic zipper was opened and the food removed with a spoon. The moisture content in the food enabled it to cling to the spoon, making eating a more normal experience.

Food containers for the Skylab astronauts consisted of Aluminium Cans with ‘Full Panel Pull-Out Lids’. Cans containing thermostabilized food had a build-in membrane to prevent spillage when removing the lid in can and had a water valve for rehydration. Canned, ready-to-eat foods were held in the can with a slit plastic cover. Instead of plastic drinking bags, Skylab drinking containers were collapsible bottles that expanded accordion style when filled with hot or cold water. In 1975, the last Apollo flights took place with the Apollo-Soyuz docking mission. Because of the short duration of the flight (nine days), many short shelf-life items were added to the foods carried. Fresh breads and cheese were included as a part of 80 different varieties of food dined
upon by the Apollo while others were placed in spoon-bowl packages or plastic drinking bags. To make eating easier, a food tray was carried on the mission. The tray did not warm the food as the Skylab tray did, but it held the food in place with springs and Velcro fasteners. The tray was secured to the crewmember's leg during mealtime.

2.0 PACKAGING OF SPACE FOODS

NASA's Space Shuttle has opened a new era in space travel. The Shuttle takes off as a rocket, orbits the Earth as a spacecraft, and lands as an aeroplane. Missions on the Shuttle can last from one to 30 days for crews of two to seven astronauts.

2.1 The Shuttle's Menu

Foods are individually packaged and stowed for easy handling in the zero gravity of space. All foods are precooked or processed, so it requires no refrigeration and is either ready-to-eat or can be prepared simply by adding water or by heating. The only exceptions are the fresh fruits and vegetables stowed in the fresh food locker. Without refrigeration, the carrots and celery must be eaten within the first two days of the flight else they will spoil.

The Space Shuttle menu currently features more than 70 food items and 20 beverages. Shuttle travellers have a varied menu every day for six days. Each day, three meals are allowed, with a repeat of menus after six days. The pantry also provides plenty of foods for snacks and between meal beverages and for individual menu changes. The pantry also stores additional contingency food to last 96 hours. Each astronaut's food is stored aboard the Shuttle and is identified by a coloured dot affixed to each package.

The space food packaging label includes the following information: item name, manufacture date, instructions for preparing the item in space (if needed), a bar code for computerized inventory or conducting nutritional studies, and an expiration date. Labels include coloured dots for crewmember identification purposes. Labels also include the amount of water to rehydrate foods and the time and temperature needed to make it the best possible meal. Lastly, place a Velcro dot on the package for attachment in micro gravity. The Velcro "hooks" should be on the opposite side of the food package label.

2.2 Packaging of foods in space mission

2.2.1 Thermostabilized (T): Thermostabilized foods are heat processed to destroy harmful microorganisms and enzymes. Individual servings of thermostabilized foods are commercially available in aluminum or bimetallic cans, plastic cups, or flexible retort pouches. Most of the fruits and fish such as tuna and salmon are thermostabilized in cans. The cans open with easy-open, full-panel, pullout lids. Puddings are packaged in plastic cups. Most of the entrees are packaged in flexible retort pouches. This includes products such as beef tips with mushrooms, tomatoes and eggplant, chicken a la king, and ham. After the pouches are heated, they are cut open with scissors. The food is eaten directly from the containers with conventional eating utensils. Some irradiated meat items are
also available. These products are very similar to thermostabilized foods in that they are ready to eat and only require warming prior to consumption. These items are packaged in flexible pouches. Heat processed foods; "off-the-shelf" items are packaged in aluminium or bimetallic tins and retort pouches.

2.2.2 Irradiated (I): Beefsteak is the only irradiated product currently used on Shuttle. Steaks are cooked, packaged in flexible, foil-laminated pouches, and sterilized by exposure to ionizing radiation so they are stable at ambient temperature. Foods preserved by exposure to ionizing radiation and packed in flexible foil laminated pouches.

2.2.3 Condiments: Condiments include commercially packaged individual pouches of catsup, mustard, mayonnaise, taco sauce, and hot pepper sauce. Polyethylene dropper bottles contain bulk supplies of liquid pepper and liquid salt. The pepper is suspended in oil and the salt is dissolved in water.

2.2.4 Intermediate moisture (IM): Intermediate moisture foods are preserved by restricting the amount of water available for microbial growth, while retaining sufficient water to give the food a soft texture. Water is removed or its activity restricted with a water-binding substance such as sugar or salt. Intermediate moisture foods usually range from 15 to 30 percent moisture, but the water present is chemically bound with the sugar or salt and is not available to support microbial growth. Dried peaches, pears, and apricots, and dried beef are examples of this type of Shuttle food, dried foods with low moisture content such as dried apricots are packaged in flexible pouches.

2.2.5 Freeze dried (FD): Most food for the Apollo missions was preserved through a process known as freeze-drying. Foods are prepared to the ready-to-eat stage, frozen and then dried in a freeze dryer, which removes the water by sublimation. Freeze dried foods such as fruits may be eaten as it is, while others require the addition of hot or cold water before consumption. Freeze-drying provides foods that will keep their nutrition and taste qualities almost indefinitely. They are extremely light and compact and require no refrigeration. These foods were packed into unique pouches developed by NASA, which have a special valve that allows water to be injected into the pouch. The water reconstitutes the freeze-dried food. If the food is to be eaten hot, the pouch is placed in a food warmer and heated to serving temperature; these packages are not available for commercial sale.

2.2.6 Re-hydratatable (R): Dried foods and cereals that are re-hydrated with water produced by the Shuttle Orbiter's fuel cell system. Packed in semi-rigid plastic container with septum for water injection. Rehydratable items include both foods and beverages. One way weight can be conserved during launch is to remove water from certain food items. During the flight, water generated by the shuttle fuel cells, which produce electricity by combining hydrogen and oxygen, provide ample water for rehydrating foods as well as drinking and a host of other uses is added back to the food just before it is eaten. To simplify food packaging a new re-hydratable food pack design is used. The bottom of the package is an injection-moulded, high-density polyethylene base. A thermoformed flexible lid made of plastic film covers the top. To add water, a large
A gauge hollow needle is inserted through a septum in the base. Food needing heating is placed in a forced air convection oven, a new feature for space flight. The maximum temperature of the oven is 82 °C and it can hold temperatures at 65 °C for an extended period. The oven can heat containers of different sizes and shapes.

Foods packaged in rehydratable containers include soups like chicken consommé and cream of mushroom, casseroles like macaroni and cheese and chicken and rice, appetizers like shrimp cocktail, and breakfasting foods like scrambled eggs and cereals. Breakfast cereals are prepared by packaging the cereal in a rehydratable package with nonfat dry milk and sugar, if needed. Water is added to the package just before the cereal is eaten.

The rehydratable food package is made from flexible material to aid in trash compression. It consists of a flexible bowl and lid with a septum adapter for adding water from the galley. Velcro on the bottom of the package holds it in the meal tray. After adding the required amount of water to the package, it is placed in the oven if the food is to be served hot or directly onto the serving tray if the food is to be served cold. The top of the package is cut off with a knife or scissors, and the contents are eaten with a fork or spoon.

2.2.7 Natural form (NF): Foods such as nuts, granola bars, and cookies are classified as natural form foods. They are ready to eat, packaged in flexible pouches, and require no further processing for consumption in flight. Both natural form and intermediate moisture foods are packaged in clear, flexible pouches that are cut open with scissors.

2.2.8 Beverages (B): Dry beverage powder mixes packed in re-hydratable containers. The beverage package is made from a foil laminate to provide maximum barrier properties for a longer product shelf life. A septum adapter is sealed in the package after the beverage powder has been added. The septum adapter holds a septum that interfaces with the galley water dispenser for the addition of water and with a straw for drinking the beverage. Foods are individually packaged and stowed for easy handling in microgravity.

Beverage containers for the Shuttle are identical to the packages for re-hydratables. A polyethylene straw is inserted through the same septum that is used for injecting water. When not in use, a clamp closes the straw. While the astronauts are eating, food containers are held in a food tray that is attached to a table in mid-deck, to the astronaut's lap while seated, or attached to a wall. Food can be seasoned with serving sized packets of mustard, catsup, mayonnaise, hot sauce, and liquefied salt and pepper. Following the meal, food containers are discarded and the utensils and serving trays are cleaned with "wet wipes."

2.2.9 Shelf stable tortillas: Flour tortillas are a favorite bread item of the Shuttle astronauts. Tortillas provide an easy and acceptable solution to the breadcrumb and microgravity-handling problem, and have been used on most Shuttle missions since 1985. However, mold is a problem with commercially packaged tortillas, especially with the longer missions on the orbiter, which has no refrigeration. A shelf stable tortilla was
developed for use on the Shuttle with extended mission lengths. The tortillas are stabilized by a combination of modified atmosphere packaging, pH (acidity), and water activity. Removing the oxygen from the package inhibits mold growth. This is accomplished by packaging in a high-barrier container in a nitrogen atmosphere with an oxygen scavenger. Water activity is reduced to less than 0.90 in the final product by dough formulation. This reduced water activity, along with a lower pH, inhibits growth of pathogenic clostridia, which could be a potential hazard in the anaerobic atmosphere created by the modified atmosphere.

2.3 Packaging of food for ‘Shuttle Extended Duration Missions’

The length of Shuttle missions has steadily increased from the first mission in 1981 of 2 days, to 14 days for STS50 in June 1992. Missions beyond 10 days are called Extended Duration Orbiter (EDO) missions. In order to accommodate the weight and volume of trash generated by the food system on these longer missions, it was necessary to develop new food and beverage packages. A trash compactor was also developed to reduce the volume of the trash, and the new packages were designed to be compatible with the compactor.

The beverage package is made from a foil laminate to provide maximum barrier properties for a longer product shelf life. A septum adapter is sealed in the package after the beverage powder has been added. The septum adapter holds a septum, which interfaces with the galley water dispenser for the addition of water, and with a straw for drinking the beverage. Although the beverage package was designed for use on EDO missions, it has replaced the square polyethylene beverage package on all Shuttle missions.

The EDO rehydratable food package also is made from flexible material to aid in trash compression. The rehydratable package consists of a flexible bowl and lid with the septum adapter for adding water from the galley. Velcro on the bottom of the package holds it in the meal tray. After adding the required amount of water to the package, it is placed in the oven if the food is to be served hot, or directly onto the serving tray if it is to be served cold. The top of the package is cut off with a knife or scissors and the contents eaten with a fork or spoon.

3.0 ORBITER’S FOOD LOCKERS

Meals are stowed aboard the orbiter in locker trays with food packages arranged in the order they will be used. A label on the front of the locker tray lists the locker contents. A five section net restraint keeps food packages from floating out of the locker in microgravity while still allowing items inside to be seen. Velcro strips secure sections of the net, making it easily opened and the food items readily accessible to the astronauts. Food is packaged and stowed in the locker trays in Houston about a month before each launch. Stowed food lockers and shipping containers are kept under refrigeration until they are installed in the Shuttle 2-3 days before launch.
4.0 DESIGNING PACKAGE FOR SPACE FOODS

The primary objective in designing a food system for the Space is to provide food that is safe and nutritious, light in weight and compact, and is packaged in a convenient form that allows easy manipulation in the weightless environment of an orbiting spacecraft. To achieve this objective requires a careful consideration of three important factors:

- **Biological:** The biological factor in food design requires the food to be both safe and nutritious. It should also appeal to the crew's sensory preferences. The food must be easy to inject and digest and not cause any hygiene or gastroenterological problems.
- **Operational:** The operational factor relates both to the food and the nature of its packaging. The package must be light in weight (engineering factor) but provide protection and stability to the food in storage for periods that might last well over 30 days. Food must be easy to prepare and require little crew attention. Easy disposal of waste food and used packaging material is another constraint.
- **Engineering:** The engineering factor has to do with not only the weight of the food and packaging but also how compact it is for storage. Thirty-day missions of the Shuttle will require large amounts of food. The food and packaging must survive the temperature, pressure, acceleration, and vibration of a Shuttle flight. Still another constraint is the quantity of water needed for re-hydration.

**Sources of constraints in food system development**

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<thead>
<tr>
<th>Biological</th>
<th>Operational</th>
<th>Engineering</th>
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<tr>
<td>Safety</td>
<td>Vehicle interface</td>
<td>Weight</td>
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<td>Nutrition</td>
<td>Stability</td>
<td>Volume water for rehydration</td>
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<td>Organoleptics</td>
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<td>Personal hygiene</td>
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<td>Ingestion</td>
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<td>Absorption</td>
<td>Waste disposal</td>
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<td>Gastroenterology</td>
<td>Schedule</td>
<td>Power</td>
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<td>Crew idiosyncrasies</td>
<td>Crew time</td>
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4.1 Weight and volume constraints:

Increased weight would result in prohibitive costs and additional volume would minimize the number of items that could be brought on board. Compliance to these smaller volume and weight constraints was met by the introduction of dehydrated foods, which were vacuum packed, and the gradual exclusion of tubed food. The tubed food resulted in excessive waste due to the packaging as well as needless weight.
4.2 Food Acceptability:

Food acceptability, although not considered significant in the Mercury flights became of prime importance in subsequent missions. It quickly became apparent that these engineered foods were unacceptable in terms of odor, flavor, color and texture. The Mercury and Gemini food lacked in all the sensory qualities: the tubed food was indistinguishable in terms of texture and odor, making eating a necessity rather than a pleasurable experience. Additionally, the texture of the cubes was significantly altered from the original material due to the high-pressure compression used in their manufacture. Most of all, the method of eating these foods was unusual (e.g. squeezing a tube in the mouth) leading to the immediate need of modifying the meal-in-a-pill concept. Although some forms of rehydratable food was available in Gemini, it was not until the Apollo missions where hot and cold water were available that these meals became more acceptable. The Apollo missions also saw the introduction of the Spoon Bowl requiring the use of a spoon to eat; a radical improvement on the squeeze tubes. The variety and acceptability of the food was drastically improved during the years from Apollo to Shuttle through the introduction of thermostabilized, intermediate moisture, irradiated and canned food.

5.0 THE SPACE FOOD CHALLENGE

Among the unique requirements for space are.

- Low weight, mass, and energy usage.
- Minimum food product shelf life of nine months for the Shuttle food system, one year for the International Space Station, and up to five years for planetary outposts.
- A food supply that will be heavily dependent on regenerable crop production (crops to be grown in space are cabbage, carrots, chard, dry beans, lettuce, onions, peanuts, potatoes, radishes, rice, soybeans, spinach, sweet-potatoes, tomatoes, and wheat) and
- Food-processing systems that operate in microgravity (e.g., the International Space Station) and reduced gravity (e.g., planetary and moon outposts).

5.1 Disposal: Disposal of used food packaging will be an issue since there will be no Progress vehicles to send off and incinerate into the Earth’s atmosphere. Packaging materials will be used that have less mass but sufficient barrier properties for oxygen and water to maintain shelf life as that now in use.

5.2 Extending Shelf Life: Food products must safely maintain a shelf life of nine months to five years under ambient storage conditions. Some refrigeration and frozen food storage will be available for long-term missions. Research and development are needed in the following areas.

- Packaging material improvements
- Novel compounds to reduce lipid oxidation, and microbial growth
- Products that prevent or minimize water migration
- Irradiation
Advances in packaging of space foods

- Novel processes such as high pressure, conductivity, and light intensity
- Modified atmosphere packaging and storage
- Accelerated shelf-life protocols for five-year food storage tests

6.0 CONCLUSION

Packaging of space food designers has broadened the range of packages available. During the past few years an influx of shelf-stable aseptic packages, retort hot-fill packages, film/foil pouches, multi-layer film pouches and microwavable plastic containers, green packaging, want environmentally friendly packaging that recycle, degrade and/or burn easily in a range of packaging configurations and made from a variety of materials have come to light. To ensure extended shelf life and food safety and to minimize weight and waste, new packaging methods and materials are needed. Further developments in the following areas are desired:

- Recyclable or degradable packaging
- Accelerated degradation
- Compatibility with composting
- Multifunctional packaging materials
- New edible food coatings
- Microwave compatible packaging.

7.0 REFERENCES

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http://www.spacekids.com/spacenews/sts101_food_000419.html
1.0 INTRODUCTION

In order to judge the performance of a package in the market place, it is important to test the different packaging materials used for their manufacture. Packaging materials need specific properties in order to protect the contents. The testing of different packaging materials is important for manufacturers, raw material contents and as well as the users. The manufacturer is always interested in testing the basic quality and to find out what new applications he can develop based on the properties of the different packaging materials and also to check the quality of his material. The converter has interest in the conformity to specifications and suitability for application. The user wants to ensure that the material he is purchasing is of required quality and adequate to protect the product from spoilage. Thus, the testing of the packaging materials is done mainly for the following purposes:

- Comparison with competitive material, e.g. to compare offers.
- Comparison of the current supply of material with the quality of that offered for the first time; also regular checking of uniformity in new supplies of packaging materials.
- Quality checks during the production of packaging materials.
- Evaluation of the suitability of a packaging material for a certain specific purpose, for instance protection against mechanical or climatic hazards.

Test procedures that are applicable for general classes of materials or packages are available and published in standardized form. (Paine et al., 1992; Griffin et al., 1972).

ASTM American Society of Testing and Materials Standards
TAPPI Technical Association for the Pulp and Paper Industry (USA) Standards
BIS Bureau of Indian Standards
ISO/R International Standards Recommendations
BS British Standards
FEFCO Federation Europeanne des Fabricants de Carton Ondule Test Methods
PIFA Packaging and Industrial Films Association Standards
ABA American Box Board Association
BPBMA British Paper and Board Manufacturers’ Association
NFPA National Flexible Packaging Association
2.0 CONDITIONING OF THE TEST SAMPLES.

It is very important that the testing of the packaging material should be carried out in standardised conditions and the samples should be allowed to reach equilibrium prior to testing which normally takes 24 hours. This is so because the properties of many packaging materials depend on the climatic conditions to which these materials are exposed. The physical properties of paper are affected by its moisture content and the moisture content varies in proportion to the relative humidity and temperature of the surrounding atmosphere. In special cases it may be necessary to check the moisture content of the test specimen, in order to ensure that the climate has had its full effect on the test specimen. Testing laboratories are constructed to maintain the standard conditions and no test is considered official if conducted under any other conditions. In a number of countries a standard condition has been established, i.e. 20°C and 65% R.H. in Argentina, Australia, Belgium, France, Germany, Netherlands, New Zealand, UK; 23°C and 50% R.H. in USA, Canada, Burma, Mexico, South Africa; 27°C and 65% R.H. in India and 20-25°C with 75-80% R.H. in Indonesia (Goyal et al., 2001).

3.0 SELECTED IMPORTANT TEST METHODS.

3.1 Grammage and Thickness (IS: 1060-1966 Part 1)

3.1.1 Grammage: Papers, foils and films are purchased on weight basis and any deviation from the prescribed weight will affect purchaser and the vender. Most physical properties such as bursting strength, thickness are specified in accordance with a particular basis weight.

Method of Test: The samples are cut by selecting the suitable template considering the type of the sample. For heavy paper (weighing above 100 GSM) template of the size 10 cm x 10 cm is taken and hung on one of the arms of the instrument. Reading is taken directly on the scale “A”. In case the paper or paper board is light and reading remains below 100 GSM then template of size 10 cm x 20 cm is used to get more accurate results and reading is taken on scale “B”. At least 5 readings are taken and results are expressed in range as g/m².

3.1.2 Thickness: Many physical and mechanical properties of paper, paperboard and flexible packaging materials are dependent upon the thickness of the material. Properties like tensile strength, sealability, and seal strength, moisture and gas barrier are directly related to thickness. In case of laminates the thickness of the constituent plies are more important as they influence the barrier properties. This test is useful for routine control.

Method of Test: Cut a piece from sample without any irregularities of size 10 cm x 10 cm. Place the specimen between two points of the micrometer, one of which has to be lifted gently to insert the paper and note the corresponding reading. The thickness can be expressed in any unit such as micron, inches, mil. etc. Take at least 10 readings.

0.001” = 25 micron = 100 gauge = 1 mil.
3.2 Tear Strength: (ASTM, D 689-79 Part 20)

This test is mainly performed on papers and it gives an indication towards the strength of the paper. It is helpful in making selection of papers based on material for packaging purposes. The tear strength requirements may be high or low according to particular end use. This test measures the energy absorbed by the test sample in propagating a tear that has already been initiated by cutting a small nick in the test piece with a blade.

**Method of Test:** The Elmendorf tearing tester has two grips set side by side with only a small separation. One grip is stationary and is mounted on an upright on the instrument base. The second grip is movable and is mounted on a pendulum. The pendulum is mounted on a frictionless bearing and swings on a shaft. The sample of 50 x 62 mm size is clamped in the two grips and a cut is made using a sharp knife fixed on the tester. When the pendulum is released, it swings down and pre-cut sample. This indicates the residual energy lost in tearing and expressed in mN (milli Newton).

3.3 Bursting Strength: (IS 1009-1966 Part I)

Bursting strength of paper and paperboard is determined in order to assess both strength and toughness of the material. It is essentially the ability of the sample to absorb energy.

**Method of Test:** The sample is fixed between clamps. The area exposed is 1.2 in\(^2\). The sample is subjected to steadily increasing pressure hydraulically exerted on a diaphragm beneath the sample until it ruptures. The pressure required to rupture the sample is automatically recorded by a pressure gauge. This test is of importance in routine check of quality of packaging material during manufacture.

3.4 Water Absorbency-Cobb Test: (IS: 4006-1966 Part I):

This test measures the amount of water absorbed by the sample. It is useful in assessing the suitability of paper and paperboards to be used for shipping containers, which may be exposed to water spray.

**Method of Test:** A weighed sample is clamped under a metal base plate and exposed to water for one minute (paper/paper board). The area exposed is 100 cm\(^2\). After the specific time, the sample is removed, blotted and reweighed. The difference in weight indicates the amount of water absorbed by the sample. The results are expressed in g/ m\(^2\).

3.5 Grease Resistance: (ASTM D-722; TAPPI T-454)

This test is important for the packaging materials used for fat rich food products.

**Method of Test:** This test is performed by putting 5 g sand on the specimen through a hollow cylinder metallic piece and then topping the sand with 1.1 ml of coloured turpentine dye. This is placed on a white paper sheet and at specified intervals, the indicator sheet is examined for the first spot and after it the experiment is
discontinued. The time between the application of turpentine dye and appearance of first stain is recorded as transudation time in seconds.

3.6 Water Vapour Permeability: (IS: 1060-1960 Part II)

One of the prime functions of the packaging materials is to act as barrier to gases and vapours. Many hygroscopic foods have to be protected from oxygenated water vapour pick up. The measure of permeability is therefore very important.

Method of Test: The water vapour permeability may be measured by means of high-vacuum techniques, although there are simple gravimetric methods available which determine Water Vapour transmission rate (WVTR) much easily. In this method the value of water vapour permeability is determined by the increase in weight of a dish filled with desiccant (anhydrous calcium chloride), covered with the test specimen and sealed with molten wax. The sealed dish is placed in a humidity cabinet maintained at 38 ± 1°C and R.H. 90 ± 2%.

The WVTR is computed by the following formula:

\[
\text{WVTR} = \frac{G \times 24}{A \times T} \text{ g/m}^2/24 \text{ hrs}
\]

where;

- \( G \) = weight gained in gm
- \( T \) = time during which gain in weight is observed
- \( A \) = area of the sample exposed in \( \text{m}^2 \)

4.0 IDENTIFICATION OF PACKAGING MATERIALS:

Over the past decades packages have become more complex and we are presently using number of plastic films in packaging. Film users and converters may use a variety of instruments from high-powered microscopes to spectrophotometers. However, for easy and rapid identification of films, film users and converters usually go for simple non-instrumental techniques.

Method of Test: The first step in analyzing a flexible film is to measure some of its physical properties by density, hardness, stiffness etc. The laminates are to be delaminated into its separate plies so that they can be separately identified. There are several methods available to separate and isolate laminated components. They can be separated by gently heating over a flame or by immersing in boiling water up to 5 hours. Tetrahydrofuran vapours are used for rapid separation of different laminates. The plastics can be identified by solubility or by the observation of burning characteristics where the colour of the flame, the way of dripping and the odour of the fumes serve to identify the type of plastic. The characteristics of the films are given in the chart No. 1. Solubility of films in a particular solvent is an excellent and more dependable test for identification. In this test one-square inch of sample is put into 15 ml of the appropriate solvent and heated to boiling point with proper care to prevent solvent loss. The flow sheet No. 1 (Griffin et al; 1972) can be used for identification of an unknown plastic film by solvent solubilities.
5.0 TESTING OF FABRICATED PACKAGES

Once packaging materials have been fabricated into package, it is important to measure properties of these packages to ensure that they conform to the desired specifications. These tests involve measurement of critical dimensions and one or two critical properties.

5.1 Testing of Glass Bottles (IS:1392 –1967)

5.1.1 Dimensional Measurements: Height, body diameter, wall thickness and finish are measured to detect possible variations that may exceed the tolerance limits, which have been established by glass manufacturers. Adherence to these tolerance limits is an important factor in operation of high speed filling lines. For checking body dimensions, gauges are used which have been specially designed for each specific bottle. The capacity of glass container is measured by selecting a sample of 12 bottles at random and checking them for volume.

5.2.2 Pressure Test: Bottles used for liquor, carbonated beverages and soda water etc. have to withstand certain amount of internal pressure. Devices are available which subject the bottles to internal pressure using a gas or liquid. The bottles are subjected to an internal pressure of 150 kg/cm$^2$ for 1 minute. The temperature at which the test is carried out is very important since, a bottle withstanding 150 kg/cm$^2$ at 30ºC may fail to withstand the same pressure at 60ºC. Bottles, which have to withstand pressure, should be carefully designed.

5.3.3 Thermal Shock Test: This test is performed when the bottles are subjected to sudden temperature difference during actual filling and use. In dairy industry sterilized milk is packed in bottles and in pharmaceutical industry, the bottles are sterilized by hot steam before use. In this test few bottles are dipped in a hot water bath at a temperature of 72 ±2ºC for 300 ± 10 seconds and when the bottles have attained both the temperatures, they are taken out along with hot water inside and suddenly dipped in a cold water bath at 30 ±1ºC for 30 seconds. The difference between the hot water bath temperature and cold-water bath temperature gives the thermal shock to the bottles. The time for transfer of bottles from the hot water bath should not be more than 60 seconds or less than 15 seconds.

5.3.4 Impact Test: Bottles that are used again and again, often meets certain amount of impact in their daily use. In order to ensure that such bottles do not fail, this test is performed. In this test a steel ball of 400 gm is dropped from a height of 10 cm on the bottle held rigidly. In case of milk bottles the ball is dropped thrice on the same spot on the bottle and the bottle should not freak or crack. In the pendulum test the steel ball swings and strikes at the bottle held rigidly.
### CHART No. 1

<table>
<thead>
<tr>
<th>Film</th>
<th>Density range (gm/cc)</th>
<th>Flammability (self extinguishing)</th>
<th>Colour</th>
<th>Behaviour</th>
<th>Odour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyethylene</td>
<td>0.910 - 0.965</td>
<td>No</td>
<td>Top yellow, bottom blue, white smoke</td>
<td>Melts and drips</td>
<td>Burnt wax</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>0.900 - 0.915</td>
<td>No</td>
<td>Top yellow, Bottom blue, white smoke</td>
<td>Melts and drips</td>
<td>Burnt wax and acrid</td>
</tr>
<tr>
<td>PVC</td>
<td>1.28-1.38</td>
<td>Yes</td>
<td>Yellow orange with green edge</td>
<td>Darkens, softens &amp; decomposes</td>
<td>Chlorine</td>
</tr>
<tr>
<td>PVDC</td>
<td>1.68</td>
<td>Yes</td>
<td>As above with green spurts</td>
<td>Black, hard residue</td>
<td>Chlorine</td>
</tr>
<tr>
<td>PVA</td>
<td>1.21-1.33</td>
<td>Yes but slowly</td>
<td>Yellow with gray smoke</td>
<td>Swells, softens and turns brown</td>
<td>Pungent</td>
</tr>
<tr>
<td>Polycarbonate</td>
<td>1.2</td>
<td>Yes</td>
<td>Yellow orange with black smoke</td>
<td>No drips, decomposes</td>
<td>Pleasant</td>
</tr>
<tr>
<td>Polyester</td>
<td>1.38</td>
<td>No</td>
<td>Yellow-black smoke</td>
<td>No drips, softens, burns steadily</td>
<td>Pleasant</td>
</tr>
<tr>
<td>Polystyrene</td>
<td>1.04-1.09</td>
<td>No</td>
<td>Yellow orange, black shoots</td>
<td>No drips, softens</td>
<td>Floral (sweet)</td>
</tr>
<tr>
<td>Polystyrene</td>
<td>1.04-1.09</td>
<td>No</td>
<td>Yellow orange, black shoots</td>
<td>No drips, softens</td>
<td>Floral (sweet)</td>
</tr>
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<tr>
<td>Polystyrene</td>
<td>1.04-1.09</td>
<td>No</td>
<td>Yellow orange, black shoots</td>
<td>No drips, softens</td>
<td>Floral (sweet)</td>
</tr>
<tr>
<td>Cellophane</td>
<td>1.48</td>
<td>No</td>
<td>Yellow, orange, Grey and smoke</td>
<td>Burns fast and complete, burnt area brittle</td>
<td>Burnt Paper</td>
</tr>
<tr>
<td>Cellulose acetate</td>
<td>1.28-1.32</td>
<td>No</td>
<td>Yellow with blue base</td>
<td>Melts, burns quickly and leaves beads</td>
<td>Burnt Vinegar</td>
</tr>
<tr>
<td>Cellulose Nitrate</td>
<td>1.35-1.40</td>
<td>No</td>
<td>Yellow</td>
<td>Burns at once and fully</td>
<td>Acrid</td>
</tr>
</tbody>
</table>
FLOWSHEET 1: IDENTIFICATION OF AN UNKNOWN PLASTIC FILM BY SOLVENT SOLUBILITIES

1. Put Sample of film in toluene

2. Put 2nd sample of film in ethyl acetate

3. Put Previous sample of film in water.

4. Dry previous sample then put in carbon tetrachloride.


6. Put 4th sample of film in 40% sulfuric acid.

Polyvinyl Alcohol

Polyamine

Polyvinyl Chloride

Polyethylene

Polyester

Polyolefin

Polystyrene

Polyvinyl chloride/acetate

Cellulose nitrate.

Polycarbonate or Rubber hydrochloride

Cellulose acetate, or acetate/butyrate

Polyvinylidene chloride

Soluble

Insoluble

Polyamide
6.0 SUGGESTED READINGS
1.0 INTRODUCTION

A package performs three main functions—it contains the product, protects the product from environmental hazards and helps in marketing the product. The global business of world packaging industry was 100 billion US dollars in 2000 and is growing in excess of 10 % per year. As we evolve into a “throw away” society, we are producing waste at a faster rate than we are finding solutions for its disposal. This concerns municipalities, which are already overwhelmed by the volume of waste but nonetheless responsible for disposing of it. Currently 10 % is recycled, 10% incinerated, and remaining 80% finds its way into landfills. Finding an approach to handle solid waste, one that is both economically and environmentally attractive, is a challenge facing legislatures and industries alike. Since packaging makes up one-third of the volume of municipal solid waste with food packaging accounting for about 12 % of the total waste, it is clearly targeted under waste management strategies in the food industry.

Packaging materials use large quantities of the world’s natural resources, and currently account for around 5 % of landfill deposits. Food packaging represents 60 % of all packaging, and an appreciable proportion of household expenditure. Not all packaging is to protect the product - much is to enhance its appearance and increase sales. We all pay at least twice for packaging - once at the point of purchase and again for disposal. There are also hidden environmental costs. In recent years the subject has generated extensive debate and a few initiatives, not all of which have been wholly successful.

2.0 WASTE MANAGEMENT METHODS

Packaging waste consists of paper and paper products, glass, metals, and plastics. Strategies for handling these components include source reduction, recycling, incineration and land filling. Methods for controlling and handling waste are:

2.1 Land filling

Although the least desirable method for waste disposal, land filling is the most commonly used. Landfills provide a means of merely getting solid waste out of site by entombing it in the ground devoid of water and oxygen required for decomposition. As a result, even organic wastes that decompose naturally take years to do so. Plastics, takes up only one tenth the space of paper, hold some merit for land filling. But there is some
Disposal of packaging waste

cconcern about the possibility of heavy metals such as cadmium or lead being leached. Research is now focusing on development of two types of degradable plastics: photodegradable plastics which degrade when exposed to sunlight, and biodegradable plastics which contain corn starch or vegetable oils and break down into small pieces. While degradable plastics may prove to be effective above ground; enhanced degradability will have little effect if any on, landfills.

2.2 Incineration

This method is extremely valuable since it can reduce the amount of waste to be land filled by 75% or more while generating electricity. Proper use of incineration does not cause air pollution. Burning of paper reduces its volume to about one-ninth, but heavy metals in the printing ink have raised concerns about emissions and ash produced during the process. Plastics burn cleanly when properly incinerated, releasing up to four times more energy than the typical components of solid waste. In spite of the advantages of incineration, the U.S. relies on this method for only about 10% of the solid waste stream. This is low in comparison with other countries such as Switzerland and Japan, which burn 70% of their solid waste for energy production.

2.3 Source reduction

This method involves the reduction of both the amount and the toxicity of all material going into the waste stream. Source reduction includes the use of lighter weight materials that does a comparable job such as cans with less wall thickness, or the elimination of unnecessary packaging. For food or ingredient packagers, these can be cost effective measures, translating into lower product shipping costs. Source reduction efforts must be carefully examined since switching from one material to another may lead to only a shift in environmental problems.

2.4 Recycling

Recycling involves the collection of used and discarded materials, processing these materials and making them into new products. It reduces the amount of waste that is thrown into the community dustbins thereby making the environment cleaner and the air fresher to breathe. Surveys carried out by Government and non-government agencies in the country have all recognized the importance of recycling wastes. The steps involved in the process prior to recycling include:

a) Collection of waste from doorsteps, commercial places, etc.

b) Collection of waste from community dumps.

c) Collection/picking up of waste from final disposal sites.

This method helps in reducing waste going for landfills or incinerators and provides a source of raw materials. But the success of this method depends on the existence of a market for recycled products. In some areas where recycling efforts are aggressive, there is a glut of scrap material. Today about 10% of solid waste is recycled.
Studies have revealed that 7 -15% of the waste is recycled. At the community level, a large number of NGOs and private sector enterprises have taken an initiative in segregation and recycling of waste. EXNORA International in Chennai recycles a large part of the waste that is collected.

2.4.1 Paper  - Close to 50% of corrugated paperboard is recycled today. Two considerations to recycled paper are first, the weaker strength of the cellulose fiber because the fiber length has been shortened and second, the inability to achieve a white color due to the ink contents. Another constraint is that not all paper mills are equipped to handle recycled materials since the supply of recycled fiber has been neither consistent nor large, but this changing.

2.4.2 Glass  - Glass packaging accounts for 2 % of the volume of municipal solid waste. Beverage and food containers account for nearly 90% of discarded glass. Glass can be crushed into cullet and reprocessed into new container materials. The recycling process conserves sand and water, and uses 15% less energy than new manufacture; however the savings must be weighed against the cost for transporting the glass to the recycling facility. New containers are the biggest market for recycled glass but cullet stock is also used in bricks, asphalt, and fiberglass insulation.

2.4.3 Metals  - Metal containers made chiefly of aluminum or steel account for about 5% of municipal solid waste volume. Aluminum makes up about 96% of the 81 billion beverage cans produced each year and today over half of all aluminum cans are recycled. Compared with new manufacture, recycling aluminum saves 95% energy and four pounds of bauxite for every pound of discarded containers.

2.4.4 Plastics  - When it comes to the recycling of plastic wastes, there are many problems. A variety of different types of plastics are used. The plastics contain a wide range of additives, and many objects contain plastics as well as other materials. The sorting of plastics may be technically difficult, unhygienic and expensive. Recycling of plastic packaging, which makes up about 9% of municipal solid waste, is relatively new. Generally, six types of resins are used: polyethylene terephthalate (PET) in soft drink bottles; high density polyethylene (HDPE), in boil-in-bag pouches and milk jugs; polyvinyl chloride (PVC), in meat wrap; low density polyethylene (LDPE), polypropylene (pp), in syrup bottles and yoghurt tubs; and polystyrene (PS) in disposable dishes and cups. These plastics may be sorted by type before they can be recycled. To facilitate identification of type the society of plastics industry has developed an easy to use, numerical coding system for use by plastic container manufacturers. Market for recycled plastics include roofing material, package strapping, pipes, yard furniture, automotive parts and flowerpots.

3.0 PLASTICS WASTE—THE INDIAN DIMENSION

Plastics with its exclusive qualities of being light, yet strong and economical, has invaded every aspect of our day-to-day life. It has many advantages: it is durable, light, easy to mould, and can be adapted to different user requirements. Once hailed as a
Disposal of packaging waste

‘wonder material’, plastic is now a serious worldwide environmental and health concern, essentially due to its non-biodegradable nature. In India, the plastic industry is growing phenomenally. Plastics have use in all sectors of the economy, viz. infrastructure, construction, agriculture, consumer goods, telecommunications, and packaging. Estimated annual average growth since 1990 has been 15% per annum with Indian demand for plastics packaging material increasing from US$ 1.1 billion in 1996 to US$ 2.1 billion in the year 2000. The Indian plastic packaging industry comprises 18,000 firms. Countrywide network for collection of plastic waste through rag pickers, waste collectors, waste dealers and recycling enterprises has sprung all over the country over the last decade or so. More than 50% of the plastic waste generated in the country is recycled and used in the manufacture of various plastic products.

**Source of Generation of Plastic Wastes**

<table>
<thead>
<tr>
<th>Source</th>
<th>Waste Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household</td>
<td>Carry bags, bottles, containers, trash bags</td>
</tr>
<tr>
<td>Health and medicare</td>
<td>Disposable syringes, glucose bottles, blood and uro bags, intravenous tubes, catheters, surgical gloves.</td>
</tr>
<tr>
<td>Hotel and catering</td>
<td>Packaging items, mineral water bottles, plastic plates, glasses, spoons</td>
</tr>
<tr>
<td>Air/rail travel</td>
<td>Mineral water bottles, plastic plates, glasses, spoons, plastic bags.</td>
</tr>
</tbody>
</table>

In developed economies with a disposable life-style, plastics contribute only 8% by weight to municipal solid waste. The rest consists of organic matter, paper, wood, metal, glass etc. In spite of low waste volumes, the industry has taken initiatives on recycling. Plastics are crushable and highly compatible; they occupy less space in landfills. Plastic wastes are predominantly eco-neutral (no leachates to contaminate soil or ground water.) Plastic wastes contribute to increasing caloric value of municipal solid waste for incineration (useful source of energy 89 GJ/T, 20 GJ/T.

**Comparative consumption and recycling**

<table>
<thead>
<tr>
<th></th>
<th>World</th>
<th>India</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowest per capita consumption</td>
<td>18 kg</td>
<td>1.8 kg</td>
</tr>
<tr>
<td>Highest plastic recycling</td>
<td>15-20%</td>
<td>60%</td>
</tr>
<tr>
<td>Plastic in solid waste stream lowest</td>
<td>7%</td>
<td>0.5-4%</td>
</tr>
</tbody>
</table>

Designing eco-friendly, biodegradable plastics is the need of the hour. Though partially biodegradable plastics have been developed and used, completely biodegradable plastics based on renewable starch rather than petrochemicals have only recently been developed and are in the early stages of commercialization.
4.0 PLASTIC WASTE DISPOSAL GUIDELINES ADOPTED (GENEVA, 2002)

Experts from some 100 governments adopted a set of technical guidelines for protecting human health and the environment from the improper management and disposal of plastic wastes. “All plastic wastes can be recycled under environmentally sound conditions,” the guidelines assert.

“Open burning is not an environmental acceptable solution for any kind of waste,” the technical working group emphasized. “Incineration under environmentally sound conditions with energy recovery should be the preferred option compared to landfilling or incineration without energy recovery.”

Since incineration without energy recovery does not contribute to saving of resources or reduction of climate change gases, the technical group advises, “this process should be replaced by processes recovering energy as far as possible.” The expert group warns that incomplete incineration of plastic wastes that contain chlorinated compounds and brominated flame-retardants will release hazardous dioxans and furans into the air.

5.0 PACKAGING INDUSTRY RECYCLING AWARENESS

Across the packaging industry there is now a high level of awareness. Enlightened organizations conscious of current environmental issues specifically relating to packaging materials. They operate to certain goals in order to reduce pollution arising out of packaging. These include:

- Operate the business in compliance with all applicable laws and regulations;
- To work towards reducing the impact of product packaging by taking steps to eliminate heavy metals, inks, colorants, additives which leave hazardous residues when disposed of;
- Reduce the volume and weight of packaging;
- Use recycled and recyclable materials in packaging;
- Support efforts to educate consumers on how they become part of recycling solution.

Even though the reduction in materials itself has a positive impact on the issues, because smaller is more beautiful, yet there are still problems to face. Cheaper to make, may not carry with it proportional economies in disposal. There is little doubt that improved packaging is a vital part of India’s progress in developing the internal food market. The best sort of packaging is that which can be used a number of times, such as second-hand pallets, reusable plastic crates, cardboard or wooden boxes, milk bottles etc.

6.0 CONCLUSION

The challenge for the packaging industry will be for all the relevant people to work together to implement the increasing global regulatory policies on food contact safety, minimizing atmospheric pollution during package manufacture and deal effectively on package waste management. Needless to say, these objectives can be met
Disposal of packaging waste

only when all the three segments of the packaging industry, namely, the material manufacturer, converter and user work together in an integrated manner.

7.0 SUGGESTED READINGS


1.0 INTRODUCTION

The Internet is a worldwide network of networks. It comprises of a large number of smaller interconnected computer networks called intranets. These intranets connect thousands of computers spanning across the globe thereby enabling them to share various resources, such as powerful supercomputers, software and databases of information. The Internet being a global system of connected computers was once available only to the government, academic, and research communities. Now this greatly publicized information superhighway is accessible to anyone. Information on the Internet, and opportunities to use it are growing at a phenomenal rate.

The past few years have witnessed an explosion of Internet activity. It is now possible for people all over the world to effectively and inexpensively communicate with each other. On the Internet, each connected individual (i.e. netizen) can communicate with anyone else across the globe, publish ideas, search literature on the relevant topic, or seek solutions to the problems from anywhere in the world with a minimum overhead cost.

From dairy and food packagers’ standpoint, the Internet can be invaluable. You can use it to:

- Get technical support for products you are using
- Provide technical support, and services information to customers
- Publish information such as technical or marketing literature
- Communicate and collaborate on projects
- Market and sell services
- Access your business while away from the office, etc.

Since the Internet is electronic, you can make changes to reflect late breaking news that could be impossible for printed publication. Change becomes easier, updates are simpler, and information is instant.

2.0 INFORMATION RETRIEVAL USING THE INTERNET

Internet is based on the concept of a client-server relationship between computers, which is also known as client/server architecture. In this type of relationship, some computers act as servers, or information-providers, while other computers act as clients, or information receivers. In order to access information through the Internet, a user has to first logon (or connect) to the Intranet server i.e. Local Area Network (LAN) e.g. organizational server or ISP’s server. Once the connection is established, the user further requests for information from a remote server. If the desired information resides on one of the computers on the host
Network, then that information is retrieved quickly and is sent to the user's terminal. However, if the information is on a server that does not belong to host LAN, then the host Network connects to other Networks until it makes a connection with the Network containing the right server. In the process of connecting to other Networks, the host may need to access a router, a device that determines the best connection path between Networks and helps Networks to make connections.

Once the client computer makes a connection with the server containing the requested information, the server sends the information back to the client in the form of a file. A special computer program known as browser enables the user to view the file. Examples of Internet browsers are Internet Explorer, Netscape Navigator, Opera and Mosaic, etc. Most of the Internet files are multimedia documents viz., text, graphics, photographs, audio and video which are combined into a single document. The process of retrieving files from a remote server to the user's terminal is called downloading.

The important aspect of Internet is that it is structured around the concept of hypertext. The term hypertext is used to describe the inter-linked system of documents in which a user may jump from one document to another in a non-linear, associative manner. By clicking on the hyperlink, the user is immediately connected to the document specified by the link. Multimedia files on the Internet are called hypermedia documents.

2.1 Accessing Internet

Access to Internet falls into two broad categories: dedicated access and dialup access. In the dedicated access, the computer is directly connected to the Internet via a router, or the computer is part of a Network linked to Internet. However, with dialup-access, a computer connects to the Internet through a temporary connection generally over a telephone line using a modem - a device that converts the digital signals generated by computer into analog signals that can be transmitted over telephone lines.

A large number of companies called as Internet Service Providers (ISPs) are coming up and are providing dialup access to the Internet at nominal fee. Examples of ISPs in India (national/international) are VSNL, Satyam Online, DishNet DSL, Pacific Internet, Rediff, NON, etc.

2.2 Network Addressing

In order to be a part of Internet, a computer must have a unique Internet Protocol (IP) Network address so that the messages can be correctly routed to and from the machine over the Internet. Internet addresses are called Uniform Resource Locators (URLs). Some URLs are a string of numbers, which are difficult to remember, and therefore alternative conventions are used. An example of such a convention is http://science.msn.com. The http refers to hypertext transfer protocol, which is used to access particular location on the Internet. The name after the colon and double slash indicates the host name, which is the name of a specific computer system, connected to the Internet.

2.3 Seeking Information With Search Engines

In many cases, we end up wasting not only our precious time but also the computer-time following useless URLs (due to lack of proper knowledge about the
exact URL of desired site) that do not lead us to right place. In order to avoid this, one should know what you are looking for and how to get it. If you are looking for a broad subject, the best place to look for is a search-engine, which is in the form of a Web directory and if something more specific is needed, then goes for one of the specialized search engines. Several search engines are available for surfing the Net.

The following table provides a list of some search engines including Indian search engines that are available for faster and easier search of information:

<table>
<thead>
<tr>
<th>URL’s of Some Popular Search Engines</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <a href="http://www.yahoo.com">www.yahoo.com</a></td>
</tr>
<tr>
<td>2. <a href="http://www.excite.com">www.excite.com</a></td>
</tr>
<tr>
<td>3. <a href="http://www.infoseek.com">www.infoseek.com</a></td>
</tr>
<tr>
<td>4. <a href="http://www.lycos.com">www.lycos.com</a></td>
</tr>
<tr>
<td>5. <a href="http://www.altavista.com">www.altavista.com</a></td>
</tr>
<tr>
<td>6. <a href="http://www.google.com">www.google.com</a></td>
</tr>
<tr>
<td>7. <a href="http://www.hotbot.com">www.hotbot.com</a></td>
</tr>
<tr>
<td>8. <a href="http://www.galaxy.com">www.galaxy.com</a></td>
</tr>
<tr>
<td>9. <a href="http://www.opentext.com">www.opentext.com</a></td>
</tr>
<tr>
<td>10. <a href="http://www.askjeeves.com">www.askjeeves.com</a></td>
</tr>
<tr>
<td>11. <a href="http://www.khoj.com">www.khoj.com</a></td>
</tr>
<tr>
<td>12. <a href="http://www.cyberindia.com">www.cyberindia.com</a></td>
</tr>
<tr>
<td>13. <a href="http://www.123india.com">www.123india.com</a></td>
</tr>
<tr>
<td>15. <a href="http://www.indiaconnect.com">www.indiaconnect.com</a></td>
</tr>
<tr>
<td>16. <a href="http://www.dejanews.com">www.dejanews.com</a></td>
</tr>
<tr>
<td>17. <a href="http://www.net">www.net</a> searcher.com</td>
</tr>
<tr>
<td>18. <a href="http://www.devsearch.com">www.devsearch.com</a></td>
</tr>
<tr>
<td>19. <a href="http://www.flez.com">www.flez.com</a></td>
</tr>
<tr>
<td>20. <a href="http://www.mwsearch.com">www.mwsearch.com</a></td>
</tr>
</tbody>
</table>

Some of the search engines are designed for specialized searches. They search for a particular topic only. For example, agrikhoj.com is searching solution for small site or Intranet exclusively meant for agriculture. This has been developed at IASRI (ICAR), New Delhi. Similarly, 'dejanews.com' is a search engine, which searches exclusively for newsgroups; 'devsearch.com' and 'Netsearcher.com' are search engines particularly for Web developers and Internet professionals. 'Flez.com' is available for searching files on FTP sites and 'mwsearch.com' allows you to search within a number of medical sites.

Finding relevant data/information not only depends on search engines but also on the type of keywords you search for. In order to do an effective search it is necessary to know about how search engines operate. The basic approach followed in most of the search engines is that of relevance ranking. This means that the engine will present the results so that the first site on the list is considered the most relevant and the relevance decreases as we move down the list. The other consequence of relevance ranking is that there may be nothing on the Web, which answers your query, but the search engine may still find a large number of results. This is because the search engines will not insist that all the keywords are present in the resulting Web sites. Even if a single word occurs in the Web site, that site will be brought back to you as a result. The first few results will hopefully contain all the keywords and may not always be the case and if no sites contain all the words then the best available will be presented as the most relevant site.

There are a number of ways in which you can narrow down your search. Boolean logic is one of the most common and effective way and involves using .AND., .OR., .NOT. and parentheses for grouping. For example, "Indigenous". AND. Dairy Products .NOT. Chhana based" will only list links containing Indigenous dairy products but exclude links regarding Chhana based dairy products. One can also use
the "+" sign in the statements. For example "Indigenous + Dairy Products" will give more focused results than "Indigenous Dairy Products". Similarly one can use "-" sign to exclude certain words.

One can also give statement enclosed in quotes if it is desired to find pages where the words appear next to each other like in "job vacancies". Multiple words give more refined results than using a single word. Also, use similar words when you search the more synonyms, one gets the more chances of getting the results. A search can be made just in a single step with the help of the pipe key, |.

If the multiple forms of a word are being searched, one can indicate with wild character *. Search engines have different symbols for truncation. Most of the search engines offer their "advance search" where all these options are listed in pull down menus. All the search engines have help facility for users, which make it easy for novice to search information.

2.4 Offline search

Many a times we face the problem of 'Connection timed out' due to low bandwidth. Offline surfing accelerates browsing while saving on connect time and telephone bills. There are two ways in which one can browse and the other is to use a software utility. Both Internet Explorer and Netscape have off line browsing options. All the browsers have the files in a temporary folder. Internet Explorer 4 or higher versions) saves the pages visited by you in a temporary Internet files folder in the Windows directory. These files can be accessed even when you are offline. In Internet Explorer 4 one can enable this by selecting the "work offline" from the file menu and then type in a URL that has already been visited and thereafter its contents will be picked up and displayed from this folder. These utilities come in handy when multimedia heavy sites are being searched and take very long time to show on your browser.

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<tr>
<th>S. No.</th>
<th>Title of Organisation</th>
<th>URL</th>
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<tbody>
<tr>
<td>1.</td>
<td>American Dairy Science Association</td>
<td><a href="http://www.adsa.edu">www.adsa.edu</a></td>
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<tr>
<td>2.</td>
<td>International Dairy Federation</td>
<td>www.fil_idf.org</td>
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<td>5.</td>
<td>An Indian Dairying Portal</td>
<td><a href="http://www.indiaday.com">www.indiaday.com</a></td>
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<td>7.</td>
<td>NAFED</td>
<td><a href="http://www.nic.in/nafed/">www.nic.in/nafed/</a></td>
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<tr>
<td>8.</td>
<td>AMUL/GCMMF</td>
<td><a href="http://www.amul.com">www.amul.com</a></td>
</tr>
<tr>
<td>10.</td>
<td>National Dairy Research Institute, India</td>
<td>ndri.nic.in</td>
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Popular International Dairy and Food Science and Technology Periodicals

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<td>1.</td>
<td>Dairy Herd Management</td>
<td><a href="http://www.dairyherd.com">www.dairyherd.com</a></td>
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<tr>
<td>2.</td>
<td>Dairy Magazine</td>
<td><a href="http://www.moonmilk.com">www.moonmilk.com</a></td>
</tr>
<tr>
<td>3.</td>
<td>Dairy Today</td>
<td><a href="http://www.dairytoday.com">www.dairytoday.com</a></td>
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<tr>
<td>4.</td>
<td>Farm Journal</td>
<td><a href="http://www.farmjournal.com">www.farmjournal.com</a></td>
</tr>
<tr>
<td>5.</td>
<td>Hoards Dairyman</td>
<td><a href="http://www.hoards.com">www.hoards.com</a></td>
</tr>
</tbody>
</table>

2.5 Application of internet

From the late 1960s up to early 1990s, Internet was a communication and research tool used almost exclusively for academic and military purposes. It changed radically with the introduction of the World Wide Web (WWW) in 1989. WWW is a set of programs standards and protocols governing the way in which the multimedia files are created and displayed on the Internet. Dairy and food scientists and scholars can use the Internet to communicate and exchange the information related to research and studies.

The Internet can also be used to have an access to various complex databases and software, which are useful for scientific data analysis and drawing appropriate conclusions out of it. Similarly, packaging business organisations can use Internet to carry out commerce online (i.e. e-commerce) including advertising, buying, distributing and/or providing services.

3.0 CONCLUSION

Internet is a wonderful facility available to the Dairy and Food packagers to retrieve vast information that supports their routine activities. They should exploit this facility and tap its potential for growth and development of their academic, professional and business activities as well as Food sector as a whole.

4.0 SUGGESTED READINGS


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(FEB 13\textsuperscript{th} TO MAR 5\textsuperscript{th}, 2003)

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