Advances in Formulated Foods

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ORGANIZING COMMITTEE OF THE CAS SHORT COURSE ON ADVANCES IN FORMULATED FOODS
(JUNE 19 to JULY 10, 2000)

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1.0 INTRODUCTION

The dual herding forces for change in the food industry have always been consumer preferences and new technological innovations. In the past century particularly, the increase in population, urbanisation, 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 harbinger of technological transformations. Increasing applications of other technologies such as mechanical engineering, chemical engineering, agriculture and marine resource contributed to large scale continuous production, for new preservation methods, for a large variety of ingredients and for new food products. The food industry will continue to change, driven by consumers' choices and by unfolding novel technology. Within the next twenty five years, the world population is expected to increase by two billion people. The population will become increasingly urban, with the number of urban dwellers surpassing the rural. Not only will the total demand for food be greater than it has ever been, but the nature of that demand will alter tremendously.

2.0 FUTURE TRENDS IN PRODUCT FORMULATION

2.1 'Authentic'

Convenience has always been the strongest drive for change. With more and more womenfolk opting to work outside the home, less time and manpower are available for shopping and cooking. Along with the concept of eating healthy foods to balance the declining medical system, there has emerged, a need for convenience foods that nourish, heal and fortify. But despite the need for convenience, the foremost requirement for foods is that they should taste, smell and feel right. The number one challenge for the food industry, therefore, is to produce foods that come under the concept of 'authentic', both in terms of flavour and texture. Demographic changes, the top-most among them being large scale immigration, have been instrumental in bringing authentic ethnic flavours into mainstream food processing. Finding a way to reproduce 'authentic' flavour and texture while translating that to more mass-produced items is a considerable challenge. When these authentic flavours and textures (whether synthesised or produced with the addition of stabilisers, starches or less expensive solids) are part of a food, the food should, essentially taste and feel as if it was produced by one's mother. Therefore, extrapolation of a mother's recipe to a commercial formulation then becomes an area of considerable expertise. The whole process would become a series of translations: selecting a product, matching it with suitable commercial ingredients and processes and adapting that formulation to an appropriate nutritional profile.
2.2 'Healthy'
Equally important is the recent transition towards 'healthy' foods. Energy and health have always been derived from food, but what will improve are sophistication in appreciating specific nutritional needs and tailoring foods and their components more closely to the finer detail of bodily absorption rates and special requirements. This introduces as a basis of food design, the whole spectrum and complexity of not only the body's requirements, but also of adjuncts that can serve as temporary or permanent aids in health. The close alliance of nutritional knowledge and the delivery of promised benefits in food products offers an unparalleled opportunity for developing a product mix that is the basis of good health. Vitamin and mineral enrichment and the use of dairy fractions including lactoferrin and lactalbumen in dairy as well as functional foods is fair widespread.

2.3 'Bio'
There is clearly a movement towards the need for food ingredients to be 'bio' and/or 'organic' in origin. The validity of 'genetically modified organisms' (GMOs) being under debate, the quest for newer prebiotics, probiotics and herbal products being used in foods and supplements is definitely a top trend. Interestingly, enzymes are not included in the GMO debate, as almost the world over, they are considered as processing aids. Prebiotics including oligosaccharides, fructo-oligosachharides, dietary fibre, and resistant starch fall into the arena of health foods. The addition of these carbohydrate materials is useful in maintaining the bacterial flora in the intestinal tract. Some studies have indicated that resistant starch is useful in moderating blood glucose levels and possibly altering the fatty acid levels in the blood stream. Interesting products that have come up in the western markets are pea flours, sweet lupin meals, inulin (a fructo-oligosachharide also used as fat-replacing ingredient for texture improvement) and other oligosaccharides. Probiotic organisms such as lactobacilli and/or bifidobacteria are increasingly being introduced into dairy products such as yoghurts, cheeses and beverages. Special varieties are being developed and patented, either as specific organisms or as part of a food formulation.

2.4 Beverages
Current trends indicate that more new beverages than any other class of food are being formulated. These include sports or performance drinks, nutritionally enriched beverages, fruit juices and juices with added proteins. Sports drinks and tea-based beverages grew from a very small quantity to about 500 million litres over the last decade of the twentieth century in Europe. The trend is the same all over the world and the steep hike is expected to continue for at least another two decades. Drinkable yoghurts have almost reached a mature point in their life cycle, with interesting new flavours being added to elongate the top of the curve. Water-type beverages containing minerals are being widely marketed. India seems to have found a very huge market potential for mineral water in the past few years and the trend is likely to stabilise through the early years of this millennium. The role of dietary calcium in preventing osteoporosis being widely understood, recent research has also suggested protective effect of calcium against other health conditions including hypertension, colon cancer and even pre-menstrual syndrome. Calcium-enriched beverages whether dairy-based or otherwise are expected to gain considerable interest and it may be envisaged that products with increasing claims of bio-availability of the mineral will be marketed in the near future.
2.5 Luxury Items

In the western countries, luxury items aimed for the elite society are a fast-developing trend. Most of these are dessert items, pastries and ingredients for these. Since dessert items are more costly than the main course products in these countries, products containing caramel sauce, ice creams in tiny servings, mousse products and custard tarts with extravagant toppings are likely to be expensive. Tremendous opportunities for alternative products and ingredients are envisaged to cater to this segment of the food industry. On a smaller expense-scale, sauces for meats, marinades and speciality processed fruits will grow in popularity. Alcohol products are acceptable in sauces in the western countries and new technologies have provided ways to add stout red wines or delicate white wines to sauces.

2.6 Foods for Demographic Groups

Foods targeted towards specific demographic groups are becoming exceedingly popular, especially in packages that make their usage easier. Infant and weaning foods have been approached warily in the past few years due to the ethical overtones attached to them, but ways and means to counter these apprehensions are being sought. With more mothers returning to work after childbirth, foods for infants and young children that reduce the cooking chores will be welcomed. As the population ages, more foods for the elderly will be produced. Already, specific products such as diabetic foods, reduced-fat and fat-free items and foods for persons with specific health requirements are appearing in large quantities in the western markets. Certain gums added as fat replacers in foods bring the added advantage of high soluble fibre and ability to lower cholesterol, hence widening their scope in formulated foods. Ethnic food preferences will continue to be dictated by immigrants. Italian, Mexican, Chinese, Japanese, Indian and Thai foods are becoming exceedingly popular in Europe and America. Although the overall numbers are much smaller than the others, interest in Indian cuisine has doubled in the past five years, thus making it the fastest-growing ethnic category. Fine dining establishments offer a future that blends the cooking from several regions. This fusion cooking might show up as avocado puree topped with an orange sauce or mango chutney over a fish-based item. Asian flavours such as ginger and soy sauce in cooking sauces, salad dressings and snack products are possible examples of such mix-and-match options.

2.7 'Vegetarianism' and 'Ban Red-Meat Products'

Self-described vegetarianism in traditionally non-vegetarian areas of the world is on the increase and is expected to be 20-25% of the population. Soy and other vegetable products are going to be used increasingly in conventional non-vegetarian products such as patties. Propelled by the recent fear of the 'mad-cow' disease in Europe and also the increasing popularity for vegetarianism, poultry and marine products are likely to gain favour the world over. These products will be marinated or seasoned very carefully and are likely to be prepared prior to purchase. The search for alternative sources of gelatin has already yielded results, with fish gelatin and plant-based hydrocolloids being exceedingly in demand.

3.0 THE TECHNOLOGY DRIVE

Although technology accumulation started with the beginning of history, its pace of growth has accelerated as never before, in the past few years. Some areas of new technology worth mentioning are manufacturing, reaction, information, software, consumer and genetic technologies.
3.1 Manufacturing Technology
All elements encompassing the resources and organisation which go into producing the food in quantities needed and to a defined specification and standard may be classified under manufacturing technology. It also includes productivity which measures success in terms of using the minimum resources to achieve the targeted output. Systematic technologies in several key areas have evolved, notable among them being the standard quality systems based on ISO specifications and HACCP process studies. These are spreading widely through the food system and consequently, techniques will be improved and applications extended. Mastery over the manufacturing process, along with receptiveness to newer organisational challenges vital to market extension and access are strongly projected messages for the next millennium.

3.2 Reaction Technology
The chemical and biological reactions that transform raw materials to finished food products are being studied and interpreted in minute details. Research, both academic and industrial, has erected a basic theoretical structure, whose applications in the industry for new processes and products can now be more easily monitored. Systematic reaction technology based on the relative rates of the changes induced during processing, provides better process control and more stringent quality maintenance. It also furnishes an insight to possible innovation and future products.

3.3 Information Technology
The growth of information technology has provided powerful tools for innovation in the food industry by means of access to extensive data, its control and manipulation. Besides better control of products, processes and their quality, information technology also offers brighter prospects for efficient storage and distribution. The time gap between raw material and consumption will be reduced substantially, so that foods at the sale point are closer to fresh. More immediate feedback from sales details will make production more efficient. The access to wide-ranging market, consumer and technical information, readily available in data banks, will make product development faster and more challenging, leading to greater creativity.

3.4 Software Technology
Globalisation of food trade coupled with liberalisation of world economies has intensified inter-corporate competition. Price wars between leading corporate giants has compelled overhead costs to be reduced through integration of smaller processing plants for larger processing capacities. At the same time, highly skilled technicians coupled with automation, are being employed to replace multitude of labour. Mechanisation is fast replacing labour-intensive manual processes. Processing is now being performed through the application of computer programmes. Future technologists are going to be essentially computer programmers capable of controlling highly sophisticated mechanised process equipment through software applications.

3.5 Consumer Technology
The consumer is the ultimate in all product-to-market chains, but his importance has been recognised fully only in the past few decades. The consumer is now a part of the industry network, particularly product design and development. More precise characterisation of consumer responses will be necessary to design specific product attributes such as colour and flavour. Such
measurements can then be incorporated into dynamic models used in planning processes, in which such attributes are deliberately changed to create a new food product. These concepts will be the future tools to create products which have not only novelty, but also a high probability of consumer preference and market acceptance.

3.6 Genetic Technology

Genetic technology is expected to generate spectacular improvements in raw materials and food ingredients, along with significant changes in their varieties and properties. Having defined the properties needed, these can be related to particular attributes and constituents of the plant, animal or micro-organism and subjected to fundamental changes through the genetic material. The introduction of new genetic material into new environments will obviously lead to certain problems of adaptability and acclimatisation, but assuming that these can be solved, the benefits to be accrued from genetic technology are manifold.

4.0 CONCLUSION

Providing for the nutritional well-being of a growing population has always been a formidable challenge facing the global community. More discoveries regarding food and its processing are coming from the ever-widening international spread of information, bringing the food of every culture and every region closer to each other. Consumers of the new millennium are better informed and thus, will expect greater choices. There will be increased demand for higher added value and product performance, creating novel challenges for the design of food products. Commitment to research in scientific disciplines will be the key to successful innovation in the food industry in the new millennium. The real message is to search for creativity in aesthetic food design, based on both national and international food culture. Food scientists and entrepreneurs suggest a holistic approach to product development, encompassing product performance, cost, quality, safety and environmental practice.

5.0 SUGGESTED READING


1.0 INTRODUCTION

Formulated foods/fabricated foods are foods designed and built according to plan from individual components, to yield products having specified physical, chemical, and functional properties (Glicksman, 1971).

The concept of fabricated food is not new. These foods have been part of our society since the beginning of recorded history. The earliest known fabricated food is bread. Bread per se does not exist in nature, and while nature made wheat, corn, rye and other cereal grains, it was man who took the harvest and formed it into a food with texture, shape and flavour that made it a joy to eat. Historically, fabricated foods were developed initially not to titillate the palate, but to use available ingredient in a convenient and utilitarian manner.

There are two basic types of fabricated foods: those designed to simulate natural counterparts currently referred to as “analogs” such as meat and dairy analogs, and those which have no counterpart in nature but are prepared to give variety and spice to the diet. One of the most common of most popular examples of the later is jell-o-gelatin dessert. Another popular and universal product is ice cream, designed to please the palate hundreds of years ago and still probably most widely consumed fabricated food in the world. Many types of fabricated food products are now available some of the more important categories are given in Table 1.

2.0 DEFINITION OF TERMS

2.1 Fabricated foods

Foods that have been taken apart and put together in a new form. Designed, engineered, or formulated from ingredients, they may or may not include additives, vitamins and minerals. Formulated foods and engineered foods are same as fabricated foods.

2.2 Restoration

Restoration is addition of selected nutrients to a food to restore nutrients lost through processing. If enough Vit.C. were added to a frozen apple pie to bring the Vit.C. back to its original level in the apples, the pie could be called a restored food.

2.3 Fabrication

Fabrication is addition of selected nutrients not normally present in a particular food. If protein were added to the apple pie, protein not being a natural nutrient to pie, this would be called fortification. Another example is adding Vit.D.to milk.
2.4 Enrichment
Enrichment is addition of nutrients to foods so as to make that food conform to some special standard for the food. Vitamins and minerals added to an ordinary flour to achieve the standard for enriched flour constitute flour enrichment.

2.5 Nutritional enhancement
Nutritional enhancement is addition of nutrients to a food by fortification, enrichment or restoration, nutrification is same as nutritional enrichment.

2.6 Nutritionally modified foods
Nutritionally modified foods have had nutrients added to them so that they contain food values at least equal to the natural foods they may replace in the diet. Textured vegetable protein has mineral or vitamins added to it so that it has all the nutrients of the meat it replaces in the diet.

2.7 Simulated foods
Simulated foods are designed to completely replace some other food; they are made to look, taste, and feel like the food they replace. Examples are meat analogs, soy milk, etc.

2.8 Synthetic foods
Synthetic foods are those made from materials generally thought of as non-food sources. Artificially sweetened soft drinks and fruit drinks are synthetic fruit juices.

2.9 Imitation foods
Imitation foods are made look like and replace a food that has a standard but they do not meet the standard requirement.

2.10 Convenience food
Foods that require less labour in storing, handling, preparing, serving or eating than the foods they replace.

Table 1 Types of fabricated foods

<table>
<thead>
<tr>
<th>Type of Food</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meat analogs</td>
<td>(Texturized vegetable protein foods)</td>
</tr>
<tr>
<td>Dairy analogs</td>
<td>(Formulated non-dairy products)</td>
</tr>
<tr>
<td>Soft moist foods</td>
<td>(Intermediate moisture foods)</td>
</tr>
<tr>
<td>Novelty foods</td>
<td>(Imitation Caviar, french-fried molded onion rings)</td>
</tr>
<tr>
<td>Low calorie foods</td>
<td></td>
</tr>
<tr>
<td>Special purpose dietary foods</td>
<td>(low cholesterol, low sodium, low fat, sugar free, etc.)</td>
</tr>
<tr>
<td>Convenience foods</td>
<td>(snack packs, T.V. dinners, etc.)</td>
</tr>
<tr>
<td>Baby foods</td>
<td></td>
</tr>
<tr>
<td>Geriatric foods</td>
<td></td>
</tr>
<tr>
<td>Snack foods</td>
<td></td>
</tr>
</tbody>
</table>
3.0 WHY DEVELOP FABRICATED FOODS?

- Lower cost: The cost of certain fabricated foods may be lower while providing about the same nutrition and satiety, e.g., margarine.

- The nutrition of the food may be enhanced: Example fortification of fruit juice with Vit.C., margarine with Vit.A. cereals with iron or other nutrients.

- Foods can be made more convenient.

- Foods can be formulated to fill special needs.

- Fabricated foods can provide other meal advantages. They can improve the balance of a meal, they can increase palatability and finally can provide satiety and other advantages.

4.0 PRINCIPLES OF FOOD FORMULATION

Fabricated foods are made by combining the three basic building blocks of all food products - protein, fats and carbohydrates - in ways that provide convenience, texture, flavour and other desirable characteristic. This involves manipulation of these 3 basic components along with water, flavours, preservation, vitamins, etc. to design products with predictable compositions, texture, flavours and storage properties.

In fabrication the aim is to achieve uniformity and high degree of predictability in product attributes which, in term, is dependent upon complex interrelationship of several aspects of physical chemistry, such as solid-liquid phase equilibria, multi-component solubility behaviour, polymorphism, nucleation and crystal growth, wetting and emulsification, stability of disperse phases, and mechanical properties of crystal assemblies.

In the design of the fabricated product, therefore, it is necessary to take into consideration the complex structures and interactions involved among food components, and whether the final system should constitute an equilibrium state, and if not, what kinetic controls can be built into the system to prevent attainment of equilibrium during normal processing, shelf-life and storage conditions. One or several intermediate steps can, in principle be stabilised by providing for a kinetic barrier. In the case of dispersed systems, such as emulsion, this is often achieved by raising the viscosity of the continuous phases or by incorporating absorbed layers of proteinaceous materials, which act as barrier to coalescence of the disperse particles. Polysaccharides are often used as viscosity modifying agents. The polymer chains of polysaccharides associate to from limited sequences of ordered structures, which in turn make up a random network and give rise to gels of different strength, textures and thermal stabilities. Similarly “edible surfactants” i.e. proteins are usually used for stabilizing metastable, highly heterogeneous, disperse systems of complex food products. The properties of polyelectrolyte macromolecules such as proteins or polysaccharides, whose internal conformation can be markedly influenced by alterations of the total charge distribution, are often modified by adjustment of pH and/or type and amount of electrolyte to suit the requirement.
5.0 INGREDIENTS OF FABRICATED FOODS

The ingredients used in fabricated foods must be readily available, economical, safe, and must serve a useful function. Various types of proteins, carbohydrates, fats, etc. used in fabricated foods have been discussed here under.

5.1 Protein

Plant proteins have played a very important role in the growth of fabricated foods. Soy proteins have been greatly used in fabricated foods because of its ability to incorporate texture into them. Although the major plant protein ingredient in fabricated foods is now soy proteins, other sources of plant protein, such as cotton seed, peanuts, rape, sesame, safflower, sunflower, wheat, corn, etc. have been used.

In addition to plant proteins as ingredients in fabricated foods, other non-conventional protein items such as protein from microbial sources, whey proteins, fish protein and similar products are finding application in fabricated foods.

Blends of proteins will be the key to good nutrition in fabricated foods. Soy protein, for example, lacks methionine but has more lysine than is needed for proper nutrition. Blending soy protein with cereal products improves the lysine and methionine balance. Animal protein ingredients, such as whey and fish protein, can fill an important role in providing amino acid balance. Mixing protein ingredients may have a secondary benefit. Meats are said to provide “Unknown micronutrients” not present in vegetable protein. This is a problem for presently used foods as well as newly fabricated food derived from plant proteins. The best nutritional defence against this unknown micronutrient charge is to strive for greater variety and diversity in out foods and food ingredients. Plant proteins as the primary source of protein in a fabricated food, for example, should be broadened to include proteins from oil seeds, nuts, grains, microbial source and of course animal sources.

5.2 Carbohydrates

Carbohydrates in fabricated foods are not included primarily for their nutritional values. Carbohydrates are used largely for functional reasons in fabricated foods. The highly soluble common sugars, like sucrose, dextrose and corn syrup, are used mainly as bodying and sweetening agents. Thus they contribute such bodying attributes such as viscosity, texture, density and mouthfeel, among others, while also imparting sweetness and flavour to the organoleptic and sensory aspects of food.

Carbohydrates polymers, more commonly known as gums and starches (hydrocolloids), are used strictly for their functional properties. With the exception of starches, carbohydrate polymers are used at very low levels, generally under one per cent of the foods stuff. These long chain polymers have many diverse functional properties, but the one major property common to all gums is that of viscosity in aqueous medium. All gums will dissolve or disperse in water to give a thickening or bodying effect. The second major property exhibited by a selected few hydrocolloids is that of setting. Gelation is the phenomenon involving the association or cross linking of the polymer chains to form a 3-dimensional continuous network which traps or immobilises the water within it to form a firm, rigid structure that is resistant to flow under pressure.
In addition to thickening and gelling, gums have many secondary functional properties that are useful in food processing and development. As shown in Table 2 these properties range from adhesiveness to whippability.

**Table 2 Functions of hydrocolloids in food products.**

<table>
<thead>
<tr>
<th>Function</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>Bakery glaze</td>
</tr>
<tr>
<td>Binding agent</td>
<td>Sausages</td>
</tr>
<tr>
<td>Calorie control agent</td>
<td>Dietetic foods</td>
</tr>
<tr>
<td>Crystallization inhibitor</td>
<td>Ice cream, sugar syrups</td>
</tr>
<tr>
<td>Clarifying agent (fining)</td>
<td>Beer, wine</td>
</tr>
<tr>
<td>Cloud agent</td>
<td>Fruit juices</td>
</tr>
<tr>
<td>Coating agent</td>
<td>Confectionary</td>
</tr>
<tr>
<td>Emulsifier</td>
<td>Salad dressings</td>
</tr>
<tr>
<td>Encapsulating agent</td>
<td>Powdered flavours</td>
</tr>
<tr>
<td>Film former</td>
<td>Sausage casing, protective coatings</td>
</tr>
<tr>
<td>Floculating agent</td>
<td>Wine</td>
</tr>
<tr>
<td>Foam stabilizer</td>
<td>Whipped toppings, beer.</td>
</tr>
<tr>
<td>Gelling agent</td>
<td>Puddings, desserts</td>
</tr>
<tr>
<td>Moulding</td>
<td>Gum drops, jelly, candies</td>
</tr>
<tr>
<td>Protective colloid</td>
<td>Flavour emulsions</td>
</tr>
<tr>
<td>Stabilizer</td>
<td>Beer, Mayonnaise</td>
</tr>
<tr>
<td>Suspending agent</td>
<td>Chocolate milk</td>
</tr>
<tr>
<td>Swelling agent</td>
<td>Processed meats</td>
</tr>
<tr>
<td>Syneresis inhibitors</td>
<td>Cheese, frozen foods</td>
</tr>
<tr>
<td>Thickening agent</td>
<td>Jams, pie fillings, sauces</td>
</tr>
<tr>
<td>Whipping agent</td>
<td>Toppings, icings</td>
</tr>
</tbody>
</table>

In many applications, more than one of these functional properties come into play, and the versatility and uniqueness of these ingredients is sometimes solely responsible for the feasibility and fabricating specific food products.

5.3 Fats

For many years, soybean oil has been major component for margarine - a well known fabricated food. In addition to soybean oil other sources of vegetable oil such as cotton seed, peanut, sesame, safflower, sunflower, palm, coconut, etc. have been used in fabricated foods. The fats are generally tailor made by various process such as hydrogenation, fractionation, interestrification, etc. to suit to specific requirement.

6.0 FLAVOURING FABRICATED FOODS

While developing a fabricated food, the flavour and fabrication must be treated as a whole to arrive at organoleptic effects that more effectively mimic what we have accustomed to eating. Therefore, development of synthetic flavours closely parallels to development of fabricated foods. As a result several synthetic food flavour, meat flavour, cheese, butter, chocolate flavours, etc. are available in market which can be used to make the fabricated products more closely resemble to natural products.
7.0 TEXTURE DEVELOPMENT IN FABRICATED FOOD

In developing fabricated foods, it is important that desirable textural properties be engineered into the food from the early stages in development. While engineering texture in liquid or semisolid formulated foods is easier, similarly texture of meat like products is more challenging. Most commonly used methods of texturizing proteins are fibre spinning, extrusion of chewy gel formation.

7.1 Fibre spinning
This process is based on changing the protein configuration by solubilizing the protein, unfolding the protein chains and reforming them in roughly parallel fashion thus simulating muscle protein fibre. In addition to pre determined levels of protein, fat and carbohydrate, colours, flavours, vitamins, minerals, amino acids and other constituents could be added as desired. During spinning other textural properties can be imported to the product fibres. Varying pressure in assembling the final extruded fibres can alter the density of texture. Toughness and tenderness can be controlled to a certain degree by the amount of stretch applied to the fibres during the initial spinning steps. Major textural effects can also be produced by additives such as gums or starches which can effect chewability, stretchability, elasticity, cohesiveness, adhesiveness, moisture retention, rehydratability, freeze-thaw stability and water activity.

7.2 Extension
Another major technique for fabricating textured vegetable proteins is by extrusion of protein compositions under heat and pressure. It does not produce well defined fibres but gives fibrous particulates that have good mouthfeel and chewiness similar to meat. The protein in aqueous dispersion is subjected to heat and pressure which causes some realignment of the protein molecules as it is extended from high pressure area into the atmosphere, creating a rapid expansion of the product with a rapid flashing of the water. The mixture is subjected to a pressure above 1000 psi and temperature of 115 to 180°C during processing.

7.3 Chewy gel formation
A third type of process for creating textural protein foods consists of preparing “chewy gels” under special condition of pH, protein concentration, water content, and heat. The resultant gel has a smooth, uniform hydrated structure that is pleasantly moist in the mouth and yet has enough textural firmness to give proper resistance to bite. Texture and mouthfeel can be modified by incorporating hydrocolloids into the gel.
1.0 INTRODUCTION

Processed food serves as an important vehicle to meet the nutritional requirements of normal individuals as well as of those who are in need of special diets. Increasing consumer awareness of the importance of diet in maintenance of health and as a therapeutic adjunct in the control of many chronic diseases, has opened immense opportunities for the manufacture of foods with specific nutritional merits. Such processed foods are grouped as dietetic foods. Dietetic is defined as “the scientific study and regulation of food intake and preparation”. It has also been broadly described as “the application of the science of nutrition to the human being in health and disease”. Dietetic foods or foods for particular nutritional uses include products for dietary management for the following people: those with specific metabolic disorders, e.g. diabetics: those who are unable to digest or absorb nutrients from a normal diet, those who have special dietary requirements, e.g. sports persons, and those whose food intake requires special compositional standards, e.g. babies. In the USA, the Code of Federal Regulations (CFR) details standards for foods for special dietary uses, which include foods for infants, diabetics, weight reduction or control, as well as hypoallergenic and low sodium foods.

2.0 CLASSIFICATION OF DIETETIC FOODS

The EEC council classifies groups of foods for which specific provisions will be laid down by specific directives, and includes the following:

- Infant formulae and follow-on-foods
- Baby foods
- Low-energy and energy-reduced food intended for weight control
- Dietary foods for special medical purposes
- Low-sodium foods including low sodium or sodium free dietary salts
- Gluten-free foods
- Foods intended for persons suffering from carbohydrate metabolic disorders (diabetics)
- Foods intended to meet expenditure of intense muscular effort, especially for sports persons
- Food supplements.
As with all other food-stuffs, dietetic foods are controlled by general food legislation relating to labeling, claims, weights and measures, hygiene of manufacturing premises and procedures, etc.

3.0 INFANT FORMULAE AND FOLLOW-ON FOODS

Infant formulae are intended for infants for the first year of life, when their mother is either unable or unwilling to breast-feed them, but may be replaced, partially or totally, by follow-on formulae from 4 months onwards when the introduction of weaning foods commences. Since, infant formulae constitutes the only source of nutrition, the compositional standard is defined, as are the ingredients which may be used to supply the nutrients and technological additives. Purity criteria with-respect to microbiological quality and defined levels of chemical contaminants is also a requirement. Follow-on foods, which are formulated to complement weaning foods also have strict compositional standards and purity criteria.

The range of formulae available includes milk- and soya-protein based products as dry powders to be reconstituted with water, or in a liquid, ready-to-feed form. These may contain only lactose as the carbohydrate source or may be lactose-free. Other claims may be made for adapted-protein, low-sodium, added-iron and sucrose-free formulae and also added probiotic micro-organisms.

4.0 WEANING FOODS AND BABY FOODS

Infants are usually weaned between 4 and 6 months as baby’s feeding behaviour progresses from sucking to biting and chewing. An EEC working party draft directive proposes dividing weaning foods into two categories for setting of compositional standards. These reflect the types of foods which are currently available in the EEC market and include the following:

- Processed cereal-based products, which are subdivided into simple cereals, cereals with an added high-protein food, pasta, and rusks and biscuits.
- Baby foods, which are primarily intended for use during the usual infant weaning period and for progressive adaptation of infants and young children to ordinary food. Baby foods constitute a very diverse category of products, comprising complete or incomplete meals, soups, desserts, puddings, vegetable juices, fruit juices and nectars.

Foods are formulated to meet the particular needs for the different stages of weaning. Those recommended for early introduction are of a smooth texture and bland flavour, not too dissimilar from milk; as weaning progresses, stronger and more varied flavours with a wider range of textures to encourage chewing are available. Strict in-house compositional standards of these foods are imposed; babies are not exposed to unsuitable levels of sodium or refined sugars, and they receive a balanced diet with respect to vitamin and mineral content. In addition, microbiological standards are very high.

The European Commission intends to detail compositional standards with respect to protein, carbohydrate, fat, and some vitamins and minerals, as well as labelling standards.
5.0 SLIMMING FOODS

There are a variety of slimming foods on the market, including the following:

- Portion control foods for which the manufacturer calculates and declares the energy content of a complete food as a convenience to the consumer.

- Energy-reduced foods, which have a minimum of 25% energy reduction of the normal food, or low-energy foods, which have a maximum of 50 kcal (210 kJ) per 100 g or 100ml of product.

- Products which are a sole source of nutrition and are, at the time of publication, classified as very-low-calorie diets (VLCDs) at 400-800 kcal (1680-3360 kJ) per day, and low-calorie diets (LCDs) which contain 800-1200 kcal (3360-5040 kJ) per day. Complete diets below 400 kcal per day are not, at present, classified as foodstuffs and may be taken only under strict medical supervision.

Energy-reduced or low-energy foods, as well as meeting the definition as above, should have the nutritional equivalence for vitamins and minerals as the comparable normal food, and the proposed compositional standards for LCDs are as follows:

- Proteins, minimum 20-50 g at 100% of the WHO/FAO quality reference.
- Lipids, maximum 30% of total energy.
- Linoleic acid, minimum 4.5 g.
- Vitamins and minerals, to 100% of the Recommended (RDA), as detailed in the EEC labelling directive.

6.0 FOODS FOR SPECIAL MEDICAL PURPOSES

The growing awareness of the unique nutritional requirements for certain medical conditions has resulted in the formulation of foods either by specialized industries or within the hospital, following consultation with the medical profession. Two distinct types are recognized: enteral nutrition, in which foods are administered via the gastrointestinal (GI) tract, either orally or by means of a tube into the stomach or intestine; and parenteral nutrition, in which foods are administered intravenously. The latter is used to provide nutritional support in situations where enteral feeding is not possible, e.g. when the GI tract is unable to absorb nutrients, or complete bowel rest is required. It is more expensive and has more complications than enteral feeding, and the support equipment requires more skill to administer.

Enteral nutrition is of benefit to the following patients:

- Those with an intact GI tract who are unable to maintain a satisfactory nutritional status on a normal diet. This may include postoperative patients, those with central nervous system or psychiatric disorders, burns or stroke victims, and comatose patients.
  - Those patients with a disease or abnormality of the GI tract which impedes digestion and absorption of nutrients.

- Patients with limited oral access to the GI tract, owing to facial or oesophageal injuries, disease, or obstruction of the upper GI tract.
People who, either because of an inborn metabolic disorder such as phenylketonuria (a disorder in which the amino acid phenylalanine cannot be metabolized), or because of individual organ failures, have specific requirements.

The products, which are always at the recommendation of the medical profession, are generally divided into two classes, either nutritionally complete or incomplete.

### 6.1 Nutritionally Complete Foods

There are two main types which are generally available in powders or liquid ready-to-use forms:

- General-purpose formulae are manufactured from normal food ingredients.
- Defined formulae are manufactured from more specialized ingredients; for example, proteins may be hydrolysed to various degrees in order to reduce the chain length and thus aid digestibility, or simple sugars may replace complex carbohydrates.

### 6.2 Nutritionally Incomplete Formulae

- Modules or supplemental formulae, usually in the form of a single source of a particular nutrient (protein, fat or carbohydrate) may be used to supplement the patient’s diet when specialized nutritional needs are recognized by the health care professional.
- Specialized products are formulated for specific metabolic conditions or disease, or for the patients with specific organ failure or nutritional requirements. These are not nutritionally complete for the general population, but are usually appropriately balanced for the specific condition.

In addition to those receiving complete nutritional formulae under medical supervision, there are groups of normal healthy people who may temporarily lose the desire to eat normal foods, e.g. the elderly or those convalescing from minor illness; these people purchase nutritionally complete foods which are freely available in shops and supermarkets.

### 7.0 LOW SODIUM FOODS

Processed foods with a low, or reduced, sodium content were originally developed for patients with kidney disorders, hypertension, and other medical conditions which require reduced sodium intake. Various studies have shown that the average salt intake is 10 times that required for physiological needs to maintain optimum muscle and nerve activity, as well as normal blood pressure. Sodium chloride has been traditionally added to food as a preserving agent, as well as a flavour enhancer. The latter property, which increases the palatability of foodstuffs, may be achieved by the use of sodium-free salt substitutes, herbs and spices.

The EEC draft directive recommended two categories of food:
• Very-low sodium: the sodium content should not exceed 40 mg per 100 g or 100 ml in the ready-to-eat product.

• Low-sodium: the sodium content should not exceed 120 mg per 100 g or 100 ml of the ready-to-eat product.

8.0 GLUTEN-FREE FOODS

Gluten-free foods are required for the dietary management of people with coeliac disease, the causative agent being the gluten content of cereals such as wheat, rye, barley and oats. Most of the symptoms result from malabsorption of nutrients from the intestine caused by damage to the cell wall.

One of the problems which many sufferers of the disease face is the necessity to avoid all foods containing cereals and, in order to maintain dietary choice, they require reliable gluten-free raw materials. The food industry is particularly suited to the manufacture of foods for gluten-free diets, to act as substitutes for cereal-based foods, utilizing rice and maize flour. Vitamins and minerals are usually added to the equivalent level with regard to the foods they are replacing. The products available include bakery goods and raw materials for baking, and pasta, as well as foods which are naturally free from gluten. Freedom from gluten is a requirement for foods for infants, and some manufacturers provide gluten-free foods for babies and young children.

For labelling purposes, gluten-free means that the total nitrogen content of the gluten-containing cereal grain ingredient does not exceed 0.05 g per 100 g, i.e. 0.3% protein of the product. In addition, a food may be labelled ‘gluten-free by nature’ to show that it is naturally free from gluten and is suitable for use in a gluten-free diet. A logo may be used for ease of identification.

9.0 FOODS FOR INTENSE PERFORMANCE - SPORTS FOOD

To maintain enhanced physical fitness, coupled with intense performance, and the stresses that this places on the body, means that sportspersons have special nutritional requirements beyond those adequate for normal levels of activity. Initially, products were designed for body building and weight training, but as appreciation for the different needs for the nature of the sport has been recognized, so products formulated for other activities, such as track and field athletics, have become available.

In view of the variety of foodstuffs currently available on the market, a working party for EEC legislation proposes to classify these as follows:

☑ Food products specially formulated to supply energy. Emphasis has been placed on the type and amount of the carbohydrate used, since scientific research has shown that it can have a significant effect on the storage and utilisation of glycogen in the body. These products are also required to supply other energy producing nutrients, such as fat and protein, in the correct ratio. In addition to direct meal replacements, supplements are also available as carbohydrate...
concentrates sold in powder form, usually with added vitamins and minerals, energy bars and instant-energy drinks.

- Food products, tablets, capsules and hydration beverages with a defined content of minerals, trace elements, vitamins, and other substances with nutritional affects, or combinations of these, supporting the physiological performance.

- Food products with a defined content of protein and/or amino acids, especially formulated for intense muscular effort. Products in this group include high protein powders, concentrates, protein-enriched foods as bars, muesli, or special beverages, and single or multiple amino acid supplements which are available in tablet or capsule form.

- A combination of the products as detailed above.

10.0 FOOD FOR DIABETICS

In healthy people, glycaemia rises during meals and returns to a fasting level at around 0.8g per litre of blood at the end of the postprandial period. In the untreated diabetic, glycaemia remains chronically higher than normal. There are two types of diabetes:

- Low or no insulin secretion or insulin-dependent diabetes; patients are under medical supervision aimed at controlling insulin supply, so that the diet is not a major concern as long as carbohydrates are supplied at a regular interval.

- Normal or exaggerated secretion, but accompanied by a resistance of tissues to insulin which is controlled by the diet and not insulin. Foods formulated for this type of diabetic allow them to receive a normal daily supply of carbohydrates (50-60% of the energy intake), which require as little insulin as possible, in order to limit the effects of insulin insufficiency.

For control of carbohydrate which limits the addition of d-glucose, invert sugar, disaccharides, maltodextrins, or glucose syrup, to 6% in ready-to-use products, and then only if necessary for technical reasons, or from natural sources.

Declaration of glycaemic-index, which allows the consumer to evaluate the repercussions of a food on the glycaemia in comparison to a reference product. To qualify, the glycaemic index of the food must be reduced by one third in comparison to that of the corresponding normal food, with at least 20% of the energy provided by carbohydrates.

For both options, the total energy and fat content should be no more than those of comparable normal foods. The choice is very wide and includes confectionery, bakery products, dairy products, desserts and puddings, fruit juices, soft drinks and beer, sauces and salad dressings, sweeteners, and tablets and pills rich in soluble fibre for diet supplementation.

11.0 FOOD SUPPLEMENTS

The EEC has been considering the inclusion of supplements in the group of generally recognized dietetic foods, provided that these were not marketed with a medical claim and thus covered by the pharmaceutical product legislation. Under consideration were single vitamin and mineral supplements, multivitamin and/or mineral supplements.

12.0 SPECIAL INGREDIENTS
Dietetic foods

To support the diverse needs of the dietetic food industry, many raw material suppliers manufacture special ingredients. These include basic nutrients such as single minerals, vitamins, amino acids, fatty acids and sugars, as well as specially treated food ingredients. The latter include proteins, hydrolysed to varying degrees, to aid digestibility or reduce allergenicity, or tailored to a specific amino acid profile which may be a balanced blend of fats, a special fraction such as medium-chain triglycerides, or a randomized or co-randomized fat blend, and carbohydrates which may be simple or complex oligosaccharides and may or may not be partially hydrolysed. The formulation of dietetic foods also needs special technological additives as process aids, thickness, emulsifiers, stabilisers, etc. to improve palatability and shelf life.

13.0 SUGGESTED READING


1.0 INTRODUCTION

Nutraceuticals, in general, are materials that are traditionally known and consumed for their nutritive value, but that also have some therapeutic, curative or physiologically regulative functions to perform. The primary function of milk protein is to provide essential amino acids, the balance of which is nutritionally fit for the newborn of each species. Besides this major function, various proteins have a protective and physiological role to play in the neo-natal as well as subsequent phases of existence. Milk proteins are precursors of several bio-active peptides. Biologically active peptides in foods denote 'extra-nutritional' constituents naturally present in small quantities in the food. They are released by enzymatic digestion of the food proteins, either *in vivo* or *in-vitro*. Milk proteins, therefore, offer the potential for developing specialised functional food ingredients displaying prophylactic properties, besides their natural nutritional virtues. This represents a hitherto unexplored area of food research, which has tremendous future potential, both in academic and commercial perspective.

2.0 BIOLOGICAL FUNCTION OF MILK PROTEINS

The nutritional significance of milk proteins in human life is undisputed. Furthermore, some milk proteins facilitate the uptake of several important nutrients such as trace elements and vitamins. Although casein components have no specific biological activity, casein micelles are good carriers of calcium as well as phosphate. $\beta$–lactoglobulin enhances the retinol uptake in the intestines. Bovine colostrum contains up to 100 g/l of immunoglobulins, which provide passive immunity for the neonate. Lactoferrin, the major iron-binding protein of human milk, efficiently delivers iron for intestinal absorption. It also functions as a growth factor for human lymphocytic cell lines. Lactoferrin and lysozyme, are capable of direct bactericidal effect on *Streptococcus mutans*, *Vibrio cholerae* and *Micrococcus luteus*. Lactoferricin, a peptide derived from lactoferrin is highly effective against a broad range of Gram-positive and Gram-negative bacteria including pathogenic strains of *Listeria*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella* and *Campylobacter*, but not against many beneficial organisms such as *Bifidobacterium*. Vitamin B$_{12}$- and folate-binding proteins are assumed to deliver these vitamins to the infant by a specific uptake mechanism. Milk also contains certain protective proteins that defend the newborn as well as the donor's mammary glands against infection.
3.0 BIO-PEPTIDES FROM MILK PROTEINS

Proteins from milk have been reported to display a physiologically significant role in the well-being of children and the elderly. The *in vivo* production of peptides from proteins stems from the action of either the enzymes secreted by the gastro-intestinal tract (GIT) or those released by the intestinal microflora. The *in vitro* processes are the consequences of fermentation in food processing activities. Several of these peptides with characteristic amino acid composition and sequences have been reported to exhibit opioid, anti-hypertensive, anti-thrombotic, anti-aggregating and immuno-modulating activity and modify nutrient absorption besides performing many other miscellaneous functions. A few of these peptides or precursor peptides have so far been characterised *in vivo* in blood or brain after ingestion of milk. Some of these physiologically active peptides from milk, their sources and structures are listed in Table 1. There are suggestions that if in future, some of the active peptides cannot be characterised *in vivo*, they can nevertheless be synthesised and used either as food additives or in pharmacology.

3.1 Opioid activity

Opiates are drugs containing opium, whose basic active substance is morphine. They have been used since ancient times in medicine to relieve pain and induce sleep. Opioid receptors are located in the nervous, endocrine and immune systems as in the intestinal tract of the mammalian organism and can interact with their endogenous ligands as well as with exogenous opioids and opioid antagonists. Some peptides which have opioid characters and affinity for opiate receptors have been isolated from hydrolysates of casein. Opioid peptides, *i.e.* opioid receptor ligands with agonistic activity modulate social behaviour and produce analgesia after intracerebral administration to experimental animals. The common structural feature among the endogenous and exogenous opioid peptides is the presence of a Tyr residue at the N-terminal end (except for α-Casein opioids) and the presence of another aromatic residue *e.g.* Phe or Tyr in the third or fourth position. This is the important structural motif that fits into the binding site of the opioid receptors. The lack of this Tyr residue results in a complete absence of bio-activity.

Opioid antagonists have been found in bovine and human κ-Cn and in α-s1-Cn. Several sequences, especially 35-41, 57-60 and 25-34 of κ-Cn were of this category and were called casoxins A, B and C respectively. They express their activity by binding to opioid receptors and antagonising the action of opioid agonists. Casoxins have relatively low antagonistic potency as compared with nalaxone.

3.2 Anti-hypertensive activity

Angiotensin, a blood polypeptide exists in two forms, the physiologically inactive Angiotensin I and the active Angiotensin II. The latter is a potent vasoconstrictor and also inhibits the vasodilator bradykinin. The inactive form is converted into the active one, by the Angiotensin I-converting enzyme (ACE). ACE is a multifunctional enzyme located in different tissues. Its inhibition results in an anti-hypertensive effect and may influence different regulatory systems of the host organism involved in modulating blood pressure, immune defence and nervous system activity.
Casein-derived ACE-inhibitors are termed casokinins and represent different fragments of human and bovine casein. Highly active casokinins are present in the bovine $\alpha_\text{s1}$-Cn sequence 23-27 and the $\beta$-Cn sequence 177-183. Milk fermented with a strain of *Lactobacillus helveticus* CP 790 and containing about 0.3% peptides showed antihypertensive activity in rats fed with 5 ml/kg body weight (i.e. 15 mg of peptide/kg body weight). The concentration of ACE-inhibitor needed to inhibit 50% of the enzyme activity was 4 mM. The opioid fragment $\beta$-CM 7 also reveals a low ACE-inhibitory activity. Water-soluble peptides that inhibited angiotensin I-converting enzyme have been fractionated from several Italian cheeses including Mozzarella by RP-HPLC.

3.3 Anti-thrombotic activity

Casoplatelins are peptides derived from the C-terminal part (i.e., caseino-GMP, the soluble $\kappa$-Cn f 106-169 that remains after chymosin action on milk) of bovine $\kappa$-Cn. One such peptide is the $\kappa$-Cn f 106-116, which has been reported to inhibit blood platelet aggregation. It also combines with the receptor sites, thus preventing the binding of human fibrinogen $\gamma$-chain to a specific receptor site on the platelet surface, hence expressing its anti-thrombotic activity. Three other fractions of $\kappa$-Cn, (106-112, 112-116, 113-116) have similar activity, but to a smaller extent.

3.4 Immuno-modulating activity

Phagocytosis is the process of ingestion and digestion of micro-parasites by amoeboid WBCs called phagocytes. Some peptides that stimulate phagocytosis have been isolated from $\alpha_\text{s1}$-Cn and $\beta$-Cn. It is noteworthy that the immuno-hexapeptide derived from $\beta$-Cn represents the C-terminal portion of $\beta$-CM 11. It is reported that 0.3 to 7.5% new-born infants in the USA and 3 to 5% of one year old infants in Japan are allergic to cow milk protein. To counter this, some hypoallergenic peptides have also been developed from casein hydrolysates. One example is an infant formula prepared, based on hydrolysates from $\alpha$-casein (selected because of its absence in human milk) using proteases from *Aspergillus oryzae* and *Rhizopus* species.

3.5 Mineral absorption

Bio-active peptides derived from the tryptic hydrolysates of casein, known as caseinophosphopeptides (CPP) possess physico-chemical properties that enable the chelation of various bi- and trivalent minerals to be carried out, thereby enhancing mineral solubility in the lower small intestine. It has been suggested that moderate and exchangeable binding of calcium to CPP is responsible for the high absorbability of calcium from milk. The Japanese market has introduced products containing CPP, that promote calcium absorption. Calcium that is removed from teeth as a result of sugar consumption can be replaced by anti-cariogenic casein phosphopeptides (ACPP). Several reports suggest that there is significant reduction in the tooth decay in laboratory animals that are fed with ACPP. There is a possibility that the prevention of dental caries by the consumption of cheese at the end of a meal may be attributed to the presence of ACPP in ripened cheese.
3.6 Miscellaneous Functions

Peptides that stimulate DNA synthesis were found in tryptic hydrolysates of β-Cn. Their mechanism, however, has not been worked out. Physiologically active peptides also have the ability to promote the growth of bifidobacteria in the GIT, thus increasing the number of these beneficial organisms in the intestines. This is attributed particularly to κ-Cn which can affect bacterial adhesion by serving as a receptor analogue. Lactoferricin B, a peptide produced by enzymatic cleavage of bovine lactoferrin was reported to inhibit and inactivate Candida albicans and Helicobacter pylori, the latter a known cause of stomach and duodenal ulcers. Consumption of cultured milk products have been associated with reduced incidence of colon cancer also. It has been reported that some casein-derived peptides can alter intestinal cell kinetics. This may be a mechanism by which fermented milk products reduce the risk of colon cancer. β-CM 5 and its modified analogues have the ability to stimulate insulin secretion and also function as anti-depressants. Specifically cleaved bio-active peptides from dietary proteins during digestion are suspected to simulate gastrointestinal hormones (gastrin, cholesystokinin, secretin and gastrin inhibitory peptide) that control both gastric as well as intestinal motility and gastric and bilo-pancreatic secretions.

4.0 CONCLUSION

Several biologically significant peptides derived from milk may be used as highly active drugs having a well-defined pharmacological effect, e.g. casomorphins in the treatment of diarrhoea, casokinins during hypertension, casoplatelins in thrombosis, CPP in dental and bone disease as well as mineral malabsorption and immuno-peptides during immuno-deficiency. Food researchers are presently considering bio-active peptides from caseins and other food proteins as health-enhancing nutraceuticals for use in functional foods. Besides fortification of food, production of desirable bio-active peptides during food processing, e.g. by use of specific enzymes or genetically transformed micro-organisms is also a target area that seems to hold the interest of these workers. In this context, cheese and fermented milk products which are natural sources of peptides (some of which may be physiologically significant) also have a potential for future food research.

5.0 SUGGESTED READING


Table 1. Some Physiological Peptides from Milk Proteins

<table>
<thead>
<tr>
<th>SNo</th>
<th>Peptide</th>
<th>Origin</th>
</tr>
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<tbody>
<tr>
<td>I</td>
<td>Opioid peptides</td>
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</tr>
<tr>
<td></td>
<td>(A- Agonists)</td>
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</tr>
<tr>
<td>1</td>
<td>β-casomorphin 5</td>
<td>β-Cn</td>
</tr>
<tr>
<td>2</td>
<td>β-casomorphin 5</td>
<td>h β-Cn</td>
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<td>3</td>
<td>Morphiceptin</td>
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<td>4</td>
<td>α-casein exorphin</td>
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<td>6</td>
<td>β-Lactorphin</td>
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<td></td>
<td>(B- Antagonists)</td>
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<td>1</td>
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<td>κ-Cn</td>
</tr>
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<td>5</td>
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<td>Lactoferroxins</td>
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<td>II</td>
<td>Antihypertensive peptides</td>
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<td>1</td>
<td>Casokinins</td>
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<td>2</td>
<td>Casoxin A, C</td>
<td>κ-Cn</td>
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<td>III</td>
<td>Platelet function inhibition</td>
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<td>IV</td>
<td>Phagocytosis stimulation</td>
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<td>V</td>
<td>Caseinophosphopeptide</td>
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<td>VI</td>
<td>Immunomodulaiton</td>
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<td>DNA-synthesis stimulation</td>
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<td>VIII</td>
<td>CPP</td>
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<tr>
<td>IX</td>
<td>Antimicrobial activity</td>
<td>Lactoferrin</td>
</tr>
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</table>

Adapted from: Meisel (1997) and Yamauchi (1992).

h = human
1.0 INTRODUCTION

Sensory properties of food are generally grouped into three categories (i) Appearance (ii) Flavour (iii) Texture. Flavour is one of the most important sensory properties and is used by the consumers for judging both quality and variety of food product. International standard organisation has defined “flavour as complex combination of olfactory, gustatory and trigeminal sensations perceived during testing. Hall (1968) has defined flavour as the sensation produced by material taken into mouth, perceived principally by the senses of taste and smell and also by general pain, tactile and temperature receptors in the mouth. The flavour of dairy products originates from microbial, enzymatic and chemical transformations. These transformation gives rise to a series of volatile and non-volatile compounds, some of which correlate well with some typical flavour notes or flavour defects. Volatile components identified in dairy products can be assigned to two main sources, namely milk aroma itself and degradation of milk constituents (lactose, fat, protein) during manufacture.

2.0 ROLE OF LIPIDS IN FLAVOUR

The role of milk fat is recognised as important for different sensory attributes of dairy products. Too high or too low a fat level leads to poor quality. Flavour of milk fat is very complex and can’t be duplicated. Milk fat is important for some of its intrinsic qualities e.g. Cheddar cheese made with vegetable or mineral fat does not develop the right flavour and moreover, the quality of the cheese is not optimal if the milk fat is structurally modified by mechanical action before being reincorporated in the milk (Foda et.al. 1974).

2.1 Free Fatty Acid (FFA)

Milk fat also serves as a precursor of flavour compounds. The importance of FFA which differ considerably in chain length and flavour intensity varies between products, but as a whole FFA are more often a source of problems than a factor of quality e.g. in cow milk the presence of even a small amount of short chain. FFA leads to an easily perceived rancid flavour, whereas in goat milk the FFA is responsible for a specific flavour, which fetches it an important premium. FFA (mainly short chain ones) is responsible for hydrolytic rancidity, which is still an important problem for Dairy Industry. FFA may develop during frozen storage, as a result of microbial lipase activity, which has been shown to resist even severe heat treatment. Usually, FFA is the most abundant components in the flavour extracts from cheeses. Individual FFA are found in nearly the same ratio as the acids esterifies in triglycerides except for butyric acid, which is released in larger amounts, because of relative activity of milk lipase. Although volatile FFA have been considered to be the backbone of
cheese aroma, no correlation could be found between flavour quality & FFA content in soft ripened cheeses. Besides, a direct negative influence on flavour, too high a FFA level may have an adverse effect on cheese quality by inhibiting some microorganisms responsible for biosynthesis of other important flavour components.

Ghee owes its pleasing flavour to the presence of 16 fatty acids C4 to C18:2 (Singhal & Jain, 1973). The lower fatty acids C6 - C12 though present in low concentration accounting only 5-10% of total FFA contribute significantly to the Ghee flavour.

2.2 Hydroxy Acids and Lactones

Milk fat contains small amounts of δ-hydroxy acids, which in certain circumstances spontaneously lactonise to form the corresponding δ-Lactones. Unsaturated C18 fatty acids may lead via hydration to hydroxy acids, which via β–oxidation lead to γ-Lactones, these also occur in butterfat. Lactones contribute significantly to the flavour of fat-based dairy products especially the heat processed one (Wadhwa & Jain, 1989). The amount of lactone precursors present in milk varies with feed, season, breed & stage of lactation. They also contribute to butter flavour. When milk fat is heated the lactone level increase and some unusual unsaturated lactone e.g. Bovalide, Dihydrobovolide have been reported. Addition of microbial lapse accelerates the lactone production & thus flavour is enhanced. Among the dairy products, Ghee owes, its unique flavour to a variety of lactone. Delta lactone are the major components in Ghee, the chief components being -C10, C12, C14, C16 & C18. Gamma lactones are the minor components (Wadhwa & Jain, 1984). Lactone level in ghee is three times that in butter oil which shows that lactone contribute significantly to the flavour of Ghee. Lactones are commonly found in cheese, even numbered δ–lactones with chain lengths ranging from C-8 to C-14 have consistently been identified in cheese. However, lactones found in butter & cheeses are probably formed through hydrolysis and subsequent cyclisation of the hydroxy acids.

2.3 Compounds arising from Fatty Acids

Methyl ketones (MeK) are common constituents in most dairy products. They may be formed either by decarboxylation of oxyacids, which are minor components of milk fat or by enzymatic oxidative decarboxylation of alkanoic acids. The first mechanism, which is greatly favoured by heating, may explain the increasing level of MeK in milk as the heat treatment becomes more severe. Unsaturated ketones have also been found in cheese, e.g. 8 nonen -2-one in blue cheese and mould ripened cheeses together with undecenone and tridecenone in Camembert. Alkan -2-ones or Methylketones are reported in several dairy products esp. heat processed. They are now regarded as integral components of good quality butter and ghee. These compounds are important in development of cooked flavour in foods in which butterfat is used as shortening. The level of alkan - 2-one in ghee (87%) is much higher than that of butter oil (62%) (Gaba &Jain, 1976).

2.4 Compounds arising from Oxidation

In most dairy products oxidation leads to off-flavour, it is only in a limited number of cases that oxidation accounts for the formation of volatile compounds which add to the quality. Oxidation of products such as butter or milk powder fat during storage has been shown to be autocatalytic (Hall et.al., 1985). Straight chain aldehydes provide a greater
contribution to flavour e.g. Propionaldehyde. Oxidation can also be initiated by exposure to natural or artificial light. In milk the light induced flavour is related to methional.

3.0 ROLE OF PROTEIN IN THE FLAVOUR

Protein seem to play a capital role in the development of flavour in protein rich foods such as cheese, since proteolysis leads to the formation of important non-volatile & volatile compounds. The volatile components originate from protein degradation via two main pathways.

- Maillard browning reactions, resulting in Pyrazines and Furans.
- Degradation of Amino Acids.

3.1 Peptides

In cheese, bitterness results from the presence of low molecular weight hydrophobic peptides arising mainly from casein. Among the different caseins α 51 casein produces more bitterness than β–casein. Although bitterness appears in all dairy products, it has been studied extensively in Cheddar and Gouda cheese. The bitterness in cheese is attributed to the accumulation of bitter compounds in the peptide fraction (Creamer et. al., 1985). The reason for the presence of bitter peptide in cheese could be due to the inability of peptidase-deficient starter strains to degrade the bitter peptides to non-bitter peptides and amino acids.

3.2 Amino Acids

They play a key role as precursor of a large number of flavour compounds.

3.2.1 Ammonia, amines and amides: All these compounds have been identified in cheese and contribute to flavour in a significant manner.

3.2.2 Aldehyde, alcohols & phenols: Aldehydes may appear in cheese together with alcohols from amino acids via the strecker degradation. Phenyl ethanol and phenylacetyldelhyde give unpleasant flavours, the latter also contributing to an astringent bitterness, 3-methyl butanol, 2-methyl butanol, 2-methylpropanol and methanol have been described as unclean, harsh and dull flavour (Dumont, 1974). Phenol and Indole are formed from Tyrosene & Tryptophan, respectively by loss of Alanine moety. These compounds and their homologues p-cresol and skatole contribute significantly to the flavour of soft ripened cheese and sweet cream butter.

3.2.3 Branched Chain Fatty Acids: Strecker aldehydes may be further oxidised to acids. These acids, which have a lower threshold value than the straight chain ones could be of importance in the flavour of these cheeses. This explains the occurrence of volatile iso-acids, which have been repeatedly identified in surface-ripened cheese.

3.2.4 Sulphur Compounds: These are the decomposition products of sulphur amino acids cysteine and methonine and are responsible for typical flavour of dairy products but in some cases lead to typical flavour defects. Hydrogen sulphide, is formed
in milk upon heating is responsible for the cooked flavour in UHT milk & sometimes in butter (Badings & Neeter, 1980). Upon severe heat treatment other sulphur components such as methane thiol may also be formed. Methanethiol and H\textsubscript{2}S are also formed during cheese repening from cysteine and methionine. Methanethiol has been shown to play a very significant role in the flavour of cheddar cheese. Dimethyl sulphide which is a normal component of raw milk, if present at too high level, lead to an unclean flavour. Several sulphur compounds have been identified in mould-ripened cheese e.g. H\textsubscript{2}S, dimethyl disulphide, demethyl trisulphide and methionol. Other compounds are also present in traces e.g. 2, 4, 5 trithiahexane; 3- methyl thio -2, 4- chthia pentane. The exact role of each of these compounds remains to be clarified (Dumont, 1976).

3.2.5 Pyrazines: It appeared that some Pseudomonas strains are able to synthesize both methoxy and alkyl substituted pyrazines. Dimethyl pyrazine has been found in Parmesan cheese, several alkyl pyrazines were identified in Emmental and Gouda. Acetyl pyrazine and 2 methoxy -3 ethyl pyrazine are important in flavour of old cheddar cheese.

4.0 ROLE OF LACTOSE AND CITRATE IN FLAVOUR

The lactic flora activity leads to a series of compounds, which are important to most dairy product.

4.1 Lactic Acid

It creates acidity in various cultured products followed by a pH drop which determines the basic structure, characteristic of each cheese variety Lactic acid may also lower the proteolytic & lipolytic activities at least in soft ripened cheeses, and lactic acid has thus an indirect but essential influence on the degradation of the main cheese constituents, which ultimately will influence the formation of flavour compounds. Lactic acid also serves as a substrate for various microorganisms such as moulds & propioni bacteria which converts lactate to propionate, that is responsible for the sweet taste usually found in Emmental & Gruyere cheese.

4.2 Acetaldehyde

It is a characteristic activity of lactic streptococci and is the most abundant volatile compound in Yoghurt. In Yoghurt, the acetaldehyde level differs greatly with different strains.
4.3 Diacetyl

It is an important flavour constituent of cultured products. It is formed from citrate present in milk by *S. diacetylactis*, *Leuconostoc citrovorum* and other organisms, which utilise citrate. It strongly contribute to acid cream butter flavour, a very high level leads to flavour defects. It plays a major role in unripened soft cheese e.g. cottage. Diacetyl is easily reduced to acetoin which is also present at relatively high level in cultured products. This compound can be further reduced to butylene glycol, which can lead to 2-butanone as a result of *L. plantarum* and *L. brevis* activity.

5.0 CONCLUSION

Among compounds arising from fat degradation FFA appear to be important as precursors of flavour compound such as methyl ketones or as precursors of compounds arising from oxidation which may have negative or positive effect. Protein degradation at least in cheese is the main route to flavour formation of essential volatile compounds such as sulphur compounds but also to non-volatile compounds. The lactic acid determine the final flavour quality of ripened cheese, besides lactic acid, the lactic flora produces acetaldehyde and diacetyl which play major role in flavour of dairy products.

6.0 SUGGESTED READING


1.0 INTRODUCTION

Human infants should ideally be nursed on mother’s milk, which constitutes nature’s best food. However, in the event of lactation failure, insufficient milk secretion and where mothers suffering from transmittable disease, human milk substitutes serve as savers of precious life during vulnerable stages of infancy. Most of the breast milk substitutes utilise bovine milk due to easy availability. The patter of bottle-feeding is a sequel to industrialisation and urbanisation. There has been an ever-increasing reliance of formula feeding practices both in developed and developing countries. Bovine milk based dried formulations have become a prominent feature of infantile dietetics. The technological advances have contributed to the fascinating evolution from simple condensed mix mixtures to the sophisticated formulations of today. There has been a tremendous growth in the dried milk industry for the manufacture of infant formula. Today nearly 185,000 tonnes of infant formula is manufactured in India representing approximately 3.8% of total milk production.

2.0 STANDARDS OF INFANT FORMULA

During 1960s the knowledge regarding various biochemical differences and resultant physiological stress of formula feeding was limited and therefore, earlier standards (IS: 1547:1960) mainly paid attention to the adjustment of fat content. Infant feeding has received considerable attention by biochemists and nutritionists alike since past two decades. This has led to the generation of precise information regarding nutritional requirements for optimal growth of infants. With the view to provide nutritionally improved formulas these standards were brought to the conformity with those of Codex Alementerious Commission with adoption of WHO code for promotion of proper infant feeding practices (IS: 11156, 1985).

Emphasis has been laid on manufacture of formulations having compositional and biochemical characteristics similar to human milk. This has changed the scenario of infant feeding where conventional formulas have been constantly replaced with nutritionally improved formulations. The changes proposed in the new standard envisaged closer proximity to human milk and minimum physiological stress due to adaptation. Provisions have been made to incorporate 12% PUFA rich vegetable oils in order to simulate fatty acid profile of the formulation with respect to ratios of small: medium: long chain fatty acids, unsaturated: polyunsaturated fatty acids, and linoleates similar to human milk. (Thompkinson
& Mathur, 1987). The protein content has been lowered owing to the physiological stress on immature kidney during infancy. However, adequate supply of essential amino acids and their optimal levels for efficient utilisation has been taken care of.

Recently the Ministry of Health and Family Welfare through a Gazette notification has amended the Prevention of Food Adulteration rules (5th Ammendment, 1991-92) in respect to redefining infant food/infant formula in a manner to incorporate nutritional aspects to the industrially prepared infant formulations. Also a number of new formulations have been introduced specifically to cater the special needs of infants born with specific physiological disorders.

3.0 TRENDS IN PRODUCTION OF INFANT FORMULAE

It is often noticed that as the infant grow, mothers milk does not suffice his growth requirements and therefore, cow or buffalo milk, depending upon availability, is invariably diluted with water and fed to the infants. Dried milk formulation for infant feeding has been developed on the same lines. In view of easy availability most breast milk substitutes utilise bovine milk for industrial preparations. However, it is important to recognise that various mammalian offspring’s are born at different stages of intrauterine development and therefore undergo different growth rates. The milk composition of various species therefore, differs so as to meet the nutritional requirement of their offspring’s. The relative ratios of protein: fat: carbohydrate: minerals as well as makeup of these nutritionally important constituents differ appreciably between human and bovine milks. Never-the-less food manufacturers, world over, have developed wide range of infant formulations to meet the nutritional requirements of different category of infants.

3.1 Standard formulae

These formulations are based on bovine milk and work as supplement or replacement of human milk for feeding of normal healthy infants. The nutritional requirements of infants through such formulations are met mainly by course adjustments of Protein: Fat: Carbohydrate ratios as a broad compositional simulation to human milk. These formulations are also fortified with general minerals and vitamins. They are generally referred to as first generation formulas developed to meet the general energy and nutritional requirements of infants born normally with out any physiological disorders.

3.2 Soy-based formulae

Certain infants are born with certain physiological disorders of transitional nature. Depending upon the nature of disorder, their requirements for nutritional and normal growth changes. Under the circumstances standard formulations may not be suitable for such infants. Infant formulas based on soy proteins have been developed to aid in the dietary management of infants suspected of being allergic to milk proteins. The protein content of such formulations is replaced either from soy flour or water soluble soy protein isolates. Other vegetable proteins, with or without suitable modifications, can also be used for the formulation of such products. Being devoid of major milk sugar, lactose, these formulations can also be used for the dietary management of infants suffering from lactase deficiency.
3.3 **Specialised formulae**

This group of formulas are specific products for the dietary management of infants with variety of nutritional and physiological disorders that are associated with the early stages of life. Certain infants, for example, are born with disorders of enzymes insufficiency to digest milk proteins or carbohydrates present in standard formulations. Such infants require proteins to be present on the formulation in pre-digested form that is easy to digest or a low lactose diet or lactose free diet. Specialised formulations consisting of pre-digested or hydrolysed proteins, hydrolysed lactose, low fat formula, formula for pre-term infant etc fall into this category. These formulations are designed to have minimum load on the under-developed digestive system. Such formulations are sold under specific brand names depending upon their applications.

3.4 **Nutritionally improved formulae**

Currently marketed infant formulas differ considerably from human milk in compositional and biochemical characteristics and thus display several nutritional inadequacies. Feeding of such formulas have proved to cause different physiological stress amongst infants. Nutritionally superior formulations have been developed for easy adaptability. These formulations bear varying degree of chemical and biochemical similarity with human milk and are referred to as humanised or metarnalised formulas. These humanised formulas possess similar ratios of major nutrients with regard to protein: fat: carbohydrate: minerals found in human milk. Apart from similar gross compositional profile these formulations also incorporate comparable ratios of whey protein: Casein; saturated: polyunsaturated fatty acids; calcium: phosphorus and sodium: potassium. Such formulations closely approach the nutritional qualities of human milk and therefore are easily adaptable by the infantile system without causing great physiological stress on the under-developed organs.

3.5 **Bifidus-containing formulae**

Notwithstanding the nutritional superiority, the humanized formulations do not offer biological protection against enteric infections as human milk. With the objective to enhance bio protective attributes of ready to use dried infant formula, a process was developed to incorporate a biomass of Bifidobacteria for its protective role in gut ecology. Being native to human gut ecological system, it has capabilities for implantation at the mucosal layer and control the growth of other intestinal bacteria that results in maintaining the balance of intestinal microflora and thereby control enteric infections. The use of whey for the adjustment of whey protien:casien ratio in the formula, enhances Bifidus growth stimulating activity. Such formulations are helpful in implanting Bifidus microflora in the intestinal tract of infants through bottle-feeding for quick restoration to normalcy during diarrhoeal attacks. With this advancement infant formula has come a step closer in fulfilling one of the biological functions unique to human milk for infant nutrition.

3.6 **Formulations with bio protective attributes**

During the last decade, manufacturers of infant food have made impressive advancement in developing technologies for up gradation of nutritional characteristics of infant formulas similar to human milk. However, susceptibility of bottle fed infants to enteropathogenic microorganisms still contributes the largest health risk. The protective effect
of human milk for infants, despite lack of transfer of antibodies from gut into the circulatory system, points to a direct protective role of human milk in the ecological system of the intestinal tract. During early infancy, risk for mortality and morbidity from common pathogens like *coli*form, *salmonella*, and *shigella* are very high. A number of innate factors in human milk influence the intestinal micro flora of the neonate that ultimately inhibits these enteropathogenic bacteria. These humoral protective factors are either derived from blood serum, such as immunoglobulins or synthesized in mother’s mammary glands like lactoferrin, lysozyme, lactoperoxidase etc. Little attention has been paid to incorporating these bioprotective factors that assume special significance in bottle-feeding practice for providing humoral protection among infants. The proceeding text describes possible actions and usage of these humoral protective factors for infant formulas.

3.6.1 Lactoferrin

The antibacterial activity of this iron chelating protein is well recognised. Under physiological conditions lactoferrin is capable of chelating iron thus depriving bacteria of the iron required for its normal metabolism resulting in their inhibition. Digestion of lactoferrin with proteolytic enzyme does not significantly alter its iron binding property, suggesting that it is quite capable of exerting antibacterial activity in human intestinal tract. The biological role postulated for lactoferrin includes bacteriostatic and bactericidal activity, an enhancer of monocytes natural killer activity and a modulator of activation of complement system. Lactoferrin is also found to be involved in the transport of iron across the duodenal brush border. Thus incorporation of lactoferrin in infant formula can help in bioavailability of iron and preventing growth of gram-negative pathogenic bacteria. Lactoferrin may be extracted from whey, a by-product of cheese manufacture, in its native form that holds promise for incorporation of this antibacterial protein to infant formulas of the future.

3.6.2 Lactoperoxidase

The lactoperoxidase system (LP) consists of three components- lactoperoxidase enzyme, hydrogen peroxide and thiocynate, an oxidizable substance. In the newborn infant saliva is quite rich in lactoperoxidase activity and the enzyme is known to be resistant to low pH and proteolysis. The saliva that enters the stomach and rich in lactoperoxidase is expected to reach the intestinal tract in an active form for activation of LP system. The lactic acid bacteria metabolically generate hydrogen peroxide. Thiocynate, the third factor of LP system, occurs naturally in animal tissues and secretions. Thus the system oxidises the chemically inert SCN into OSCN. Exposure of bacterial cell to this oxidative product results in leakage of potassium and amino acids from the cell and inhibition of carbohydrate uptake and synthesis of DNA and RNA leading to cell lysis specially of the gram negative organisms. Bovine milk that contains 30 ug / ml lactoperoxidase and 2-8 ppm thiocynate could be an important source for the supply of SCN required for activation of LP system. Controlled application of the system in infant formula may be very useful for protecting neonatal health.

3.6.3 Lysozyme

In view of the antibacterial effect and possibly general immune system of neonates, there has been a considerable interest in developing food applications of lysozyme. The concentration of lysozyme in human milk is 3000 times greater than bovine milk. The biological significance of lysozyme lies with its possible protective effect against gram-negative potential pathogens. Although lysozyme is isolated from egg, bovine lysozyme has greater
lytic activity. It is stable at low pH and resists gastric juices under in-vivo situations. Lysozyme containing formulations tend to enhance Bifidobacterium population in the intestinal tract. Thus the incorporation of lysozyme in infant formula could be useful in view of its influence under the ecological system of the intestinal tract.

3.6.4 Immunoglobulins

Intestinal immunity is the result of a highly complex interaction of humoral and cellular components. The bactericidal properties of milk are attributed to the compliment mediated antibody system. The secretory IgA, which displays unique property for the defence of mucosal membrane, is inadequate during infancy, as it is not reabsorbed among infants. Bovine milk, which is deficient in IgA, however, provides strong bactericidal and bacteriostatic effects involving IgG and IgM. The post colostral milk displays varying levels of bactericidal activity against E.coli. This could potentially influence the gut microflora and perhaps responsible for gradual suppression of E.coli. Ingestion of heated milk produces circulatory antibodies to beta-lactoglobulin and casein, which seems to be critical in the retention of antigenic properties of milk. The bovine colostrum provides neonatal ungulates a rich supplement of antibodies. Possibilities thus, exist to incorporate lyophilised bovine colostral whey into the infant formula.

In this manner it may be possible to augment the future infant formulations with the unique priorities of human milk with respect to containment of humoral protective factors apart from the nutritional properties to fulfil the requirements of an human infant in the absence of availability of sufficient quantities of mothers milk or in case where mothers are unable to feed their infants due to socio-economic reasons or fear of transmutable diseases.

4.0 PACKAGING

Packaging is an important aspect that is essential for safe and easy marketing of any food item and retention of natural characteristics. A wide variety of rigid as well as flexible packaging materials are available and used for packaging of food products worldwide. Generally infant foods are packed in metalised tin containers, which can be sealed, oxygen evacuated and filled with an inert gas to protect the contents against chemical and microbiological spoilage. Tin containers having snap on plastic lids are now available that can keep the contents safe against moisture, air and pests. In order to reduce the ever increasing cost of tin containers, laminated flexible packaging material are in great use. The laminated pouches, after packing and sealing are then placed into individual cardboard cartons for easy handling. Processes are also available where inert gas can be injected in these laminated packages to avoid chemical deterioration (oxidation) of susceptible constituents during storage at ambient temperatures. In the western world, liquid infant formulations are available in aseptically packed simple glass bottles or food grade poly bottles. These are used as single service throwaway containers. The contents of each bottle are sufficient for one time feed requirements of an infant.
5.0 EPILOGUE

The technological advancement for the production of infant formula has gone a long way in manufacture of variety of infant formulas for dietary management of normal, pre-infants, and infants born with variety of nutritional as well as physiological disorders. Both nutritionists and biochemists have provided ample knowledge for the technocrats to manufacture infant formulas having similarities in general characteristics to that of human milk. Considerable scope however, exists for enhancing the bio protective attributes of infant formulae that could provide humoral protection in the infantile gut ecological system. These factors are vital for establishing a healthy microflora in the intestinal tract and potentially play an important role of protecting the infant against enteric infections.

6.0 SUGGESTED READING


Gazette of India (Extra ordinary part II) Ministry of Health and Family Welfare (Dept. of Health) Notification No. GSR 257 (E), May 1991


1.0 INTRODUCTION

Dairy ingredients are preferred ingredients for their functional supremacy and good flavour, colour and nutritional profile. Born at the end of the sixties, application of membrane techniques in the dairy industry for the production of dairy ingredients is now largely spread out, particularly after the commercialization of high mechanical and physico-chemical resistant mineral membranes. Membrane separation processes have presented new possibilities for the production of newer intermediate dairy products that can be used in different foods based on their functional properties. The membrane filtration processes currently available include reverse osmosis (RO), nanofiltration (NF), ultrafiltration (UF), microfiltration (MF) and electrodialysis. The distinction between the various membrane processes is somewhat arbitrary and has evolved with usage and time.

Ideally, RO membranes should retain all components other than the water itself. RO has widely been used to concentrate dairy fluids and also make further products like khoa (Kumar and Pal, 1994) and condensed, concentrated and dried products. RO processed milk has also been successfully used in the manufacture of yoghurt, dahi, ice cream and several other dairy products. The principal application of NF is for separation of mineral ions in the $10^{-9}$ m size. The main emerging application of NF in the dairy industry is in partial demineralization of whey. Electrodialysis process is based on the removal of charged mineral ions from the non-charged material. This process has wide application in demineralization of whey for use in many special dietetic foods including infant formulae.

UF membranes retain only macromolecules or particles larger than 1-20 nanometers. This process typically employs membranes with molecular cut-off in the range of 10000 - 75000 D. During UF process, a portion of lactose and minerals is removed. One of the major benefit of UF technology is its ability to retain whey proteins, that are normally lost in whey in traditional manufacturing processes of cheese, chhana, paneer. UF membranes reject fat and all true proteins in milk. The proteins can be further concentrated by progressive removal of lactose and ash by a subsystem called diafiltration.

During the last over three decades, UF technology has increasingly being used in the dairy industry because of many inherent advantages viz., saving on energy, improved yield of protein, enhanced nutritive value of the product and availability of a lactose stream in the form of permeate. The newer application of UF in the dairy industry is in the separation and
fractionation of individual milk proteins. Fractionated milk protein isolates are finding increasing applications in infant foods formulations.

MF processes are designed to separate particles in the so called micrometer range (0.1-10 micrometers). This process retains fat globules, microorganisms and somatic cells, but allows passage of proteins in addition to lactose and minerals. A promising application of MF has been the selective separation of native casein micelles from the whey proteins (Sachdeva and Buchheim, 1997). The spray dried native casein micelles can be used in applications where traditionally calcium caseinate has been used (Maubois and Ollivier, 1992).

2.0 CONDENSED AND DRIED MILKS

RO has widely been used to concentrate milk and make condensed and concentrated products and dried milks. A host of condensed and dried milk products have conventionally been used in the formulation of different food products since long. Sweetened condensed milk, skimmed sweetened condensed milk, unsweetened condensed milks and evaporated milks are some of the condensed milk products that are traditionally used in chocolate, confectionery and bakery industry. Infant food producers, confectioneries and dairies use unsweetened condensed milk as a concentrated source of desired dairy components in many of their products. Milk powders including whole milk powder and skim milk powder are similarly used in bakery, confectionery, meat and other food products all over the world. These milk ingredients are nutritious and functional, and also contribute to the taste and colour of the food products where they are used.

3.0 UF MILK RETENTATE

UF milk retentate has widely been used for the manufacture of cheese and other fermented short shelf-life products where protein increase is desirable but lactose and ash increase is not desirable (Darghn and Savello, 1990; Green, 1990, Singh et al., 1994). In the Indian context UF retentate seems to be a highly promising base for long-life paneer (Rao, 1991; Singh et al., 1994). UF technology has also been applied to produce low lactose powder, non dairy whitener, rasogolla mix powder, cheese base and milk protein concentrates.

3.1. Low lactose powder

Lactose intolerance is a global problem. UF technology is employed for the manufacture of low-lactose powder. Additional diafiltration treatment is employed to further reduce lactose. During the ultrafiltration process, some of the soluble salts like calcium, sodium and potassium are bound to go in the permeate. These salts are important for giving milk its natural taste. To maintain the salt level and thereby revive the original taste of milk on reconstitution, salts are added to the retentate before spray drying. Further, to improve the drying properties of the retentate and reconstitutability of the powder, 4% malto-dextrin is added to the retentate before spray drying (Patel et al., 1991).
3.2. Non-dairy whitener

Non-dairy whiteners are widely used as a substitute for fresh milk, cream or evaporated milk in coffee, tea, cocoa or drinking chocolate and are also suitable for adding to foods like soups, sauces, puddings and cereal dishes. The suitability of using UF skim milk retentate as a whitener has been reported by Jimenez-Florez and Kosikowski (1986). Mukherjee (1996) standardized the manufacture of non dairy whitener using UF skim milk retentate as a base.

3.3. Base for rasogolla mix powder

Manufacture of rasogolla is probably most difficult amongst all the milk based delicacies. It requires lot of art and experience in addition to the right type of raw materials. The use of ultrafiltration process has been made to produce base for the rasogolla mix powder (Pal et al., 1993). Cow skim milk is ultrafiltered to about 3-fold concentration. To reduce the mineral and lactose level to almost the same level as in chhana, UF retentate has to be diafiltered. The pasteurized cream is added to diafiltered retentate followed by spray drying adopting standard conditions. The dried retentate is blended with selected additives to produce desired flavour and texture.

3.4 Cheese base and processed cheese

Cheese base is a paste of the same composition and pH as Cheddar cheese but without the Cheddar flavour and structure. It is used to replace the young cheese component for the manufacture of processed cheese. For the production of cheese base, milk is pasteurized, standardized to 3.8% fat, cooled to 50°C, ultrafiltered to 30% TS, diafiltered to reduce lactose to desired level, further ultrafiltered to 40% TS, re-pasteurized, cooled and 1% Cheddar starter culture added and evaporated to 60% TS. Processed cheese is made by blending cheese base (30%) with 70% normal aged Cheddar cheese.

3.5 Milk protein concentrates

Milk protein concentrates (MPC) is a relatively new dairy ingredient based on ultrafiltration and drying of skimmed milk. Typically with a protein content from 50-85% of total solids, MPC can be considered as a functional ingredient to be used in the manufacture of other foodstuffs. To obtain milk protein concentrates with 85% protein/TS, it is necessary to employ diafiltration treatment. The main application of MPC today are in spreads and dressings. It is also used as a protein base in processed or even recombined cheeses. This high protein and high calcium ingredient can be used for the preparation of many dietetic foods including foods for elderly people and sport persons.

4.0 CONDENSED AND DRIED WHEY PRODUCTS

Whey is a source of precious nutrients like lactose, whey proteins, minerals and vitamins. It can be preserved as plain or sweetened condensed whey. In North America alone, there was 25000 tonnes of condensed whey and 50,000 tonnes of whey solid in wet blends were produced in 1993 (Horton, 1995). RO technology is widely used to partly concentrate the whey.

By far the single largest use of whey solids on global basis is in the form of whole dry whey and it continues to grow. This is whole whey that has been condensed and spray dried as such or after blending with certain other liquid ingredients. These powdered whey products
are marketed as commodity ingredients to be used in the manufacture of confectionery, chocolates, biscuits, breads and in the manufacture of animal feed.

A major problem with many whey based products is their salty flavour owing to their high mineral content. Demineralized sweet whey (25-65% demineralization) can be used in foods such as coffee whitener, soft serve ice cream, milk shakes, whey drinks and caramel, citrus drinks, salad dressing, animal feeds, bakery goods, confectionery coatings and dry mixes. A range of demineralized spray-dried, whey-based products for use in infant feeds and dietetic applications have been developed based on products manufactured by demineralization and ultrafiltration of whey.

5.0 FRACTIONATION OF MILK PROTEINS

Application of membrane processing has opened up new possibilities for fractionation of milk proteins having unique functional characteristics. Theoretically, most milk proteins should be separable directly by selective membrane filtration of skim milk form the largest size to the least as follows: lipoproteins in milk fat globule membrane > casein micelles > immunoglobulins > lactoferrin > serum albumin > β-lactoglobulin > α-lactalbumin > casein-derived peptides.

The application of MF to skim milk in combination with other membrane processes and/or chromatography processes opens up possibilities in isolating and purifying caseins and the peptides derived from them that can find application in the pharmaceutical industries. Of special interest in this regard are peptides derived from β-casein that have been shown to exhibit morphine-mimicking, cardiovascular and immunostimulating activities.

5.1 Whey protein concentrates

UF process is now a major means of WPC production throughout most of the dairy countries of the world. WPC with 35% protein is perceived to be a universal substitute for NFDM, because of the similarity in gross composition and its dairy character. WPC can also be seen competing with casein, egg albumin and soya proteins within the existing markets. Microfiltration of whey to obtain delipidised whey protein concentrates with improved properties has recently been tried out using different approaches (Gesan et al., 1995; Karleskind et al., 1995).

Whey protein based fat mimetics have recently been used in low fat variants of frozen desserts, yoghurt, fat spreads and cheese. These fat mimetics are made from concentrated cheese whey by special thermal and mechanical treatments which result in a controlled globular aggregation of denatured whey proteins termed as microparticulation (Buchheim and Hoffmann, 1994). Suspensions of such microparticles, with diameters in the range of about 0.1 to 3 μm can produce a creamy texture similar to that of globular fat particles, like the milk fat globules.

A special groups of ingredient called whey protein texturizer has been developed (Thompsen, 1994), that have unique properties of improved emulsifying property than whey protein concentrates, form gel without heat giving highly viscous solutions and give a firm gel upon heating. These can find application in comminuted meat products, mayonnaise, salad dressing and spreads, bakery products, French fries and potato products. These can also be
used for preparations most suitable for heat induced structuring processes - thermoplastic expansion, microwave expansion and thermogelation. Such textured products act as extenders in various meat products.

5.2 Fractionated whey proteins
The health and medical benefits of individual whey proteins are gaining acceptance at an increasing rate. Isolation of whey protein fractions can help in preparation of infant formulae with protein compositions more reflective of human milk. Dietary whey protein significantly retards the development of colon cancer and thus has potential as a functional food ingredient. The new generation infant formula will require increase in the \( \alpha \)-lactalbumin and lactoferrin contents to get protein compositions similar to that of human milk (Regester et al., 1996).

5.3 Preparation of biological peptides
Enzymatic modification of milk proteins permits development of peptides having unique physico-functional properties of pharmacological significance. These bio peptides have been implicated in physiological roles such as biotransfer of trace elements, immunomodulation, antihypertension, antithrombosis, regulation of the gastrointestinal tract and the general behaviour (Morphine like activity). UF technology is being used as the most appropriate tool for separating low molecular weight peptides and free amino-acids from proteins substrates utilizing enzymes (Gauthier and Pouliot, 1996; Leppala, A.P., 1996; Maubois et al., 1996).

6.0 LACTOSE
Another very important dairy ingredient is milk sugar i.e. lactose that has various applications in food and pharmaceutical industries due to its multiple functional properties. Lactose is added to salad dressing, mayonnaise, soups and sauces to enhance flavour and confer added stability to various proteins in the formulations against flocculation at acid pH and pasteurization. The hydrolysis of lactose yields a sweet syrup containing glucose and galactose that have nutritional advantages in some dietary applications. Lactose hydrolysed syrups from permeates and whey's are becoming commercially available and are being used in confectionery and ice cream. A major use of lactose is in humanised infant formulae. Lactose has been used for years in the pharmaceutical industry as a coating agent for pills and tablets. The most recent application for lactose and its derivatives is in the formulation of 'nutraceutical' health foods.

7.0 DICALCIUM PHOSPHATE
Whey minerals are the other whey constituents which can be recovered from the ultrafiltration permeates of acid whey. These melting salts of whey in the form of calcium-magnesium phosphate, can be used as food ingredient in meat and fish products (Sienkiewicz and Riedel, 1990).

8.0 CONCLUSION
Production of dairy ingredients is a major activity in the developed countries like Europe and United States and provide the Indian Dairy Industry a very exciting opportunity to
undertake their manufacture not only to meet the domestic demand but to get into the export markets in United States, Europe and South East Asia. Rapid developments in the range and capabilities of membranes have the potential to profoundly affect the dairy industry as a whole. Being an excellent tool for the fractionation of milk proteins, a new range of products having unique nutritional and functional characteristics (gelling, foaming, emulsification, water holding capacity) have been developed by employing membrane processing. Membrane processing in combination with new efficient demineralization techniques and better knowledge and processes of enzymatic hydrolysis have helped in production of innumerable valuable fractionated dairy ingredients having significantly greater nutritional and biological values that have application in value added products, health foods and pharmaceutical products. More recently, membrane processes have been utilised for the preparation of enzymatic derivatives of milk proteins having pharmacological significance.

9.0 SUGGESTED READING


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1.0 INTRODUCTION

Starches from different sources have varying properties in food industry for nutritional, technological, functional sensory and aesthetic quality. There are many types of starches, which can be derived from various sources such as tapioca, maize, wheat, potato, rice and many other sources. The thickening and gelling properties of starch have a positive influence on the sensory, technological and functional characteristics of food products. However, depending upon processing conditions and types of food, the native starch per se may not have the desired functionalities. Unmodified food starch is used in food industry as a fermentation medium in the brewing industry, in sugar grinding as a bulking agent in dry mixes as a dusting agent, a molding medium in candy making, etc. However, in many applications where a cooked starch is used to thicken or provide texture to food systems, unmodified starch has serious limitations. Hence, modification of the native starch through various sources such as physical, chemical, enzymatic or genetic processes can provide the desired properties. The demand of modified food starch is increasing in various convenience and ready-to-serve foods. Modified food starches are chemically very closely related to native starches. General safety aspects of modified food starches showed no evidence of toxicity.

2.0 STARCH TECHNOLOGY

Starch is a polymer consisting of anhydroglucose units linked together primarily through α-D - (1 - 4) anhydroglucose bonds to form either a linear polymer known as amyllose or a branched polymer known as amylopectin. Depending upon the plant source, amyllose may consist of about 200-2000 anhydroglucose units compared to thousands for amylopectin, which may have molecular weights of several million.

Starches from most plant sources such as regular maize, cassava or tapioca, wheat, potato, etc., contain about 17-27% amyllose. The exceptions are starches from waxy grains such as waxy corn or maize, waxy rice, etc., which are nearly pure amylopectin, and high amyllose grains like high amyllose corn, which may contain up to 55-80% amyllose depending upon the genetic background.

The starch in plants normally occurs in the form of minute granules, which are insoluble in cold water. The size and shape of the granules vary depending upon the plant source. Rice starch has very small polygonal granules, 3-5 μ in diameter, corn starch granules
are polygonal or rounded and average about 15 μ in diameter, and potato starch granules are oyster shaped with size 100 μ in diameter.

The granules owe their integrity and insolubility in cold water due to intermolecular hydrogen bonds between segments of amylopectin branches. When an aqueous suspension of starch is heated beyond a critical temperature, which varies with the starch type, the hydrogen bonds weaken and the granules imbibe water, swelling to many times their original size and undergoing an irreversible change. As the process proceeds, the viscosity increases dramatically, and as the hydrogen bonds break the swollen granules rupture into molecular dispersions and aggregates, the viscosity decreases, with the extent varying with the type of starch (Wurzburg, 1995).

### 3.0 METHODS OF STARCH MODIFICATION

Starch modification processes involve relatively minimal alteration of the chemical nature of the starch but significant changes in its physical behaviour. The resulting products perform more effectively than unmodified starch or impart unique properties that are unattainable with native starches.

#### 3.1 Physical modification

Physical modification is the ability of starch to form a paste in cold water. This process consists of heating the starch slurry above its gelatinization point quickly followed by drying before reaggregation or retrogradation of dispersed starch molecule occurs. Roller drying and extrusion heating treatments are mainly used for this type of modification.

Extrusion may be used to produce a wide range of pre-gelatinized starches, however, extrusion cannot be applied to products in which high viscosity is required. Heat and moisture treatment involves subjecting moist starch (35% moisture) to heat treatment for more than 100°C for several hours. This process is generally preferred for potato starch.

#### 3.2 Chemical modification

Chemical modifications involve bleached starch, converted starches, cross linked starches and monosubstituted starches.

##### 3.2.1 Bleached Starch

The treatments for bleach starch involve treating suspensions of un-gelatinized starch granules with minimal amounts of oxidizing agents such as hydrogen peroxide, ammonium persulfate, sulfur dioxide, chlorine as sodium hypochlorite, potassium permanganate and sodium chlorite. The objective of bleaching treatments is to whiter starch. This is particularly true with corn starch, which has a yellowish colour due to traces of xanthophyll, carotene and related pigments associated with corn gluten (Wurzburg, 1978). These impurities are then solubilized and removed by washing.

##### 3.2.2 Converted Starch
The processes for making converted starches involve reducing the viscosity of native starches by weakening the starch granule and decreasing the size of its molecules through scission of the glucosidic linkages. By weakening the granule strength and decreasing the size of the molecules, conversions reduce the tendency of the granules to swell and absorb water and decrease the water binding capacity of the dispersed molecules and aggregates. Therefore, converted starches can be dispersed in water at higher concentrations than native starches.

3.2.2.1 Acid modified starch: Acid modified starches are made by hydrolyzing aqueous suspensions of starch granules with hydrochloric and/or sulfuric acid as catalysts with mild heat treatment, thus keeping the temperature well below the gelatinization temperature of the starch. The acid is neutralised and the granules are recovered by washing dewatering and drying after acid modified starch conversion.

3.2.2.2 Dextrin: Dextrins are produced by roasting powdered starch, usually in the presence of traces of mineral acid such as hydrochloric acid and moisture. Since these are made by dry treatment, there is no limit to the extent of conversion because of solubilization.

3.2.2.3 Oxidized Starch: Oxidized starches are produced by treating aqueous suspensions of starch granules with sodium hypochlorite as converting agent. Chlorine oxidizes starch randomly, thus introducing carboxyl or carbonyl groups in place of both primary and secondary hydroxyls. The carboxyl groups introduced in place of some of the hydroxyls are bulkier and more hydrophilic than the hydroxyls they replace. As a result, stabilizing effect is exerted on the molecule, reducing their tendency to retrograde or associate.

3.2.3 Cross-linked starch
Cross-linked modified starches depend on the amount of cross linking agents and residues in the starch. When unmodified starch is heated in water, the hydrogen bonds responsible for the integrity of the granules weaken, the granules start to swell imbibing water, and on continued cooking, the hydrogen bonds break and swollen granules rupture and collapse. When this occurs, the viscosity drops and the texture of the sol changes from a short salvelike nature to an elastic unpalatable texture. The objective of cross linking is to reenforce the hydrogen bonds in the granule and chemical bonds linking together nearby molecules within the granule. These chemical bridges are much stronger than hydrogen bonds and will help retaining the integrity of the swollen granules after the hydrogen bonds have been destroyed. Cross links may be introduced in the granules by reacting glucosidic hydroxyl on nearby molecules with bifunctional chemicals capable of adding adipate or phosphate cross links (Wurzburg, 1986).

3.3 Enzymatic modification
α-amylase is used to produce enzyme thinned starch during enzymatic treatment. Enzyme thinned starch is produced by passing a starch slurry alongwith heat stable bacterial amylase through a jet cooler. The gelatinized and partially thinned starch paste is passed through holding coils to obtain the desired viscosity. Passing then inactivates the enzyme
through the jet cooker at elevated temperature after which the thinned paste is ready for use (Dias et al., 1997).

4.0 APPLICATIONS IN FOOD INDUSTRY

Milk based foods are produced in many forms with a range of consistencies from firm textured products though thick, spoonable products to thin, pourable toppings. Water binding and thickening are the main functional qualities of starch required in all types of milk desserts. The characteristics of the end products address the amounts of thickening material to prevent serum separation.

4.1 Ice-cream and Frozen Desserts

Starch modified by treatment with acids and oxidised with a solution of sodium hypochlorite was found to be most suitable. The optimum amount of modified starch varied from 1 to 1.5% for ice-creams and fruit juices and organoleptic quality was improved considerably. Modified starches acted better in frozen custard and puddings as compared to conventional stabilizer carrageenan and carboxy methyl cellulose (Oleneve and Filchakova, 1971). In addition to better rheological and organoleptic properties, modified starches also produced better over run in frozen desserts.

4.2 Cheese

Starch is used as stabilizing and thickening agent. Process cheese products and fresh cream cheese with conventional ingredients and modified starch (0.1 - 0.5% by wt.) permits the reduction of melting salt content of process cheese and enhances the keeping quality. Modified starches can partially replace caseinates for imitation cheese products. Processed cheese with good texture, aroma and keeping quality is produced by melting the cheese with a mixture of 2.5 - 4.0% melting salt and 1.0 - 2.5% of phosphate modified starch (Starmiska, 1977).

4.3 Cultured Milk Products

In acidic conditions as in cultured dairy foods, the starch breaks down and loses its natural ability to swell in water and increases the viscosity of these foods. However, starch modified with phosphate and other edible product prevents it from breaking in acidic foods. The modified starches are being successfully used in cultured dairy foods for thickening the body, prolonging shelf life, preventing wheying off and to produce a better looking product (Bassett, 1983).

4.4 Soups, Sauces and Gravies

Soups, sauces and gravies require desired consistency. The thickner imparts texture, glossy, transparent appearance and imparts desired mouth feel. Commercial soups are available in powder form, which require pre-gelatinized starch or modified starch. The consistency of sauces and gravies is greatly improved by addition of modified food starches.

4.5 Pasta Products

Modified food starches impart optimum mouthfeel in pasta products. The viscosity stability is attained against heat and shear. It prevents retrogradation of starch in pasta products.
5.0 SAFETY ASPECTS OF MODIFIED FOOD STARCHES

Modified food starches contain low to relatively low levels of substitution groups. Bleached and converted starched with the exception of oxidised starches either involve no significant change in the chemical structure or produce changes similar to those that starch undergoes in human digestion in well accepted food processes such as baking. Cross linked starches contain very low levels of substituents and thus exert minimal effect \textit{in vitro} and \textit{in vivo} digestibility as well as acute toxicity. Chronic and multigeneration studies on cross linked starches provided evidence of their safety. The Expert Committee on Food Additives (1982) confirmed the acceptable daily intakes (ADI) of modified food starches were “not specified”. American Academy of Paediatrics (1978) recommended the use of modified food starches in infant foods with the exception of hydroxy propylated starches.

6.0 CONCLUSION

Starch is a low priced, abundantly available raw material for food industry. There are many types of starches which are derived from tapioca, maize, wheat, potato, rice, etc. The thickening and gelling properties of starch have a positive influence on the sensory, technological and functional characteristics of food products. Native starches lack to exhibit desired attributes in ready-to-serve convenience foods. Due to various starch modification processes, the use of modified food starches is increasing in food industries. Modified food starches are reported as safe as of native food starches.

7.0 SUGGESTED READING


1.0 INTRODUCTION

Proteins are the most expensive substance to produce among the three main nutrients in food. It is likely that as populations grow, they will be first to become limiting. Ideally, food proteins should be safe, economical and nutritional with good flavour and desirable properties for processing. It is therefore that formulated foods are often designed to provide adequate nutrition to larger population at moderate prices. As meat is a high cost ingredient, meat based formulated foods are expensive. Use of several non-conventional food ingredients have thus found application in manufacture of variety of restructured meat products.

In comminuted meat based food formulations, milk proteins are increasingly being used as fillers, binders and extenders. Milk proteins are available in various forms such as caseinates, coprecipitates, skim milk powder, whey proteins, total milk protein, milk protein concentrates and milk protein hydrolysates for incorporation in food product formulations. The choice of milk protein in a food system is guided by their potential functional properties which in turn are monitored by their constituents, composition and processing conditions employed for their isolation. These milk protein isolates offer excellent functional properties such as solubility and dispersibility, opacity, acid stability, water holding, fat binding, viscosity, gelation, heat stability and emulsion stability besides being nutritional ingredients for food applications.

Preparation of functional meat emulsion is the foremost important step for the manufacture of good quality processed meat products. Binding of water and fat are the two most important processes in the stabilisation of complex system of meat emulsions. If the muscle protein is not sufficient during the production process, unstable products would result and their technological deficiencies become apparent in the form of breakdown of emulsions. These limitations can be eliminated or reduced by incorporation of suitable milk proteins that can improve the formation of stable emulsions.

2.0 NON-FAT DRY MILK

Non-fat dry milk (NFDM) is produced from pasteurised skim milk, which is vacuum concentrated and spray dried. In essence, NFDM is the product resulting from the removal of fat and water from milk and contains lactose, milk proteins both casein and whey proteins,
and minerals in the same relative proportion as does fresh milk. Non-fat dry milk can be used as a functional protein ingredient in a variety of comminuted meat products.

The efficiency of NFDM in stabilisation of meat emulsions depend upon the ratio at which they are mixed and the extent of protein-protein interactions. The addition of NFDM is reported to be important for heat stability if nitrites in stabilised meat products have to be reduced because of potential nitrosamine formation. NFDM increases the frequency of fat agglomeration while improving stability. Water absorption and gelation phenomena of proteins play a greater role in determining the stability of comminuted meat systems. NFDM is more effective in stabilisation of meat emulsions than many vegetable proteins. Sausages prepared from mutton fat with 0.5% skim milk powder have been found to have significantly improved aroma, texture and juiciness. SMP (35% protein) as a filler in comminuted meat products has good water binding effects, but lactose may sometimes cause discoloration of meat products because of Maillard reactions with proteins. Blending of meat and NFDM improves meat emulsion stability and best results have been obtained with the ratio of mutton to SMP as 100 to 15 (w/w) in sausage making.

Various meat products such as liver paste, semi perishable sausages, mortadela, frankfurters and chopped meats with SMP at 1.5-4% level have definite functional advantages and improved sensory characteristics. The presence of SMP even upto 40% in soft sausages do not affect the taste of product significantly. Quality of chunked and formed lamb roasts containing SMP showed an increase in flavour acceptability, muscle chunk separation and moisture content and SMP extended roasts were most palatable. Addition of NFDM upto a level of 15% gave the best flavour and produced the most acceptable chicken sausages.

Because of the high solubility of milk proteins, sausage batters extended with NFDM are not as viscous compared to all meat control. However milk proteins in SMP are present in a micellar, low-viscous form which is not optimum for emulsifying purposes as calcium may negatively influence the binding properties of lean meat products. The reduced form of calcium SMP appears to be more logical and more functional choice for meat products.

### 3.0 CASEINATES

Caseinates are produced in numerous forms viz. sodium, calcium, potassium and magnesium caseinates for food applications. The caseinates are made from lactic or acid casein by rinsing, treating with various alkaline salts, heating and mixing followed by spray drying. The type of caseinate required would depend on a number of factors such as extent of comminution, texture of the product needed and processing conditions used i.e. whether hot or cold processed and whether it is pre cooked or sold raw for home frying. Sodium caseinate provide high solubility, clean flavour profile, high water and fat binding and freeze thaw stabilisation in meat emulsions. Calcium and potassium caseinates are used in processed meat products demanding a lower sodium formulation, provided they are functionally similar to that of sodium caseinate. Sodium caseinate can also be polymerised with small amount of formaldehyde to obtain high viscosity sodium caseinate having greater water binding and gelling properties to make efficient stabiliser in specialised meat products.
The functional ability of the caseinate lies in the unique distribution of the electric charges on the polymeric molecule, hydrogen bonding and richness of hydrophilic as well as lipophilic bonding sites. Sodium caseinate has been reported to improve the gel strength of individual meat protein fractions while calcium caseinate having a more conglomerated structure disturbed the gelation of meat proteins. Because of high proline and the low-sulphuric amino acid content, caseinates will have a random coil structure with a low percent helix. As a consequence, caseinates will show no heat gelation and denaturation and will have a high viscosity in solution. Caseinates, when used in the desired way, retain a part of the soluble fraction of meat protein in their native form which is otherwise prone to denaturation at the interface, enabling it available for gel formation upon heating possibly through protein-protein interactions of meat and milk proteins. Caseinates are active at the fat-water interface to prevent fat separation and do not affect the naturality of meat products when used at less than three percent level in meat products. Caseinates are adsorbed preferentially over meat proteins and because of fat capsules created by the presence of caseinates, water loss during heating is reduced. The small fat capsules lodge into the network of swollen fibres and prevent shrinkage. Addition of caseinates in meat emulsions result in thickening of the gravy during freezing and prevents it from running out, but excess of incorporation of caseinates may lead to drying up of the products.

Sodium caseinate could replace 10-20% of meat in Roman roast recipe, 5% of meat in canned chicken patties, 50% of meat in sausage products without adversely affecting sensory quality and nutritional value. Flavour, juiciness and texture scores improved in the nugget samples containing caseinates. Sodium caseinate at 1% level could be beneficially used to improve the quality of nuggets from spent hens. Caseinates are also reported to improve juiciness of hamburgers. Caseinates have proved to offer better functional qualities when used in combination with vegetable proteins in comminuted meat products. The emulsion stability of batters containing caseinates and refined wheat flour was significantly higher and frying loss was much less compared to control samples of chicken nuggets. Sensory quality of cooked sausages containing 1-5% sodium caseinate was similar to that of the control but had minimum cooking loss.

Addition of caseins upto 1% increased the yield of cooked ham, nuggets from spent hens and luncheon meat but higher levels of addition decreased the yield. Cooking losses were also reduced by addition of sodium caseinate in cooked ham, beef frankfurters, chicken nuggets and smoked chicken sausages.

4.0 COPRECIPITATES

Coprecipitates are manufactured by heating skim milk to denature most of the whey proteins, treating with acid to isoelectrically precipitate the caseins and whey proteins and further processing as in casein manufacture. Alternatively, coprecipitate can be prepared using both acid and calcium chloride. The level of calcium in the product is determined by the pH of precipitation, the amount of calcium chloride added and the washing conditions. A recent development in the manufacture of milk coprecipitate that offers excellent potential is
the process for coprecipitating casein and whey proteins in an undenatured complex that contains all of the protein components in a highly functional form. The use of coprecipitates can prove more effective in food applications particularly in modifying texture. Coprecipitates with an excellent amino acid profile render highly nutritious protein supplement as they contain 97% important amino acids as against 80% in casein. Their higher protein efficiency ratio (2.8) makes them particularly important for protein supplementation of formulations with relatively low nutritive value. The whey protein-casein complex of coprecipitate provides the type of matrix, the meat industry is probably looking for and coprecipitates can be produced with a wide range of water absorption characteristics to meet variety of functions in different comminuted meat products.

Wet coprecipitate has total solid and protein contents similar to those of beef and mutton, respectively. When it was used to replace 10 and 20% meat in hot dogs and mortadella preparations, no significant differences were found in yield, texture, organoleptic characteristics, digestibility and microbiological quality. With the addition of coprecipitate in meat, the release of fat decreased, pH increased, product colour lightened and sensory quality remained unaffected. Coprecipitates increased water holding capacity and stickiness but reduced the penetration and shear stress values in freeze-dried ready to cook meat preparations. Type of coprecipitate was observed to influence shear force value of mutton nuggets and were found highest in samples with high calcium coprecipitate.

High and low calcium coprecipitate have been found to have synergistic effect with meat proteins especially at 20% rate of substitution of meat in sausage manufacture. At low pH, coprecipitates improve emulsification performance, while water binding capacity is improved at both high and low pH. Sausages containing milk coprecipitates at 40% level of substitution were of equal organoleptic quality to all meat sausages. It was also found that only 20% meat protein was necessary for satisfactory emulsion quality in meat and coprecipitate blends. Different milk coprecipitates viz. low, medium and high calcium types at 15% level of substitution significantly affect emulsion stability, yield, moisture and protein content of minced meat system. Low calcium coprecipitate is better suited in manufacture of mutton nuggets while mutton patties could be prepared with any type of milk coprecipitate without adversely affecting the quality.

Addition of sodium tripolyphosphate improves the solubility of coprecipitate for increasing its viscosity building capacity thereby improving water holding/binding properties and making it more suitable for sausage industry. Utilisation of soluble coprecipitates has been demonstrated in meat cutlets in which 30% of meat can be replaced with coprecipitate. The coprecipitates are also reported to have good potential in meat products such as frankfurters, luncheon meats as meat replacers or extenders. Use of milk coprecipitate in the manufacture of hamburgers and mutton nuggets reduced frying loss and shrinkage during frying, which may be attributed to enhanced water and fat binding capacity of high calcium coprecipitate in the emulsions.

In India, good quality nuggets have been made from spent hen meat with high calcium coprecipitate substituted at 20% level. High calcium coprecipitate has also been used in the
manufacture of chicken meat loaf without adversely affecting the quality attributes of the end product

5.0 WHEY PROTEIN CONCENTRATES

Whey protein products containing more than 35% whey proteins (α-lactalbumin and β-lactoglobulin) on a dry basis are called whey protein concentrates. Manufacture of whey protein concentrates involves multiple steps. The whey obtained from cheese or casein manufacture contains 93% water and only about 0.6% protein. It is clarified and then concentrated by ultrafiltration to remove major portion of water, lactose and ash after which it is spray dried to powder. Whey protein concentrates with more than 35% whey protein and upto 80% protein are produced by ultrafiltration and diafiltration. By introducing ion-exchange as pretreatment to ultrafiltration, whey protein isolate with 90% protein can be manufactured. When WPCs are prepared by different processes, they vary in chemical composition, nutritional quality and functionality. Careful testing prior to its use in meat products is therefore needed due to these functionality differences resulting from processing variables.

Whey protein concentrates are highly nutritious, with a protein efficiency ratio (PER) of 3.0-3.2 against 2.5 of casein and contain significant amount of essential amino acids such as lysine, tryptophan, methionine and cystine. Whey proteins are, however, low in proline and have many S-S bonds leading to a globular, strongly folded and organised structure. During heating they unfold and build intermolecular di-sulphide bonds. Whey protein concentrate forms irreversible gels by resulting into extended 3-dimensional net work. Gelation entraps water within capillaries of the gel matrix, thus providing additional water holding capacity. A strong gel net work helps hold this water and prevent moisture loss improving the yield, appearance, mouthfeel and juiciness of the meat products. Whey proteins contain both hydrophobic and hydrophillic regions to provide emulsifying properties that are more irreversible than with corresponding caseinate emulsions. Although the interactions between meat protein and whey protein play a decisive role in stabilisation of meat emulsions, they are very complex and not well understood.

Whey protein products are used in variety of meat and meat products to provide improved stability and organoleptic characteristics. Aqueous solutions of WPC have been injected into meats such as ham, bacon, pork shoulders, poultry, brisket and veal. The incorporation of WPC influenced fat binding capacity of meat emulsions and reduced the cooking time. Emulsion stability of the sausage batters with WPC have been found to be significantly higher than the control as evidenced by the lower values of fluid loss. It could be attributed to gelation, high water and fat binding properties of WPC. Whey proteins form interfacial membranes around oil or water globule due to presence of both hydrophillic and hydrophobic regions. WPC also provides stability through total entrapment of fat within the gel net work. Improved stability of structured beef containing WPC has been attributed to
protein - protein interaction between myosin and α-lactalbumin or myosin and β-lactoglobulin.

WPC formed irreversible gels by restructuring into 3-dimensional net work. Gelation entraps water within capillaries of the gel matrix providing additional water holding capacity to improve the yield of meat products. The increase in yield has also been attributed to better fat retention as whey protein with its excellent surface active properties allowed them to reorient and reduce the interfacial tension with increased opportunity for fat protein interaction.

Whey protein concentrates are used to modify the textural characteristics such as hardness, cohesiveness and elasticity in meat products. The effect of WPC on firmness and shear force value of the product depends on the type of meat product, its formulation and processing of whey protein concentrate.

6.0 SELECTED READING


1.0   INTRODUCTION

Butter is one of the historic yellow fat serving mankind since many years. Due to escalating prices and declining purchasing power of the consumers, butter remains beyond the means of masses. Consumption of butter had declined considerably due to changing life style and better awareness towards health problems. As such butter, a high fat product, is associated with presence of high cholesterol and saturated fatty acids that play a crucial role in coronary heart diseases. Spreadability at low temperature is yet another problem associated with butter. Therefore, spreads were developed which have better spreadability even at low temperature and retains shape even at high ambient temperature. These soft spreadable products are usually high in polyunsaturated fatty acid (PUFA) content and are therefore perceived to have better nutritional profile. The competing spreads containing high moisture offer economic advantage with important characteristics like flavour, mouth feel, spreadability and keeping quality.

Today’s consumer welcome the availability of a wide variety / range of blended spreads (Table 1) getting a wider choice as regards to nutritional properties, flavour and physical properties that has been available hitherto from traditional butter and margarine.

2.0   DEFINITION

Butter, margarine and spreads all are visco-elastic solids. The principal ingredients of fat spreads are fat, milk proteins, emulsifiers, stabilisers, water and sodium salts, flavouring ingredients and preservatives. Each of these ingredients affects the emulsion characteristics and processing of the final product. As the availability of spread able products increased attempts were made to define and classify such products for the convenience of manufacturers and consumers alike.

International Dairy Federation (IDF) provided a general definition of "yellow fat spreads as food in the form of spreadable emulsion, indented for spreading, which is mainly of the type water-in-oil, comprising principally an aqueous phase and edible fats and oils."

Prevention of food adulteration act (PFA 1993) has defined "fat spreads as a product in the form of water-in-oil emulsion of an aqueous phase and the fat phase of edible fats and oils, excluding animal fats." It shall contain fat not more than 80%, moisture not less than 16% or not more than 50%, milk solids not fat, common salt (2%), flavouring agent (4ppm), permitted preservatives (1000 ppm). Vegetable spreads shall contain not less than 25 IU of vitamin A per gram.
3.0 CLASSIFICATION

In general depending upon the source and nature of component fat and total fat content, table spreads have been classified into three to five categories. A composite picture of the classification is presented in Table 2.

3.1 Milk fat spreads
These are spreadable products where the total fat content can vary from 20 - 80 % and are made-up of exclusively milk fat.

3.2 Mixed fat spreads
These are products where the total fat content is derived from mixture of milk fat and vegetable oils (hydrogenated, refined or intersterified fat) and the content of milk fat could vary from 10 - 30 %.

3.3 Vegetable fat spreads
The fat content of such products are a mixture of any two or more of hydrogenated, unhydrogenated, refined vegetable oils or intersterified fat. The milk fat content should not be more than 3%, in case it is to be used for enhancing flavour to overcome oily flavour.

4.0 DEVELOPMENT OF FAT SPREADS

Butter and margarine both contains 80% of milk fat and does not suite public demand for low fat foods. As eating habits changes there is a definite decline in the high fat sector with the growth shifting towards the low fat sector. This is because these substitutes are products with harmonizing safety along with good nutrition. The attraction for a suitable alternative arises from the fact that spreads can cut both on total fat and saturated fat intake and easy spreadability at refrigerated temperatures. The driving force behind the development of spreads, invariably containing less fat than butter and margarine, was the health needs of the product. Three phases mark the development of table spreads.

The first extended the raw material base from original animal body fat to other suitable edible fats such as vegetable oils. Attempts in this direction were greatly facilitated by the process of refining and hydrogenation. This was mainly to increase the availability of other table spreads.

The second phase related to the compositional aspects necessitated by two needs, one physical and the other chemical. With the universal use of household refrigerator butter stored tended to be hard and difficult to spread on bread. To make it softer higher levels of liquid fats/oils were used and special processing conditions have to be applied to attain desired rheological properties.

In the third phase the opportunity afforded by efficient emulsifying agents and process equipments was utilised for making spreads to cover other nutrients such as protein. The present scenario in the Indian market is the availability of various brands of table spreads based on replacement of milk fat with varying degree and having varying rheological properties. At the same time their good taste; flavour and low cost as well as necessary spraedability meet the customer’s requirements.
5.0 INGREDIENTS FOR TABLE SPREADS

5.1 Fat

It is an important component of spreads that governs consistency, flavour, nutrition and spreadability characteristics. There are several sources of fat that have been used for table-spread formulations. Depending upon the kind and type of spread the fat source is chosen accordingly. Spreads are available that contain exclusively milk fat, or mixture of any other animal fat and vegetable fat/oil, or milk fat and blends of vegetable oils. The behaviour of fats and fat blends during processing and storage of spreads can be related to the solid fat index and temperature profile that controls several product characteristics like appearance, firmness, spread ability and pack ability. For milk fat spreads generally cream (40-70% fat) is used. Butter may also be used as a source of fat for low fat spreads. Where ever available butter oil also has been used for the manufacture of low fat spreads.

The blends of various fats/oils have been used to improve the spreadability of the product at refrigerated temperature and impart nutritional characters though incorporation of PUFA rich vegetable oils. Cream and vegetable oil blends have been successfully used for the manufacture of blended fat spreads. Variety of vegetable oils like sunflower, rapeseed, corn, cottonseed, soybean, coconut etc have been used in refined or hydrogenated forms.

5.2 Protein

This non-fatty constituent plays an important role in texture of the spreads. Proteins helps in emulsifying fat and absorb water thereby making the product physically stable. The type and level of protein affects body and texture of low fat spreads. In addition to contributing flavour, milk solids not fat acts as a preservative by sequestering metals that promote oxidation. Various sources of milk proteins namely skim milk, SMP, calcium reduced SMP, partially defatted SMP, casemates, co-precipitates, butter milk, butter-milk powder, whey, WPC, low lactose whey, dried whey, condensed milk -skin and whole, WMP and ultrafiltered milk protein concentrates etc. have been used for the manufacture of table spreads. The general level of usage varies between 5 - 15%.

5.3 Minor ingredients

These ingredients of spreads exhibit functional and in some instances nutritional properties which may be important to the consumer acceptability. The Codex Alimentarius Standards permits the use of gelatins, mono, di-oligo sacchrides, maltodextrins, natural starches, egg yolk and salts in all edible table spreads. As the fat spreads contain 30-50% moisture excessive free water leads to syneresis and poor consistency.

5.3.1 Stabilizers having high water holding capacity contribute significantly towards improving textural characteristics of spreads. Use of vegetable gums such as locust bean, CMC, guar gum and carrageenan etc. have been used at the rate of 0.2-0.5% singly or in combination.

5.3.2 Emulsifiers are yet another important ingredient that holds the emulsion ingredients together and avoid destabilization. The type of emulsion, nature of ingredients and processing conditions govern the type and level of emulsifier. Usually mono and di glycerides, lecithin, glycerol monostearate, polynol A, phosphotides, and mixture of lecithin, cephalin and inositolphosphotides in cotton seed oil carrier have been used at a level of 0.15-0.5%.
5.3.3 Acidogenic substances are sometimes added to retard bacterial growth thus helping in extending the shelf life of the product. Acids such as lactic, citric, acetic and hydrochloric and salts of glucono-delta lactones are added, after Pasteurization, to control pH of the system. A pH lower than 4.7-5.5 would result in syneresis and higher pH would lead to the formation of O/W emulsion. Best body and least weeping have been obtained with pH 5.7-5.9.

5.3.4 Sodium chloride is added to improve flavour acceptability of the spread. In addition it helps in inhibiting the growth of bacteria and fungi and thereby acts as preservative. Usually the salt content of spreads varies from 0.75 to 1.25%. Higher salt levels (1.5%) do not have any perceptible influence on body and texture. Common salt plays a significant role in increasing the viscosity of spreads containing caseinates.

5.3.5 Flavourings A variety of natural and artificial flavouring compounds have been used in table spreads. To mimic butter flavour starter distillates, cultured buttermilk and ripened cream have been used. For spreads to have cheesy flavour commercial cheese flavour concentrates are added or it can be achieved through addition of natural ripened cheese at the rate of 20% of the finished product. Spices and seasonings such as cumin, pepper, garlic onions and ginger etc. have also been used for flavouring spreads.

6.0 LOW CALORIE SPREADS

As a result of increased consumer awareness of diet and health issues, the public demand is for foods low in fat, low in saturated fats and cholesterol free foods. It is for this reason there has been considerable growth for low fat products with improved texture, taste and shelf life. Low fat spreads were originally introduced in 1960s contained 40% fat. They comprise of oil-in-water emulsion with a fat phase having milk fat and or blend of milk fat and vegetable oil and aqueous phase of water, proteins, stabilizers and emulsifiers, salts, flavourings, preservatives etc. Processing of low fat spreads is similar to high fat spreads except that parameters have to be critical as a result of emulsion instability.

The aqueous and fat phases are prepared separately. The heated aqueous phase is added to the fat phase under controlled conditions creating a good quality emulsion. Low fat spreads are inherently unstable. The stability of low fat spreads is enhanced by homogenization of aqueous phase prior to emulsion formation and or use of gelling agents. The influence of viscosity and functionality of the aqueous phase on emulsion stability, spreading and eating characteristics of the spread are significant. Also crystallization and extrication of the product are important parameters, which should take place under controlled conditions during processing. Low fat spreads normally contain 50% water. Addition of milk proteins improves the taste and nutritive value of the spread. The nature of the fat phase comprising of butter-oil or vegetable oil based, contributes significantly to the plasticity and organoleptic properties of the low fat spreads.

A low fat spread called "Klick" was launched in Sweden that contains 25% fat, buttermilk, skim milk casienates, butter oil, vegetable oil, starch, salt and emulsifier with a shelf life of 8 weeks at 8°C. processes have been developed for the manufacture of low fat spread without addition of stabilisers and emulsifiers and addition of milk proteins. This product is low in fat and low in cholesterol than most low calorie butter alternatives. Removal of fat results in loss of fat-soluble vitamins and it may adversely affect nutritional quality of the low fat spreads. This has been overcome by devising a method to enrich the spreads with added vitamins.
6.1 Fat replaces

Development and use of wide variety of food ingredients called fat replaces have made it possible the production of many low fat or no-fat spreads. There are two primary type of fat replacers i.e. energy free fat substitutes and energy reduced fat mimetic. The fat substitutes are neither digested nor absorbed and therefore contribute no fat, energy or cholesterol in the diet. Several fat substitutes are available which can be added to the spreads. They include carbohydrate fatty acid polyesters, malonate esters, esterified propoxylated glycerol etc.

Fat mimetic have the ability to replace mouth feel of fats. These are protein based, carbohydrate or starch based or cellulose based. Simplesse, Trailblezer and Finesse are some of the protein based fat replacers, which give mouthfeel of fat in the spreads. Carbohydrate based fat replacers are digested and absorbed. They are bland in taste and soluble in water. They provide spreadability and appearance to the low fat spreads. Cellulose based fat replacers contribute only to creamy mouth feel to the products.

6.2 Future trends

With the increasing health awareness amongst the present day consumers there has been an increase in the demand of low fat low cholesterol PUFA enriched products. The trend towards fat reduction in dairy products may one day lead to the demand for no-fat products by the consumers. Such products can only be possible by incorporating large quantity of carbohydrate and or proteins to substitute fat. It may be possible to formulate products that contain non-calorific synthetic compounds in place of fat. Modified protein sources will find increased applications as fat replacers. Low fat spreads have already proved a great technological and marketing success. Future may hold the advent of spreads that contain considerably less or no-fat at all.

7.0 SUGGESTED READING


ROLE OF SENSORY EVALUATION IN DEVELOPMENT OF FORMULATED FOODS

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1.0 INTRODUCTION

In a modern food-processing unit, a number of quality assurance procedures are used to examine and maintain quality of a product at different stages starting from reception of raw materials to surveillance of the finished products. These tests are physical, chemical, microbiological and sensory. Amongst all these methods, sensory evaluation is of paramount significance. In fact, with the tremendous growth of economy, and competition, the high cost of R&D and too high failure rates in new food products developments, the research workers and technologists has started turning to sensory responses, as validating tests for better prediction of success. The sensory quality has to be included in the formulation to new products since it is the only integrated multidimensional measurement with following advantages.

- It identifies the presence or absence of perceptible differences.
- The important sensory characteristics are measured in a fast and quantifiable manner.
- Identifies particular problem that cannot be detected by other analytical and instrumental techniques.
- It helps in ensuring that the consumers get consistent, non-defective and enjoyable product.
- Used for establishing correlation with chemical, physical and instrumental measurements.

The sensory evaluation procedures have been studied in considerable details with the result that this scientific discipline has come to be recognised as of fairly objective in nature (Learmond, 1987). The inherent variability of sensory evaluation by human subjects 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 (Ogden, 1993).

2.0 SENSORY EVALUATION PROCEDURE

A successful implementation of sensory evaluation programme for development of formulated foods requires proper laboratory facilities, trained sensory panels and adoption of pre-use sensory methods. A sensory panelists works as an analytical instrument, hence should be carefully selected and rigorously trained for a particular product so as to obviate inconsistency (Pal et.al. 1995).
2.1 Laboratory facilities

Nakayama and Wessman (1979) observed that sensory evaluation facilities at the manufacturers levels should be as elaborate or as large as those in R&D Centre. The emphasis is on conducting tests that produce valid, reliable and reproducible results. They recommended that the facilities be divided into two distinct areas - one for sample preparation and another for evaluation- with appropriate lighting, ventilation and temperature controls so as to create an environment conducive to preparation and evaluation. Stone and Sidel (1993) emphasised that the laboratory facility should be flexible enough to handle current and future testing activities as well as to provide a workable environment for the staff. In case computers are used, sensory evaluation laboratory should include space for data processing equipment, which includes digitizer, personal computer (PC) with colour display, storage peripheral, printer/plotter, and modem if one is linked to a mainframe. If paper scorecards are used for sensory evaluation, then a digitizer system is most efficient, flexible and least costly. The digitizer converts the marks on scorecards to numerical values; each value is displayed on the screen of the microcomputer and then transmitted to storage. After all, data are entered and hard copy obtained from printer; the appropriate software is entered into the microcomputer and the analysis is completed and results printed (Stone and Sidel, 1993). One can also, use direct data entry using electronic score card. A recent introduction is the use of score sized tablets that display a scorecard page (Balmier and Woman, 1991).

2.2 Screening and selection of panelists

A desired type of panel can be selected on the basis of following sensory skills (Amerine et al., 1965):

- Discriminating differences between solutions or substances of known chemical composition ability to recognise flavours or odours,
- Performance in comparison with other panel members and
- Ability to discriminate differences in samples to be used later in the test.

The selected subjects are trained in identification and/or quantification of desirable and undesirable sensory attributes of the food product. Normally, a discrimination test is preferred for these activities. The panelists evaluate many randomly selected samples of the product before he or she becomes qualified to make sensory checks. To confirm the panelist’s performance, panel difference test and just noticeable difference test have been suggested. The major point to be emphasised with regard to panelist qualifying is not the rigid adherence to one product or test procedure exclusively, but rather the provision of some diversity and making the job enjoyable for the subject. The importance of teaching individuals to gain confidence in their ability as sensory panelist is of paramount importance (Stone and Sidel, 1993).

Maintaining a constant trained panel for analytical testing during long-term product storage studies is difficult. Two alternatives can be adopted in this situation: establish a large reserve of panelists and draw from the reserve as necessary, or start with a large number of active panelists that required to sustain a constant panel throughout the study.

A representative sampling on product and an adequate amount of each treatment variable are essential. A sample size in excess of that required is recommended as a
precautionary measure for prolonged storage studies. Sampling procedures for controlled laboratory studies designed to evaluate the effect of factors such as formulation, processing, packaging or storage conditions are usually less restrictive and may include pilot-plant or non-distributed commercial products. Product homogeneity is also necessary. The test sample should be documented, coded and placed in predesigned storage environments. The total number of the samples used for storage studies be determined by the experimental design, the sensory evaluation procedures and the total test programme, including microbiological, physical and chemical analysis (Dethmers, 1979).

2.3 Sensory tests

A large number of the sensory tests are available and new methods continue to develop. Broadly, these tests can be classified into three groups, as follows (Stone and Sidel, 1993).

- Discriminative (difference testing)
- Descriptive
- Affective (acceptance/preference)

Discriminative testing is one of the most useful analytical tools available to the sensory professionals. It is on the basis of a perceived difference between two products that one can justify preceding to a descriptive test in order to identify the basis for the difference. Within this general class are a variety of specific methods, e.g.

- Paired comparison test
- Duo-trio test
- Triangle test
- Multiple sample test, and
- Other test methods such as dual and multiple standard tests.

The main objective for all these methods is to answer a simple question: is the stored product different from the fresh one? Obviously the response to this question can have major consequences. If the conclusions from a discrimination test are to be accepted by management as reliable, valid and believable, hence it is important that each test be conducted with proper consideration for all aspects of the test design, product preparation and handling, implementation, data analysis and interpretation. Failure to appreciate all the subtleties of a test increases the risk of data misinterpretation.

Descriptive analysis has been defined as a sensory methodology that provides quantitative descriptions of products based on the perceptions of a group of qualified subjects (Stone and Sidel, 1993). It is a total sensory description taking into account all sensations that are perceived: visual, auditory, olfactory, kinesthetic and so on, when the product is evaluated. Descriptive analysis results provide complete sensory descriptions of an array of products and provide a basis for determining those sensory attributes that are important to acceptance. The results enable one to relate specific process variables to specific changes in some of the sensory attributes of a product. From the product shelf life viewpoint, descriptive-information is essential in finding out the types and extent of changes that have taken place during storage from which one can establish cause and effect relationship.

A descriptive test involves relatively few subjects whose training is primarily focused on development of descriptive language, which is used as a basis for scoring the product. Some of the useful descriptive methods recommended for food analysis are: flavour profile, texture profile, quantitative descriptive analysis and scoring.
Affective or acceptance testing, a valuable and necessary component of every sensory program, is performed keeping in view the consumer’s levels. It refers to measuring liking or preference for a product. In that respect, this method is most relevant to the development of new and formulated foods. Preference can be measured directly by comparison of two or more products including control, if available with each other, that is, which one of two or more products is preferred. Indirect measurement of preference is achieved by determining which product is scored significantly higher than another product in a multiproduct test or which product significantly more people score higher than another. The two methods most frequently used to directly measure preference and acceptance is the paired comparison test and the 9 point Hedonic scale.

3.0 FORMULATED PRODUCTS DEVELOPMENT

In the formulation of entirely new foods, or modification of the existing products, sensory tests can provide helpful input in many ways (Erhardt, 1978, Baker et al., 1994). These are discussed as under:

3.1 Confirm intentional/unintentional changes in product/ingredient formulation

Sensory evaluation can provide data to confirm that changes have been made in the direction indicated by the consumer tests. They can also be used to determine whether unintentional changes have occurred in the product during reformulation. The evaluation provides assurance that the desired changes are perceptible in an objective test situation.

Sensory evaluation can also be used to determine whether additions of a certain ingredient affect the flavour of a product; e.g. whether vitamin fortification replacement of fat with vegetable or mimic results in the perception of “off” or undesirable notes. A discrimination test will indicate how confident we can be that flavour differences are not perceptible between the control and fortified samples. Panelists can evaluate competitive product to identify changes and improvements and to compare new products to their competition to determine similarities and differences. Replacing an ingredient because of cost or availability without changing the product characteristics is difficult. In-house sensory panels are ideally suited for evaluations of this kind. Discrimination tests using sensitive panelists will determine which samples match the control and which are perceptibly different. If panelists do not detect a difference and if the test methods and procedures are sound, the requester can be comfortable accepting the substitute ingredient.

3.2 Determine if optimization has been achieved

In new product development, sensory tests provide the developer with correcting information and guidelines for product improvement. Tests can be used to determine which characteristics of the latest formulation do or do not meet the product mix. Sensory panels to determine whether optimization of product quality has been achieved can also evaluate formulations. Effects of usage conditions e.g. use of microwave oven on product characteristics can be described and measured, and results can be compared to previous test results to document improvement and progress.

3.3 Observe changes during processing/storage

Scaling-up products from bench-top to pilot plant, and from pilot plant to large scale production will often result in product changes. Sensory panels can be used to defect and identify the differences between the desired product and production. With an accurate description of the changes perceived in the production sample, the cause can sometimes be more readily identified and corrected.

Ageing effects can be studied through sensory evaluation. Tests can be specifically designed to identify and monitor product changes due to storage. Such stability evaluations
are an important phase of product development, and trained panelists and a sound test design is terra incognito in providing valid data for shelf-life determination.

3.4 Identify areas for improvement
The effects of various packaging materials on product characteristics can be evaluated using in-hour panels. Test samples can be evaluated at certain checkpoints over time to test for possible changes in the product. Changes in the processing of product may alter the product characteristics, and sensory tests can be used to determine whether differences between the control product and the product produced by new process are perceptible.

3.5 Monitor product quality
Tests can be designed to monitor the quality of the manufactured product and to determine whether products slowly drift away from the intended quality over a period of time. Products obtained through commercial production can be evaluated against the sensory specifications established during the R&D phase. Identification and description of product differences between plant shifts and runs is helpful in spotting problem areas and maintaining product quality.

3.6 Substantiate advertising claims
Sensory tests can also be used to provide data to substantiate advertising claims and statements. If the product is billed as “better tasting”, “shiner”, “brighter”, or “more comfortable”, panelists can pinpoint products characteristics and their responses can be measured.

4.0 SUGGESTED READING


1.0 INTRODUCTION

Manufacturing of fermented whey beverages such as soft drinks, whey wine, beer like products and low alcoholic beverages appears to be most economical and viable processes for returning the wasted milk nutrients into value added products among various innovative microbiological processes of whey utilization. Several authors have reviewed processing of whey in the preparation of wide varieties of palatable beverages through microbial fermentation since whey has been found to be a suitable growth medium for the proliferation of selected strains of lactic acid bacteria and yeast. These products have been categorized as functional group, pleasure, health, nutrition etc. Recently commercial interest in fermented whey beverages has increased in several European countries notably Germany, Holland, Austria and Switzerland, possibly as a result of health consciousness of the modern consumers. In India there has been a tremendous increase in the production of cheese and coagulated milk products resulting in a proportionate increase in whey which is posing a great problem in view of stringent pollution regulations. BOD of whey is 200 times more as compared to domestic sewage leads to a serious problem of environmental pollution and in addition it act as a source of bacteriophage dissemination which is responsible to the failure of starter culture for making cheese and other fermented dairy products. Although attempts have been made in past globally to utilize the nutritious whey through the fermentation processes in the production of organic acids, ethanol, vitamins, flavouring compounds, baker’s yeast and polysaccharides but have not been fully exploited and still most of whey is drained by dairy industries. Keeping in view an increased trend in consumption of soft drinks focus have been given on research and development of various types of fermented whey beverages and some of them have been marketed successfully because of their distinctive characteristics as compared to other beverages.

2.0 SIGNIFICANT FEATURES OF FERMENTATION OF WHEY INTO BEVERAGES

Fermentation is one of the oldest forms of food preservation and biological upgrading of dairy by-products into value added foods have been well established. Processes of manufacturing of fermented whey beverages have developed following transfer of technology from related fermentation of milk into yoghurt, acidophilus milk, Kefir and kumiss, which possesses nutritional and probiotic properties in addition to their palatability. The component of whey that poses greatest disposal problems is lactose which constitute about 76% of total whey solids (6-7 %) present in whey along with protein, fat, minerals and water soluble vitamins. Presence of all
these nutrients in whey are considered to be suitable to convert whey into lactic and alcoholic beverages through selective lactic acid bacteria and yeast, respectively. Drissen & Berg (1992) emphasized the significant feature of adopting the process of manufacturing of fermented whey beverages by dairy industries for the following advantages.

1. The composition of whey make it a suitable base for fermentation
2. The dairy industry possesses the know how regarding fermentation such as cheese and yoghurt making
3. The dairy industry has the equipment for fermentation process.
4. The dairy industries being trusted by the consumers
5. As a result of these features, the dairy industry can manufacture a nutritious and palatable health whey drinks by their own identity rather than being associated with just another soft drink manufacturer.

Advantages of fermenting whey into various types of beverages have also been highlighted by Gandhi (1998), Saxelin (1998) and Alander et al (1999).

3.0 DEVELOPMENT OF FERMENTED WHEY BEVERAGES

Broadly development of fermented whey beverages have been classified into two categories depending upon the starter culture used to carry out the fermentation process in whey. These are a) Lactic fermentation or non-alcoholic fermentation and b) Alcoholic fermentation. Different types of fermented whey beverages developed under these categories have been described by various research workers and some of the processes have been patented.

3.1 LACTIC FERMENTATION

Whey has many properties which makes it suitable for manufacture of lactic fermented whey beverages. These beverages are obtained due to lactic acid bacteria (LAB) fermenting lactose in whey to form lactic acid. This lactic acid bacteria imparts flavor and is known to suppress the growth of pathogenic and spoilage organisms. In addition to this some LAB particularly *Lactobacillus spp.* produce antibacterial substances during fermentation and presence of viable LAB in finished products reported to have curative properties in controlling gastro-intestinal disorders (Saxelin, 1998, Alander et al, 1999). A whey beverage designated as rivella was developed in 1952. It was prepared by fermenting deproteinized whey with lactic acid bacteria, filtering, condensing, adding sugar and flavouring, rediluting and carbonating. The product has met with considerable acceptance as a soft drink and its manufacturing during
Fermented whey beverages

early 1960 spread to other European countries (Holsinger et al, 1974). Simultaneously other lactic beverage developed was whey Kwas in Poland by using thermophillic lactic culture by using Kefir culture. Patented process of Acidowhey by using L. acidophilus culture (Gandhi, 1988), whey drink by using Lb casei ssp. rhamnosus were developed and have been accepted by the consumers. Besserzhnov (1968) got patent for the preparation of yoghurt flavoured whey beverages. A flow diagram for the preparation of fermented whey beverage by using lactic acid bacteria is given in Fig. 1.

3.2 ALCOHOLIC WHEY BEVERAGE

3.2.1. Whey wine

Research workers have shown keen concern in development of alcoholic beverages such as wine, champagne, beer like product, since whey has many properties, which make its suitable for the manufacturing of these beverages. Some of these beverages have been well accepted by the consumers and are being produced commercially in USA and Ireland. Patents have been granted on the processes of production of alcoholic beverages. The foremost foods researchers demonstrated a successful transfer of a bench top process to a pilot scale or semi-commercial scale, producing a fermented whey beverage (pop wine) with standard dairy cheese plant equipment (Fig. 2 ). They developed a flavoured variety of this beverage and marketed (Delaney, 1981).

Wzorek and KosiKowski (1983) prepared whey wines from reconstituted acid whey powder. They removed the protein by ultrafiltration. The permeate had a total solids concentration of 26-28% before demineralizing to a mineral level of 1% or less. Any residual whey taints after fermentation were removed with bentonite and charcoal at the level of 5 g/lt and 2 g/lt respectively. Processes for whey wine production before advent of UF were limited to a low alcohol percentage in the final wine. The lactose level of the fermentable whey had to be increased to about twice the level of the desired alcohol content of the finished product. Fortification of some other fermentable sugar such as sucrose and glucose have been suggested by Sienkiewicz and Riedel (1990). An alcoholic beverage made from whey has been reported by Zalashko et. al. (1997). Composition and organoleptic traits of finished products are similar to table wine.

3.2.2 Beer like Whey Beverage

Whey has also been reported to have certain materials similar to the colloids of beer wort and has great capacity for binding carbonic acid. On prolong heating under pressure it develop caramel like flavour which are similar to the taste and odour of the cured malt Dietrich (1988) developed a beer substitute by making 5.4% malt wort with 2.5% deproteinized whey. The malt whey mixture was fermented by Saccharomyces lactis. After 5-7 days the product had developed a true beer flavor and characteristics. Russian workers developed two beverages that contained added sugar, flavouring and raisins. It was then brewed with hops and fermented with yeast. The finished product contained approx. 3.8% alcohol. Use of 85% of hydrolysed whey permeat as a replacement of 12.2% of brewing extract in production of beer showed similar flavour stability and foam character to those of commercial brews from the breweries in Poland (Elmer, 1983).
Use of whey powder in browning, replacing some of the commonly used cereal adjuncts was investigated. Wort containing hydrolyzed lactose (glucose and galactase) from whey were produced that possesses normal fermentability and produces beer of acceptable quality when compared with a corn adjunct as control. Thus whole whey or whey concentrate can be used as suitable substitute ingredient of cereals in the manufacturing of beer and beer like products.

4.0 CONCLUSION

In view of immense nutritive value of whey which are responsible to cause its disposal problems, it is necessary to utilize these whey solids into value added products. Since there is an increasing trend in shifting of consumer’s attitude towards consumption of fermented milk products due to good organoleptic properties and microbial interaction with G.I. microflora the manufacturing of fermented whey drinks can be seen in the similar way. Secondly due to the presence of lactose sugar and other valuable nutrients make whole whey and whey concentrate suitable for making wine and beer like products similar to traditional beverages. Thus there is a tremendous scope in the development of variants of fermented whey beverages and to explore the possibilities of adopting these technologies by the dairy industries.

5.0 SUGGESTED READING


Fermented whey beverages


Sienkiewicz, T. and Riedel, C.L. (1990) Whey and whey utilization: Publisher Verlog. Th-Mann G-Buer, Germany


FIG. 1 - MANUFACTURING STEPS INVOLVED IN THE PREPARATION OF LACTIC FERMENTED WHEY BEVERAGES

Whey

↓

Fat separation/Clarification

↓

Heat Treatment

↓

Cooling

↓

Inoculation with pure and active Lactic Starter culture (Single or mixed)

↓

Incubation

↓

Filtration

↓

Addition of Sweetening agent & flavour

↓

Packaging

↓

Cold storage

↓

Marketed under cold chain
FIG. 2 - MANUFACTURING STEPS INVOLVED IN THE PRODUCTION OF SWEETENED CLEAR WHEY WINE

Whey

↓

De-proteinization

↓

Dextrose addition

↓

SO₂ addition

↓

Inoculation with active Yeast culture

↓

Fermentation

↓

First racking (to remove sediments)

↓

Second racking

↓

Fining

↓

Sweetening

↓

Filtration

↓

Bottling

↓

Pasteurization

Fermented whey beverages
1.0 INTRODUCTION

The demand for cheese flavours has increased due to consumer demand for a wider choice of convenience and low-fat products that possess cheese flavour. Cheese flavours can be produced by procedures such as synthesis or partial synthesis of individual components, isolation of individual components as flavour complexes from natural raw materials or the formation of flavour complexes by physical/chemical synthesis (Lucas and Kunz, 1992). However, the identification of all the compounds present in a given cheese flavour has not been determined, and the cost of synthetically producing those which have been identified as being important is probably cost-prohibitive. Therefore, enhancement of the major flavour pathways that occur in natural cheese presently provides the most economic route to the production of intense cheese flavours. This is best achieved by enzymatic-modification of cheese. The product made using the enzyme(s) and fresh cheese curd and/or young cheese is popularly known as enzyme-modified cheese (EMC).

2.0 CHEESE FLAVOURANT

The flavour profile of enzyme-modified cheese can be up to 30 times the intensity of natural cheese and it is essentially used as cheese flavourant. The cheese flavourant technology has evolved from curd slurry model system. The curd slurry technique is a very useful technique for assessing the capability of specific enzymes and starter cultures to generate good cheese flavours in an environment similar to that used during cheese flavourant production. Initially, curd slurries were developed by Kristoffersen et al. (1967) as a technique for accelerating cheese ripening. A liquid cheese product with characteristic Cheddar, Brick or Romano flavour could be produced from fresh curd in 4 or 5 day, indicating the possibility of generating a range of intense cheese flavours in a short time from a base substrate by modifying various process parameters. A series of cheese flavours can be produced by this technology.

Essentially, the technology used to produce cheese flavourant involves incubating cheese/curd with exogenous enzymes (proteinases, peptidases, lipases and esterases) in a slurry system under controlled conditions until the required flavour is attained.

3.0 PROCESS TECHNOLOGY OF DRIED CHEESE FLAVOURANT

The process of cheese flavorant production involves incubating mature or immature cheese with specific exogenous enzymes and/or microorganisms, terminating the process by pasteurisation and standardising the final product to a desired flavour intensity and
composition. In general, most cheese flavorants are produced from cheese pastes made from an immature cheese of the same type to give the most authentic flavour. Other components, notably butter fat and cream, are included as a source of extra flavour compounds. Other flavour enhancers, such as monosodium glutamate, yeast extract, diacetyl and other compounds associated with specific cheese flavours may be added, although some may have to be declared on the labelling of the final product into which the cheese flavourant is added. A schematic of cheese flavourant production is given in Fig. 1.

![Schematic of cheese flavourant production](image)

Off-cuts or shredded cheese  
(60 to 65% dry solids)  
↓  
Mix  
Water & emulsifying salts (optional)  
↓  
Cheese Slurry  
(40 to 55% dry solids)  
↓  
Pasteurise  
(72°C/ 10 minutes)  
↓  
Cool  
(40 to 55°C)  
↓  
Incubate with enzymes  
(40 to 55°C/ 8 to 36 hours)  
↓  
Repasteurise  
(72°C/ 25 to 35 minutes)  
↓  
Cheese Flavourant Paste  
-  
Emulsification and Homogenization  
With encapsulating agents  
↓  
Spray Drying  
↓  
Dried Cheese Flavourant

**Fig. 1. Schematic representation of dried cheese flavourant manufacture.**

Consistency and quality of the initial substrate is critical for flavour development as variations will affect the final flavour (West, 1996). A number of different processes are used, depending on the cheese flavourant type, manufacturer's preference, product application
and appearance of the end product. During the production of cheese flavourant, spoilage by bacteria can be a major problem, as optimum conditions exist for their growth. Equipment must be sterile and all obvious measures must be taken to prevent contamination. Dulley (1976) demonstrated that the inclusion of potassium sorbate had a major effect on controlling levels of contaminants, such as yeast and coliforms. Other bacterial inhibitors such as nitrates, sorbic acid and nisin are commonly used (Mann, 1981). Microbial spoilage is a bigger problem in system in which a lipase is not used, as high levels of short chain FFA can have a bacteriostatic effect (West, 1996).

The control of process parameters during cheese flavourant production is critical in obtaining a consistent product. Vafiadis (1996) commented on the importance of time and temperature control in the manufacture of cheese flavourants. The heat treatment used to inactivate the enzyme is critical, as care must be taken not to destroy the developed flavour by over-cooking. It is also crucial that all enzymes are inactivated, as excess activity will lead to off-flavours and problems in the final product. Therefore, it is necessary to monitor batches of cheese flavourant for residual proteinase activity generally 72 h after manufacture.

3.1 MICROENCAPSULATION AND DRYING OF CHEESE FLAVOURANT

Microencapsulation is a technique by which liquid droplets or solid particles are coated with a thin film of protective materials. The droplets or particles are called "Core" material and thin film coating is called "Wall" material. The film or wall material protects the "Core" material against deterioration, limits evaporation of volatile core (in case of flavours) and also facilitates the release of core under predetermined conditions. Fats and oils, flavours and aroma compounds, oleoresins, vitamins, minerals, colorants and enzymes have been successfully microencapsulated.

Spray drying is most common microencapsulation technique in food industry. A Boake Roberts discovered spray-drying technique for producing “encapsulated” flavouring in 1937, when he accidentally added acetone to tomato puree, which helped him to maintain color and flavour of tomato powder. Subsequently, spray drying has become the most important commercial process for making dry flavourings. Re-MI (1998) presented a review on microencapsulation by spray drying with special emphasis on the microencapsulation of volatile materials. Microencapsulation by spray drying offers advantage over conventional microencapsulation technique (i.e. Coacervation, fat or wax encapsulation, plating or adsorption, inclusion in cyclodextrins etc.) by producing microcapsules via relatively simple, continuous process. The spray-drying equipment used for the production of dry flavourings such as cheese flavour, butter flavour etc. is essentially the same as is used for the production of dry milk.

Tuley (1996) discussed the microencapsulation of food ingredient in detail which covered aspects like reducing loss of flavour compounds during processing through encapsulation technology. The flavour microcapsules for spray drying are formed with the help of wall and core material. The wall material is dissolved or dispersed in water in concentration, which is, largely, dependent upon the wall material. The flavour or core
material is then emulsified in the solution of wall material using suitable mechanical means (high speed mixing, homogenization etc.). A stable emulsion of fine droplets of core material in wall solution is critical for microencapsulation. The stabilized emulsion is pumped through atomizer (nozzle or disc type) under predetermined conditions of pressure or speed of atomizer; inlet and outlet air temperature; infeed temperature and infeed rate etc., in the spray drier where drying takes place. The design of spray drier chamber may play a role in better flavour retention and stability of core material. The process of microencapsulation using spray drier is a continuous process and therefore, can take care large production rates.

3.2 EXOGENOUS ENZYMES FOR CHEESE FLAVOURANT PRODUCTION

Since proteolysis, lipolysis and lactose hydrolysis are the main biochemical events during maturation, proteinases, peptidases, lipases and β-galactosidase were evaluated for their potential use (IDF, 1990). The enzymes were either from a non-cheese-related source, or extracted from cheese-related microorganisms (Visser, 1993). Neutrase is probably the most commonly used, either alone or with peptidases. A list of commercial enzymes available for cheese flavourant production is given in Table 1.

Addition of proteinases leads to an increase in protein degradation but very often results in the development of bitter flavour and reduced cheese yield. Law and Wigmore (1983) showed that combining proteinase with Lactococcus peptidases gave an acceptable cheese. Their experiments led to the development of a commercial product known as Accelase. Ramasamy et al. (1996) Used Accelase AHC 50 for successfully accelerating the cheddar cheese flavour development in cheese slurry. The use of lipases to reduce the maturation time of cheese and to give varieties like Provolone, Cacciocavallo or Ras their characteristic piquant flavour has also been evaluated.

Since the use of a single enzyme very often disturbs the equilibrium of the flavour components in cheese and causes flavour defects, enzyme manufacturers have developed ‘enzyme cocktails’. Several workers, therefore, advocated the addition of enzyme in proper ratio for balanced flavour development.

Several workers extracted enzymes from the following cheese-related microorganisms: Lactobacillus, Pediococcus, Leuconostoc, Propionibacterium, Brevibacterium, Micrococcus and Pseudomonas. The enzymes have been added as crude cell-free extracts or in a partially purified form in cheese or cheese slurry for developing intense cheese flavours required in cheese flavourants (El Soda and Pandian, 1991; Lee and Joo, 1993).

4.0 USES OF CHEESE FLAVOURANT

Cheese flavour ants are produced not for use in cheeses as such but to be applied in other foods that conventionally contain natural cheese (Lucas and Kunz, 1992). High-intensity cheese flavourants in paste and powder form are major alternative to the use of natural cheese in processed consumer foods requiring a cheese flavour (Missel, 1996). Cheese is traditionally added to products as a spray dried preparation for flavour, appearance
and texture enhancement. The amount of cheese used varies, and the overall flavour and quality of the product depends on the type of cheese used. (Anon, 1990; Hermann, 1993; Freund, 1995; Missel, 1996; West, 1996).

Cheese flavourants are used in food recipes to fulfil several roles, e.g. as the sole source of cheese flavour in a product, to intensify an existing cheesy taste or to give a specific cheese character to a more bland-tasting cheese product. They have approximately 15-30 times the flavour intensity of natural cheese and are available as pastes or spray-dried powders (Freund, 1995). The addition of intense cheese flavours to these products creates the desired flavour without an increase in fat content, as same can be added at levels of 0.1% (w/w) and contribute less than 0.07% fat (2.28 calories) per 100 g (Buhler, 1996).

Cheese flavourants are ideal in frozen cheese type products as the casein from natural cheese tend to coagulate and produce a grainy texture; since the casein in Cheese flavourants have been hydrolysed to more soluble peptides and amino acids, the problem is overcome (Missel, 1996). Other advantages are reduced production costs (by as much as 40-80%), increased production capacity, enhanced product stability, improved consistency, improved functionality, batch to batch consistency, reduced storage space and ease of handling. Intense cheese flavours also allow better control in the development of new products and refining of existing products.

Cheese flavourant available includes Cheddar, Mozzarella, Romano, Provolone, Feta, Parmesan, Blue, Gouda, Swiss, Emmental, Gruyere, Colby and Brick. These Cheese flavourants have a wide range of applications in salad dressings, dips, soups, sauces, snacks, crisps, pasta products, cheese analogues, frozen foods, microwave meals, ready-made meals, canned foods, crackers, cake mixes, biscuits, fillings, cheese spreads, low-fat and no-fat cheese products and cheese substitutes/imitations. These products are generally added to foods at levels of 0.1-2.0% (w/w), although they can be used at levels of up to 5.0 % (w/w) (Freund, 1993, 1995; Buhler, 1996; West, 1996). Talbott and McCord (1981) described a guide to determine the dosage of EMC for replacement of natural cheese. To determine the dosage the percentage of natural cheese in the product is multiplied by the desired replacement percentage and divided by the flavour intensity of the Cheese flavourant. Certain high-intensity products can replace up to 50% of the cheese used in some applications (Buhler, 1996).

Regulatory considerations regarding the use of Cheese flavourants differ in Europe from the US. In Europe, a framework directive on flavourings has been established, which lists a number of categories of flavourings, flavouring substances, flavouring preparations, process flavouring, smoke flavouring and mixtures thereof (Freund, 1995). Cheese flavourants are categorised as flavouring preparations, which are defined as substances obtained by physical, microbiological or enzymatic means from material of vegetable or animal origin. In the US, Cheese flavourants are GRAS (generally regarded as safe) approved and as such can be added to specified categories of pasteurised process cheese, non-standard
identity cheese, non-traditional reduced-fat and fat-free cheeses and various prepared foods (Freund, 1995).

5.0 CONCLUSION

To produce a consistent cheese flavourant, it is necessary to have a highly controlled process; therefore, a detailed knowledge of the enzymatic reactions under the conditions used must be fully understood before any attempt is undertaken to produce cheese flavourants. Various commercial enzyme preparations are available for the production of cheese flavourants. Similarly, starter culture extract are currently receiving much attention in cheese flavourants' production. Because these extracts have been successful in producing high quality natural cheese and obviously contain the necessary pool of enzymes required for good cheese flavour developments.

To retain flavour components of cheese flavourant during drying, the process of microencapsulation is now well established. One has to select proper encapsulating agents, emulsifying and homogenizing conditions for efficient microencapsulation. The spray drying processing parameters are to be standardized for better flavour retention and stability.

Currently, the consumer demand for novel, nutritious and convenience foods with a cheese flavour, is driving the development of customised cheese flavour products, which has highlighted the requirement for further research into cheese flavour pathways and the identification of specific cheese flavour compounds. Development in this area is ongoing and already different cheese flavourants have been produced from the same initial substrate and from blends of dairy and non-dairy ingredients leading to the development of novel, cost-effective cheese flavour products.

6.0 SUGGESTED READING


Dried cheese flavourant


**Table 1. Commercial Enzyme Preparation**

<table>
<thead>
<tr>
<th>Neutrase (B. Subtilis)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naturage (Protease + Peptidase+ culture)</td>
</tr>
<tr>
<td>Flavourage (Protease + Lipase)</td>
</tr>
<tr>
<td>Accelase (Protease + Peptidase)</td>
</tr>
<tr>
<td>Lipomods (Lipase + Esterase)</td>
</tr>
<tr>
<td>Promod (Protease + Peptidase)</td>
</tr>
</tbody>
</table>

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1.0 INTRODUCTION

The food industry plays an important role in our present-day society. Without the food industry, urbanisation as we know it today would not have been possible.

Presently the food industry employs bio-based processes, which account for about 95% of the industrial applications of living systems (Bronn, 1976).

Food technology, or, better, food process engineering, should be based on a profound understanding of the physical or biochemical mechanisms, underlying the processes and conversions relevant in food processing and storage.

With respect to the potential impact of biotechnology on the food industry, one has to be aware of the fact that the food industry cannot be considered as a coherent industry overall. In the “traditional” food industry, in which the processing methods are rooted in empiricism, the basic skills for the exploitation of biotechnology in the processing routes are mainly lacking. On the other hand, a small group of large-turnover science and technology-based companies recognises the potential of biotechnology and is progressively taking advantage of it (Holmes and Jarvis, 1982).

2.0 BIOBASED PROCESSING IN THE FOOD INDUSTRY

2.1 Classification According to Objectives

2.1.1 Synthesis of Consumer End-Products

A large number of the bio-based processes in the food industry are directed to the synthesis of consumer products, and the biological process is mainly directed toward adding flavour and fragrances and/or toward preservation. Typical examples are the production of alcoholic beverages, fermented dairy foods, cheese sauerkraut, and fermented fish (Thijssen & Roels, 1983).

2.1.2 Synthesis of Food Additives

Biobased processes are having an increasing impact on the synthesis of food additions. Examples are the following:

- The synthesis of food acidulants like lactic acid, gluconic acid, and citric acid.
- The synthesis of sweeteners such as glucose syrups and high fructose corn syrups.
2.1.3 Directed Modification of Foods or Food Additives
In this category a multitude of examples can be mentioned, such as the tenderisation of meat with the enzyme papain and the improvement of the functional properties of proteins using protease.

2.1.4 Production of Processing Aids
The productions of microbes or microbial populations, to be used as “starter” cultures in the production of dairy products. The use of yeast in bread baking can be also be considered an example of this type of application.

2.1.5 Waste Treatment
Biotechnology is a very important factor in the treatment of wastes from food production or food processing operations. In some instances food wastes can be used for the production of single-cell protein as food or feed. Furthermore, aerobic and preferably anaerobic wastewater treatment can be applied to reduce the chemical oxygen demand of industrial wastewater.

• The Sweeteners Market: A recent example of the impact of biotechnology

  One relatively straight forward example of the impact of biotechnology on the food industries relates to the developments in the sweeteners market (Van Tilburg, 1983), which was traditionally the realm of sucrose, derived from cane and beet crops, and glucose syrups derived from starchy crops.

  A number of breakthroughs in the availability of enzymes and the technology of their applications have drastically influenced this competitive position during recent years. Biotechnology had its impact on the sweeteners market.

  Relatively recently efficient enzymatic processes were developed for the liquefaction and subsequent saccharification of starch syrups into glucose syrups with a free glucose content of 93% or more. The conventional acid-based saccharification technology resulted in syrups with a much lower free glucose content. In addition, the acid catalyzed process was characterized by the formation of often objectionable byproducts. In all, the application of the enzymes amylase in starch liquefaction and glucoamylase in saccharification has made the production of glucose syrups much more cost effective.

  However, despite extensive studies, the alkaline isomerization of glucose did not produce the desired results: The resulting fructose-containing syrups contained undesirable, nonmetabolizable materials such as psicose and colored materials, which are costly to remove. Developments in enzyme technology such as the discovery of a thermostable xylose isomerase, which also catalyzes the conversion of glucose into fructose, and the subsequent development of techniques allowing the fixation of enzymes into (or onto) suitable carrier particles paved the way for the advancement of high-fructose corn syrup (HFCS) technology.
3.0 POTENTIAL IMPACT OF BIOTECHNOLOGY

It is not likely that genetic engineering by itself will provide a major thrust in the impact of biotechnology on the food industries. However, most likely it will provide additional tools in the development of better organisms for the production of consumer products and better production organisms for processing aids or food additives.

3.1 Development in the Synthesis of Consumer End-Products

A number of developments have been made of characteristic note in these processes and can be expected to have an increasing impact in the future:

- The use of a more industrial, often continuous processing-based approach toward the process, for example of yogurt production (Lelievedl, 1984).
- The staging of the integral complex process into a more sequential mode of operation, for example, the decoupling of coagulation, acid formation, and flavour formation processes in butter production (Lankveld, 1981).
- The use of starter cultures, perhaps genetical engineering modified in the more removed future.
- The use of immobilized cells in, for example, the production of alcoholic beverages.
- The use of enzymes such as lipases in the flavour formation in cheeses.
- A more extensive use of additives such as thickeners and flavourings (Cooney et. al., 1980 and Ratled ge, 1978).

4.0 FOOD FLAVOURS AND FRAGRANCES

As far as food flavours and fragrances are concerned, the debate over the natural versus nature-identical versus synthetic plays an important role. A presently unresolved question is whether the products of biotechnological processes, for example, using microbes or enzymes, would be considered natural or nature-identical compounds if the starting materials were natural compounds. In the realm of flavours and fragrances, there certainly remains considerable room for growth, since 90% of the total sales in this sector are currently derived from synthetic products (Poldermans & Roels, 1985).

4.1 Production of Polysaccharides and Carbohydrate Processing

Polysaccharides of various origins, such as starches, various plant gums, and algal gums, are widely used in the food industries as thickeners, stabilizers, or, in the case of starch, as a source of raw material for the production of sweeteners and ethanol. Apart from the developments in the sweeteners market, which have already been discussed, developments can be foreseen in the production of microbial gums by fermentation with xanthan gum being a notable example.
5.0 USE OF ENZYMES IN CHEMICAL SYNTHESIS AND AS PROCESSING AIDS

The use of enzymes in the food industries has shown considerable progress in the past few decades and will no doubt continue to do so in the near future. In fact there are a number of important reasons for predicting progress in this area. First, there are developments by the enzyme producers. The deployment of a truly interdisciplinary biotechnology in the last decade has turned the technology for enzyme production into a highly science-based activity, and in fact, given sufficient market volume expectations, almost any enzyme tailored to specific processing needs can presently be offered on the market at reasonable costs.

Second, enzymes as they exist in nature are highly suited to the treatment of proteins, oils, carbohydrates, and other products of natural origin.

A further impact of enzyme technology can be foreseen in the recovery of compounds from plant, anima, or microbial material.

6.0 NEW ANTIMICROBIAL SYSTEMS

In view of the trend toward products that contain no chemical preservatives or which have not been extensively sterilized, it would seem rewarding to take a closer look at the antimicrobial systems that appear in nature. Certain hydrolytic enzymes, like lysozymes, keratinases, and d-aminopeptidases, may be promising in this respect.

7.0 WASTE TREATMENT

Most of the solid wastes of the food industries are sold as animal feed or as an energy source (boiler feed) Biotechnology could contribute to the development of higher added value applications for these materials, either by microbe-or enzyme-aided partial digestion or combinations thereof (Heijnen, 1984).

8.0 CONCLUSION

The total annual turnover in bio-based processes can be assumed to be well over 100 billion and alcoholic beverages account for about two-thirds of this figure. Fermented tools account for another 20-25% of the applications of biobased processes. It is evident from one discussion that, although modern science based biotechnology will certainly have an impact on the processing routes employed in these sectors. It would not be very realistic to state that modern biotechnology is responsible for the total market volume in these industries. Rather, it indicates the potential of modern biotechnology to improve food processing technology.

9.0 SUGGESTED READING


Impact of biotechnology


1.0 INTRODUCTION

The Processed Cheese (PC) products can include a large number of non-conventional ingredients to come up with a constant stream of new product ideas. The PC preparations, cheese analogs or cheese substitutes allow the production of products with a wide range of physicochemical and organoleptic properties. These products are growing in popularity largely on account of their readily controllable characteristics, versatility and relatively good keeping quality. They are economical to produce and offer cost advantage over natural cheese particularly in countries where imported casein is cheaper than domestic milk SNF and vegetable fat is cheaper than milk fat. The production of cheese substitutes has been substantial in the US market, especially in the pizza trade and cooking applications. Use of various types of high protein products like rennet or acid casein, caseinates and vegetable proteins and replacement of milk fat with vegetable fat makes the processed cheese products vary enormously in composition, formulation, flavour etc. leaving tremendous scope for innovation.

2.0 DIVERSIFIED INGREDIENTS

2.1 Acid casein and caseinates

Acid casein, sodium caseinate and calcium caseinate can be used as additives for PC preparations and as raw materials for products similar to PC. Of these, calcium caseinate (i.e. acid casein which has been neutralised with calcium hydroxide) is mainly used in PC products according to recipes specially devised for this raw material. In one such recipe the cheese SNF has been partially replaced by Ca caseinate. A pronounced improvement in spreadability was attained with a mix of 6-8% dried SM, 5-7% Ca caseinate, 12% ripe cheddar cheese, 14% butteroil and 3% emulsifying salts. Methods for making PC by direct acidification of milk with dil. HCl to pH 4.6 have been suggested. The acidified milk was heated to form a coagulum and the curd processed with added emulsifying salts, salt and flavourings. Addition of acid before heating was found to produce curds, which are easier to melt in the cooker.

Acid casein and sodium caseinate contain very little Ca and are hardly capable of forming a framework upon which to build and contribute little to a firm structure. In most PC products adding larger amounts of acid casein or sodium caseinate has an adverse effect on flavour (Klostermeyer, 1989). They are, however, easily integrated into the processed cheese sol and have an excellent emulsifying capacity.

2.2 Rennet casein

Rennet casein retains its original calcium content and thereby its ability to form structures but is hydrophobic in the same way as natural cheese. If it is to be used as the
protein raw material in the manufacture of imitation cheeses, rennet casein has to be converted to a paracaseinate sol for which emulsifying salts with long chain polyphosphates are required. Rennet casein can be used in PC products to achieve a long structure without impairing the flavour of the finished product. Manufacturers like to add rennet casein to products destined for toasting, which are supposed to have good re-melting properties and tailing e.g. Mozzarella substitutes for Pizzas. Dry rennet casein exhibits several advantages for manufacture of different types of PC products, because of its flavour and storage stability.

2.3 Dried milk, whey powder, whey paste and concentrated buttermilk

These dairy ingredients have a tremendous effect on the texture of PC products. The lactose contained in dried milk and dried whey promotes creaming and it is not advisable to add these while manufacturing block PC but is recommended for spreads. The use of chemically modified whey proteins in PC manufacture was reported to have better spreadability than control samples (Fayed and Metwally, 1999). Another process involves concentrations of SM-whey mixture to a dry matter content of 50-60 per cent, addition of rennet, coagulation and further processing of the cheese base mixture so obtained. The utilisation of dried, delactosed SM has also been recommended. The use of concentrated buttermilk, buttermilk, quarg or dried buttermilk in PC products has also been reported (Kairyukshtene and Zakhaiova, 1982). The use of sweet whey lactalbumin to replace some or all of cheddar used in PC spreads has also been suggested.

2.4 Skim milk, buttermilk and whey concentrates obtained by ultrafiltration (UF)

Use of rapidly ripened ultrafiltered retentates as substitutes for matured cheese in the manufacture of PC has been investigated. Increase in the level of replacement of mature cheese with ripened retentate increased the moisture content in cheese spread. Acidified UF concentrates with pH less than 5.6 as a base for the manufacture of PC is presented in a European Patent (Simbuerger, 1997). Use of concentrated cheese bases in the blend can replace real cheese in the formulation and bring about significant cost saving.

For several years dried UF retentates of SM, so called total milk proteins (TMP) have gained increased importance as an alternative high milk protein product for various types of reconstituted and recombined dairy products and other foods. Abou El-Nour et al. (1996) reported that upto 40% rennet casein can be replaced by TMP for obtaining fully acceptable block type PC analog. A further increase of TMP resulted in undesirable properties.

The use of UF in the production of dried whey results in an increase of protein concentration and decrease in lactose and salt levels. These dried products have a protein content of approximately 20-60 per cent. A process for a PC preparation using one or more type of natural cheese in combination with either WPC or non-fat milk solids or yoghurt has been reported by Brenton and Seger (1998). The whiteness of PC spreads was found to improve with increasing amounts of WPC (Abd-El Salem et al., 1998) as also their viscosity (Abd-El Salam et al., 1999). In another study, replacement of 25% acid coagulated soft cheese by WPC was found to have no adverse effect on the quality of PC spread (Al-Khamy et al., 1997). Changes in sensory and rheological characteristics during storage of PC foods prepared with added WPC, showed that flavour deterioration significantly accelerated with increasing WPC content (Thapa and Gupta, 1992). Firmness of PC foods containing added WPC decreases significantly and melting quality increases as moisture content increases from 41-48 per cent (Gupta and Reuter, 1993).
The use of ultrafiltered buttermilk in the manufacture of reduced fat PC has been described by Raval and Mistry (1999). These had lower free oil and meltability than control cheese, but had higher apparent viscosity.

2.5 Vegetable fats
Development of PC products with vegetable oils and fats offer advantages of low cholesterol content, low raw material prices, uniform quality without seasonal change, high degree of security for supply, neutral taste and on shelf life. The mainly used oils are those from soya, coconut, cotton seed, groundnut and sunflower. A particular vegetable fat is selected according to factors such as availability, price, resistance to oxidation and also nutritional and physiological conditions. Hydrogenated vegetable oils are less susceptible to oxidation because of lower levels of polyunsaturated fatty acids. However, oxidation only exists in the event of any separation of fat from the processed cheese-like product. Vegetable fats do not have any adverse effect on flavour though butterfat makes a more positive contribution. An Egyptian study showed that PC made with vegetable fats contained more unsaturated fatty acids than those made with milk fat (El-Sonbaty et al., 1998).

2.6 Vegetable proteins
The development of technology for incorporating vegetable ingredients to PC to impart improved nutritional properties has been reported. New types of PC with 20 to 40 per cent fat in dry matter and with fillers of vegetable origin and aromatiser were produced which improved organoleptic and nutritional qualities of the PC products.

Because of their completely different composition and structure, vegetable proteins can be regarded as a poor substitute for cheeses, caseins and caseinates. The most important vegetable protein isolate is the soya protein, the other sources being groundnut protein, pea and bean protein, potato protein, cotton seed protein and wheat gluten. The vegetable proteins tend to swell up when they absorb water, particularly in the presence of emulsifying salts. The consistency is pudding like and the flow properties inferior. In trials carried out using blends of cheese, casein and soya, it was only possible to use a maximum of 30% soya isolate as a proportion of the protein content of the blend.

Properties and acceptability of PC manufactured using soy protein concentrates showed that the textural properties were not as good as those reported for a similar industrial product made with lower proportion of soy protein. As the proportion of soy increased, an increase in bitterness was detected and texture became grainy and sticky (Swarez, 1998). In another study a cheese like food was prepared using soy milk in which 60% or more of the soluble saccharide fractions in the raw soybean were removed and the food closely resembled cheese prepared using milk as raw material (Matsura, 1997). Swarez (1995) produced imitation cheese using PC technology and reported that product containing greater than 8.5 percent soyflour was not satisfactory. El-Sayed (1997) attempted replacement of skim milk powdered proteins in PC blends with plant protein isolates and reported that the sensory scores decreased with increasing plant protein level upto 15 percent. This decrease was related to flavour rather than colour or body and texture.

Peanut protein isolates have also been used in PC products but with limited success. The consistency is more like cream cheese and that of spread type products with increasing amount of peanut isolate used.
2.7 **Added for colouring and flavouring**

Annato has proved effective as colouring agent in PC products though lack of resistance to heat sometimes results in pinking defect.

Spices can be added in quantities between 0.1 and 1% to accentuate the flavour of PC products without affecting their consistency and texture, though they may occasionally affect their colour. Natural and artificial cheese flavour and cheeses, which have undergone accelerated ripening process or the enzyme-modified cheeses are also used.

2.8 **Emulsifying salts**

Emulsifying salts are not emulsifiers in the true chemical sense because they do not contain a fat-soluble end. Their major role is to supplement the emulsifying capability of cheese proteins. No single emulsifying salt is capable of providing all the desirable attributes in the PC products. The preparation of formulated mixtures needs to be regulated by the type of raw material as well as requirements of the final product. The real art of combining lies in designing combinations, which enhance positive characteristics of individual emulsifying salts and nullify their negative characteristics.

3.0 **CONCLUSION**

Processed cheese products are bound to gain popularity mainly because of the cost advantages and the wide range of consumer specificity that these products may offer. The Indian dairy industry should be keen an formulating and marketing low cost PC preparations using non-conventional ingredients so that they can reach the common man. The technology leaves enough scope for modifying the sensory attributes to suit the Indian palate.

4.0 **REFERENCES**


Processed cheese preparations


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1.0 INTRODUCTION

Paneer is an important indigenous dairy product, primarily used for preparation of various culinary dishes. Paneer consists of the protein and usually nearly all the fat, insoluble salts and colloidal materials, together with part of the moisture of serum of the original milk in which are contained lactose, whey proteins, soluble salts, vitamins and other milk components. It contains approximately 53-55 per cent moisture, 23-26 per cent fat, 17-18 per cent protein, 2-2.5 per cent carbohydrate and 1.5-2.0 per cent minerals. Paneer is characterised by typical mild acidic flavour with slightly sweet taste. It has firm close, cohesive and spongy body and smooth texture. Paneer is not able to find its rightful place in Indian market due to its relatively high cost of production and short shelf life. Therefore, attempts were made in our laboratories to develop a number of varieties of paneer with different attributes and cost of production to suit the purse and taste of different class of consumers.

Despite several efforts to increase the milk production, the per capita availability of milk still remains less than the minimum nutritional requirement. As a result, there is a wide spread protein malnutrition in the poorer strata of the society. On the other hand, consciousness to the high milk fat intake has become apparent due to increasing occurrence of the coronary complications. Under the circumstances, utilisation of food solids from the vegetable sources (like soybean and groundnut offers great promise to boost paneer production on one hand and to lower its cost of production on the other.

2.0 MILK FAT - COST AND DIETARY CONSIDERATIONS

Researchers and Medical boards have considered milk fat as a possible risk factor in causing coronary heart disease (CHD). Reports revealed that high dietary fat intake shortens clotting time of blood. High intake of fat increases risk of heart attack because of high proportions of saturated fats in the diet. Many nutritionists believe that if fat intake is reduced to provide less than 30 per cent of the calories through fats and oil, dietary fat would not be a risk factor at all in heart disease.

Furthermore, most of the vegetable fats and oils used for consumption are more unsaturated than animal fats and also they contain no cholesterol. Moreover, the cost of milk fat is approximately twice as high as vegetable oils. In a country, where the individual earning capacity is limited, this has an important bearing.
In view of the increasing occurrence of coronary complications there is considerable interest to reduce/replace the milk fat in paneer with vegetable fat. The surplus fat extracted from milk can be used for other useful purposes.

Aarhus A.O., Denmark had produced two special vegetable fats for use in dairy industry to provide alternative to butterfat, Polawar E 31 and Confao 5, both of which can be used in cheese and recombined milk products.

3.0 VEGETABLE PROTEINS: NUTRITIONALLY SOUND AND COST EFFECTIVE

As the world expands, there has been a great pressure for the consumption of plant products as foods. The development in food science during past two decades showed the promising path for plant products to reach a broad potential for human consumption. The use of plant proteins is not restricted any more to animal feed. New products are being made available so that the consumers can choose a product from variety of foods.

Besides their nutritive value, functional properties of vegetable proteins play a vital role in monitoring the quality of the finished product. If the functional properties are properly exploited to suit the requirements for food, new product development would be facilitated.

Functional properties of the proteins refer to the physico-chemical properties, which affect the behaviour in food systems during preparation, processing, storage and consumption. Functional properties of vegetable proteins include solubility, water absorption and binding, elasticity, emulsification, fat adsorption, flavour binding, foaming, etc.

The importance/requirement of each of these properties varies in different formulations. For example, paneer like product calls for two desirable functional properties such as gel formation/coagulation and water absorption/binding.

The soybean has been used for food in orient for centuries. The importance of soyprotein lies in its high level of essential amino acids (except sulphur containing cystine and methionine). Two kgs of soyflour contain as much protein as 14 litres of milk. The soy protein acts as a moisture binder, emulsifier, stabilizer and it improve the product appearance thereby increasing its utilisation for high quality food at comparatively low cost.

Soybean and soyprotein derivatives have been extensively used in dairy type of foods, viz. beverages, simulated sweet cream, sour cream, margarine and spread, frozen desserts and whipped toppings, etc.

4.0 PANEER TYPES

In recent years, there has been growing interest in the manufacture of paneer like products utilising non-conventional food solids like vegetable proteins and fats. A brief description of different types of paneer is presented here under.

4.1 Conventional Paneer
Technological diversification in paneer making

The conventional paneer is manufactured from standardised buffalo milk. To meet the legal requirements a minimum of 5.8 per cent fat in buffalo milk having 9.5 per cent SNF is essential. Therefore, a fat to SNF ration of 1:1.65 has to be maintained in milk. This results in a paneer, which is quite rich in fat content.

4.2 Low Fat Paneer
The conventional paneer is quite rich in fat content, which not only pushes up the price of paneer but also makes it unsuitable to those consumers who are conscious of high fat and want to have relatively low fat paneer. Therefore, attempts were made to develop low fat paneer. Recent research at this Institute has shown that quite good quality paneer could be manufactured from milk with fat content as low as 3.0 per cent. Fortification of low fat milk with soy-solids improves its rheological and sensory qualities and further reduces its cost of production.

4.3 Cow Milk Paneer
Due to various cattle breeding programmes, the cow milk production is increasing in our country. As such cow milk is not suitable for paneer making. Therefore, conventional method of paneer manufacture needs modification. Our research work showed that for production of good quality paneer, addition of 0.10 per cent calcium chloride to milk and coagulation at a higher temperature of 85ºC instead of 70ºC is required.

4.4 Recombined and Reconstituted Milk Paneer
Due to seasonal nature of milk production, there is a drastic cut in milk supply during summer, whereas the requirement of paneer goes up during these days, because of marriage season. Consequently prices shoot up like any thing and the consumers are at a great loss. Therefore, attempt was made at this institute to develop paneer using milk powder and a fat source. Suitable technology has been developed for the manufacture of acceptable quality paneer from whole milk powder and also from skim milk powder and butter oil.

4.5 Filled Paneer
During flush season there is so much milk that some times the dairy plants declare milk holidays. This results in slumps in sale price of milk. Thus the producers of milk suffer under such situations, the fat is normally recovered as cream which is subsequently, converted into ghee. But the skim milk does not find proper use. In order to enhance the profitability of milk it is very important to make best use of valuable solids of skim milk. This can be done by developing filled paneer where vegetable oils can be blended with skim milk, which in turn can be converted into paneer. Our research showed that quite acceptable product could be developed using skim milk and vegetable oils/vanaspati. The paneer thus developed contains 16-18 per cent protein, 22-23 per cent vegetable fat, and 55-56 per cent moisture. The process developed is relatively simple and permits the use of commonly available equipments for manufacture on both small and industrial scale. The cost of production is considerably reduced.

4.6 Protein Enriched Filled Paneer
In general there is protein deficiency in Indian diet. Paneer provides an excellent opportunity to enhance its protein content by fortifying non-conventional and relatively low cost vegetable protein from soybean. A new process has been developed at this Institute. The process involves supplementation of vegetable proteins in the form of calcium isolates or calcium groundnut isolates to the skim milk and vegetable fat mixture. The product is
nutritionally (protein increased by 50%) and economically superior to the conventional paneer. It is ideally suited for dietary management of consumers suffering from protein malnutrition and coronary complications.

4.7 Vegetable Paneer

A new paneer like product has been developed from soy solids and groundnut solids. The composition of vegetable paneer is 19-21 per cent total solids, 6.0 per cent fat, 10-12 per cent protein, and 0.8 - 1.0 percent ash. The cost of production is just half of the conventional paneer and hence would be within the reach of poorer segment of the population and also solves the seasonal imbalances of paneer.

4.7.1 Paneer like product from Soymilk

4.7.1.1 Tofu: A product known as tofu, similar to milk paneer was invented by Liu-An, a Chinese King of Hsi-Han dynasty, who ruled over the Eastern region of China more than 2000 years (about 160 BC) ago. Tofu was first introduced in to Japan in the year 1183, then to other Asian countries. Thus, tofu has long been very popular food in Eastern Asia.

The method of manufacture is simple. Soybean is converted into soymilk (5-6% TS), which in turn is coagulated by calcium sulphate. The coagulum is formed and whey is separated out. The curd is then pressed in perforated hoops. Thereafter it is dipped in water and sliced into desired size pieces and consumed while fresh.

4.7.1.2 Soypaneer: A paneer like product was prepared from the soymilk and its combination with sunflower seed milk and skim milk (Vijaylakshmi & Vaidehi, 1982). The result indicated that a ratio of 60:40 of soymilk and skim milk yielded an acceptable product. Recently indigenous type of paneer was made from soybean and defatted soy flour. The process was more or less similar to tofu except organic coagulant was used.

The manufacture of paneer-like product from soymilk, influence of various technological parameters on yield, composition of the product, % recovery of proteins and % TS recovery was studied to optimise the processing conditions for manufacture of a good quality product. The parameters studied included type of coagulant (calcium chloride, calcium sulphate and citric acid), strength of coagulant (1, 2 and 3%), temperature of coagulation (70, 90 and 100°C) and total solids content in soymilk (6, 7.5 and 9% TS). The yield of paneer-like product, its % TS and protein content as well as % protein and TS recoveries were maximum with citric acid. From the different concentrations tried 1% strength of coagulant gave maximum% yield, TS and protein content in the paneer-like product. Among three different temperatures of coagulation, coagulation at 70°C gave maximum yield with less TS but greater TS recovery. The yield, TS and protein content of paneer-like product decreased with the increase in the TS content of soymilk. To obtain good quality paneer-like product the soymilk, with 6% TS should be coagulated at 70°C using 1% citric acid as coagulant (Pandya, et al., 1998).

4.7.2 Paneer like products from Groundnut and Groundnut Solids
Groundnut is a highly concentrated form of food containing about 30 per cent protein whereas the flour and isolate of groundnut protein contain 51.5 and 95.6 per cent proteins, respectively. The only draw backs that it is deficient in lysine and methionine.

Paneer prepared from groundnut milk yields very weak, soft and fragile body and texture which results in surface erosion of paneer cubes during frying and cooking. However, addition of skim milk (50%) yields very desirable product.

4.8 UF – Paneer

During the last two decades, the evolution of cheese manufacturing practice has been fairly predictable, with emphasis on mechanisation and automation. More recently, an era of change and innovation has begun with the introduction of membrane processing. The economy is an important aspect in the manufacture of any type of products. The high cost of production is a big handicap in marketing and popularizing of dairy produce. Membrane processing (ultrafiltration) has a potential application in the manufacture of paneer. The technology has been developed at this Institute for the manufacture of paneer using ultrafiltration.

5.0 CONCLUSION

Methods have been standardised for the production of conventional, low fat, filled, fortified and vegetable paneer. Process modifications have been established for paneer from cow and recombined/reconstituted milk. This will ensure utilisation of available raw materials and provide a wide range products for various income and dietetic groups.

6.0 SUGGESTED READING


1.0 INTRODUCTION

Milk and milk byproducts improve the nutritional quality, taste and keeping quality in bakery products. Milk protein products are used particularly in bakery products due to foaming, coagulation and water binding properties. Ultrafiltered milk protein concentrates are employed for protein fortification in bakery products mainly for improving the consistency and controlling the structure of foods. The addition of milk solids in bread leads to various changes such as increase in bread water absorption, reduction in the volume of bread and imparting open grain and hard texture. Milk byproducts especially whey and whey proteins can be used as functional ingredients in variety of bakery products. Whey proteins exhibit good functional properties such as solubility, foaming, emulsifying, gelling and water binding properties.

2.0 FUNCTIONAL IMPORTANCE OF MILK BYPRODUCTS

Milk byproducts, especially whey proteins could be used as functional ingredients in a variety of food products. Whey proteins possess very good functional properties such as solubility, foaming, emulsifying, gelling and water binding. Whey protein concentrates contain sufficiently high protein concentrations in a predominantly undenatured form, with minimal lactose and lipid contents, thus serve as functional protein sources for the food industry. Milk byproducts exhibit similar functional properties as of soy and egg protein products in food application. Cakes prepared with egg and soy based proteins impart typical flavour thus adversely affecting the acceptability of these products. Hence milk byproducts can replace egg and soy proteins with similar functional properties (Moulin and Galzy, 1984). Buttermilk has high phospholipids contents which makes it functionally more important. Buttermilk solids, show good emulsifying properties thus help in emulsifying the cake mixes.

3.0 BREAD

3.1 Structure and ingredients in bread

Bread is a cellular structure produced by carbon dioxide. Adequate development of cellular structure leads to the lightness and tenderness in the product. Greater volume is generally associated with high quality baked products. Good texture and other desirable properties in baked products are related to their volume. The ingredients in bread are wheat flour, sugar, yeast and salt. Gluten is the main functional protein of wheat flour. Gluten forms an elastic mass after mixing with water in correct proportions. The elastic mass forms the wall of gas vesicle, or bubbles in the dough. Starch granules and other particulate masses are embedded in these films, completely or partially surrounded by the thin layer of hydrated protein. The kind of mixing action that appears to be the most effective in promoting gluten development is repeated stretching and folding action.
4.0 CAKE

4.1 Structure and Ingredients in Cake

Cake is distinct among baked products because of its combination of a high degree of sweetness with a highly developed cellular structure. The major cake ingredients are: eggs, wheat flour, sugar and shortenings. Eggs contribute binding, leavening, emulsification, flavour, colour and nutritive value. In addition to nutrient, flavour and colour contributions, egg mainly functions as structure builder in cakes. Eggs form film and entraps air when it is whipped and on heating, it coagulates to produce rigidity. The entrapped air in the egg foam is the primary leavening system. Eggs also serve as an emulsifying agent and hence promote dispersion of fat (Potter, 1968).

5.0 FUNCTIONAL PROPERTIES OF MILK BYPRODUCTS

5.1 Whey protein concentrate

Whey protein concentrate (WPC) exhibits major properties as solubility, emulsification, foaming, heat setting, fat binding, water holding, etc. and minor properties as viscosity, dough formation, adhesion, texturisation, browning, moisture retention, etc. WPC represents a most important class of functional ingredients.

5.1.1 Solubility

Solubility is a functional property of proteins. Protein solubility may be defined as that proportion of nitrogen in a protein product which is soluble under specified procedure. It acts as prerequisite for other functional properties such as foaming, emulsifying and gelling properties. Complete solubility of whey protein concentrate is necessary for optimum functionality in terms of foam formation, emulsion property, beverages and similar applications.

Solubility of 10 per cent protein dispersions of WPC ranges from 90 to 100 per cent. The high degree of solubility of WPC in acidic food products is one major advantage over casein products. Casein, caseinates, lactalbumin and coprecipitates show minimal solubility and functionality in food products having low pH or containing Ca ions (Morr, 1984).

Heat treatment has the strongest influence on the solubility of WPC. Pasteurization of whey has no significant effect on WPC solubility but heating of UF retentate causes a significant reduction in solubility. Partial denaturation due to heat treatment makes in protein solubility much more sensitive to the effects of pH and salts (deWit, 1984).

5.1.2. Emulsifying property

Emulsifying property is due to the ability of protein to reduce the interfacial tensions between hydrophobic and hydrophilic components and is linked to the water solubility of the protein. Emulsion capacity and emulsion stability is linked to the emulsion property. WPC has a good emulsifying capacity, which has proved useful in emulsifying the oils present in many food systems. WPC has higher emulsification capacity than non fat dry milks (Melachouris, 1984).

Lipids and phospholipids are generally considered to be detrimental to the functionality of WPC and whey protein isolates, but these constituents improve the emulsifying ability.
Pretreatment of whey before UF such as cooling to 0-5°C, adding CaCl$_2$, adjusting to pH 7.3, warming to 50°C and removing insoluble precipitate gives less functionality for emulsification as lipids are removed to a larger extent by such treatment (Kim et. al., 1989).

5.1.3 Foaming and whipping properties
Foaming is the creation and stabilisation of gas bubbles in a liquid. The rapid diffusion of proteins to the air-water interface to reduce surface tension followed by partial unfolding of the protein is essential for the formation of protein based foams. Foaming results in encapsulation of air bubbles and the association of protein molecules, thus, leading to an intermolecular cohesive film with a certain degree of elasticity (de Wit et. al., 1988). Denatured whey proteins exhibit good whipping and foaming properties. The presence of fat content in WPC reduces the foaming properties of whey proteins. Reduction of the fat content improves both whip volume and foam stability. The presence of sugar, salt, fat, the amount of WPC as well as whipping time will affect the final product in good applications. The presence of 1.5% or more milk fat in WPC effectively suppresses whipping and foaming properties. HTST pasteurisation of UF retentate had no significant effect on maximum foam expansion of WPC dispersions. Controlled denaturation by moderate heating of WPC solutions, prior to foam formation results in improved whipping and foaming properties. Maximum foaming and whipping property in WPC is obtained with heat treatment of 55-60°C for 30 min., thereby maximum overrun could be increased from 800 to 1275 per cent as compared to egg white having overrun 900.

5.2 Skim milk proteins
The utilisation of skim milk protein products as food ingredients is largely dependent on their physico-chemical and functional properties. Hydration and surface active properties of skim milk proteins are considered to be important in bakery product.

5.2.1 Hydration properties
Many of the functional food applications of dairy proteins depend on their ability to hydrate thus bind, water. Generally, globular proteins bind approximately 0.5 gm of water per g of protein. In contrast, intact casein micelles bind 2-4 gm. of water per gm. of protein. Mechanical entrapment of water in micellar matrix is particularly responsible for large water-holding capacity (Mulvihill, 1991). Swelling is related to hydration and/or voluminosity has been used as the principle for the determination of water binding capacity. Sodium caseinate has a maximum fluid uptake of about 8 ml water per g. which is much higher than that of whey protein in WPC (2 ml water per g.) (Kinsella, 1984).

5.2.2 Surface active properties
Proteins from the mixture of polar and non-polar amino acid residues causes them to concentrate at the interfaces. Polar/non-polar interfaces are good solvents for proteins. The surface absorption cause decrease in interfacial tension. Foamability is related to the rate of decrease of surface tension at the air/water interface by adsorbed protein, flexible proteins such as those of β-casein are unstable and drain rapidly. Caseinates generally produce higher foam overruns, but produce less stable foams than egg white solids or WPC (Mulvihill and Fox, 1989).
6.0 CONCLUSION

Milk protein products are used in bakery products due to foaming, coagulation and water binding properties. Whey proteins exhibit good functional property such as solubility, foaming, emulsifying, gelling and water binding. Milk byproducts can substitute egg and soy proteins with similar functional properties. Complete solubility of WPC is necessary for optimum functionality in terms of foam formation, emulsion property, beverages and similar applications. Lipids and phospholipids are generally considered to be detrimental to the functionality of WPC and whey protein isolates but these constituents improve the emulsifying ability. Hydration and surface active properties of skim milk proteins are considered to be important in bakery products.

7.0 REFERENCES


1.0 INTRODUCTION

From the point of domestic consumption as well as exports, India is a sleeping giant in agricultural and processed food products. It is the largest milk producing country in the world. It boasts of an exclusive economic zone of 2 million square kilometers indicating the potential for both milk and meat products. Inspite of this, only 1.8 per cent of total production is commercially processed which is far below the level compared to many developed countries. Our share in global exports is just about 0.5 per cent. It has been emphasised time and again that to provide a filip to the Indian Dairy Industry, the huge potential of unorganised sector of traditional dairy products will have to be tapped. Suitable technological innovations which lead to value addition, product diversification, export promotion, elimination of cold chain for distribution and marketing and safe and hygienic manufacturing practices applied to traditional dairy products might offer tremendous boost to the dairy industry. In this context, the role of developing a suitable process for the commercial manufacture of kheer both in liquid and dry forms assumes great significance.

2.0 TECHNOLOGICAL GAPS

Kheer making is an age-old practice followed in almost all parts of India. References of kheer or payasam can also be seen in our ancient epics like the Ramayana and the Mahabharata. This product is consumed in every household in a routine manner. Kheer, as a delicacy is served in marriages and other social functions and as prasadam in temples specially in South India. Kheer as such has a very poor shelf-life. The product as obtained from conventional method of manufacture in steam kettle has a shelf-life of only one or two days even under refrigeration. This poses severe restrictions on its organised marketing and transportation over even small distances what to talk about long distance marketing. The processes which could enhance the shelf-life of kheer are not easily practiced. Methods to suitably pack the product and add ease of convenience are also not available to improve the marketability of the product.

Looking to these constraints in the large-scale manufacture, packaging and marketing of kheer, an attempt has been made to solve some of these problems recently. Two methods have been tried to improve the shelf-life of this product namely, first by sterilization & in-package cooking of kheer in retort pouches in an overpressure rotary sterilizer and secondly by developing a process for the manufacture of kheer in dry form containing milk solids, rice grains and sugar. In this paper, an attempt has been made to briefly present the processes so developed with their underlying principles and their implications for other indigenous dairy products.
3.0 PROCESS FOR LONG LIFE READY-TO-SERVE KHEER

Kheer is a particulate food product, which essentially means that it has a liquid phase and a solid phase. Processing of single-phase products is a simple affair. They can be handled in a sterilizer, in a UHT plant, in a microwave heating system or even can be processed in ohmic heating system. However, processing of particulate products poses several problems as far as achievement of uniform and adequate heat treatment for both the phases is concerned. Over processing of liquid phase may still be inadequate for solid phase of the product. Sterilization is a process which can safely destroy almost all microorganisms and their enzymes and their spores. This method has been tried in the past for improving the shelf life of kheer. However, this resulted in uneven heating of rice and milk phase. Even though milk became very brown but rice grains still remained uncooked. Processing in metal cans also poses its own problems as heat transfer is not very efficient.

An overpressure rotary sterilizer however offers several advantages over the conventional retort in the sense that the product is constantly under movement so that uneven heating is eliminated(Fig. 1). Packaging material could be retort pouches which are laminates of aluminium foil, polypropylene and polyester. These pouches have the ability to withstand the high processing temperatures (above 100 °C). When the product is being sterilized, the contents inside the pouch are at a temperature above 100 °C and pressure inside the pouch is very high. When the heating process is over and cooling cycle starts there is a sudden drop in pressure and temperature in the retort which ordinarily can not match with the can / pouch temperature. This leads to bursting of pouches causing economic loss to processor and an unsafe and contaminated product to consumers. A retort with a provision of counter pressure solves this problem effectively.

3.1 Advances in overpressure rotary sterilization

A safe sterilization process needs constant monitoring of temperature and pressure during the entire processing cycle. Retorts have been designed which can be linked to advance data loggers and computers to automatically compute the temperature inside the pouch as well as inside the retort. This not only helps in monitoring the minute to minute variations in product temperature but also can serve as a tool to effect a corrective action, if necessary. Thermocouple wires made of Cu / Constantan or Pt -100 can be inserted inside the retort pouches through a specially drilled packing gland consisting of O-rings, threaded rings and nuts. These thermocouple outputs pass via the retort door to the data logger which takes the input and converts them into process lethality values (Fo values and Cg values).

A compressor is run all along the process to maintain the overpressure. Air is stored in an overhead tank which is linked to the main body of the retort. Any increase or decrease in set pressure or temperature will cause a “system abort” for the complete safety of process and of operators. These retorts are equipped with control panels for proper handling and tanks with cooling water (usually chlorinated) for cooling the product even when overpressure is maintained. It is also important to regulate the cage rotation otherwise there is a danger of mashing of the product under high agitation. Product needs to be put under a cooling water bed so that no thermophillic growth takes place as the pouch temperature is still high (approximately 50-60 °C) when it comes out of the retort. There is also a need to see the
process efficacy by subjecting all the batches made to heat sterility test for \textit{Clostridium botulinum} or \textit{Bacillus stereothermophilus} spores.

Kheer made by this method had a shelf-life of more than 5 months at room temperature and did not require any refrigeration for storage. There was no uneven heating and no clump formation as it happens in a conventional sterilizer.

4.0 \textbf{PROCESS FOR INSTANT KHEER MIX}

Due to declining resources, FAO and the World Food programme of the United Nations (WFP) have envisaged a fall in the food aid to India and hence strongly advocates, the development of indigenous food products, which are tasty, nutritious, low-cost and practical. As a result to solve this problem, yet another method to enhance the shelf life of kheer in a different way has also been attempted. This method involves the spray drying of milk concentrate and rice powder along with sugar and then subject this powder to fluidized bed drying to make the powder with better reconstitution properties (Fig. 2). Further, to supplement the rice phase in kheer, rice grains were partially cooked and then dried in fluidized bed dryer to remove all the moisture. This results into quick-cooking rice which can be cooked in hot water in less time. The shelf-life of such a treated rice is also enhanced.

Spray dried powder when mixed with instant rice is packed in metallized polyester laminates and can be stored at room temperature without any loss of quality for a period of 6 months. This product upon reconstitution can give ready-to-serve kheer which is very nutritious and delicious.

4.1 \textbf{Advantages of Instant Kheer Mix}

In the market, there are several instant food products which are rice and wheat based. These products require reconstitution in milk and a boiling time of close to 30 min. In comparison to this, instant kheer mix made by the above mentioned method can be reconstituted in water and does not require milk. It is a pre-cooked food and saves considerable time in kheer making (approx. 10 min. only is required by this improved method). It can be manufactured at very low prices as compared to similar imported food products, whereas it might offer almost similar nutritional advantages. It also requires minimal energy due to very low requirements of fuel.

5.0 \textbf{WHEAT-BASED CONVENIENCE FOODS}

Wheat is a major food product in Indian diet. Wheat-based products including semolina, dahlia etc. occupy a prominent position in our food habits. It is but natural that convenience foods based on semolin and dahlia must also be developed, which could provide ease of preparation and product safety to consumers and at the same time provide valuable nutrition of milk and wheat proteins. Market is flooded with products consisting of instant seviah mix consisting of seviah beans, sugar, and dry fruits which requires reconstitution in milk for around 30 min to get seviah kheer. Efforts have to be directed to develop instant powders based on seviah and dahlia which require only water for reconstitution.
6.0 CONCLUSION

Thermal processing can be used to enhance the shelf-life of all the dairy products. The mode and extent of heating determine the quality and shelf-life of products. Thermal processing in the form of sterilization and drying has been successfully used to enhance the shelf-life of one of the most popular traditional dairy products namely kheer. The underpinning principles can be further extended to several other dairy products such as rabari, lassi, kunda and many more products. Development of suitable processes for commercially manufacturing long-life indigenous dairy products will go a long way in improving the product profile of dairy industry in India.

7.0 SUGGESTED READING

1.0 INTRODUCTION

Foods that have been designed, engineered or formulated from various ingredients, including additives are called formulated foods. Structuring, shaping or blending various ingredients into finished food products makes formulated foods. The products are rapidly increasing in number in grocery stores. Consumer acceptance of fabricated foods is based largely on their convenience, appearance, sensory values, reproducibility and economic value.

Many formulated foods have made a major impact on traditional foods and beverage. Process cheese, process cheese spread, process cheese foods,, imitation process cheese, paneer curry, margarine, different kinds of low fat spreads, imitation ice cream, non-dairy whiteners are the typical examples of formulated foods.

At the turn of the century, developments in melting processes, involving natural cheese of various ages have given birth to a line of process cheese products with controlled flavour, body & texture and extended shelf-life.

Process cheese products are satisfying an increasing number of consumers. Again, value added derivatives of processed cheese can be developed and marketed. Among them a possibility exists for:

a) Cheese-butter spread
b) Seasoning flavoured processed cheese in cans
c) Cheese slices
d) Cheese sauces to enhance flavour and nutrition of Indian cuisin and
e) Powdered cheese for soups and toppings on potato or grain-based chips/snacks

In addition, various shapes, sizes, configurations and sliced versions are created to provide varieties with novel applications. The consumer can use these products as ingredients in cooking of several dishes or as ready-to-eat snacks. The products are designed to be consumed as spread or as slices in sandwiches and function as dip or
toppings on snacks. Cheese can be used as an ingredient in bakery products. Cheese crackers are quite popular in Western countries. Natural cheese can be dried to prolong its shelf life. Dried products can be used in bakery products, soups, sauces, snacks, crisps, pasta products, ready meals, biscuits, fillings, cheese substitutes/imitations etc. Cheese/paneer pakoura is getting popular in our country. A ready-to-eat long life paneer curry has been developed at this Institute.

Whey obtained as a by-product has been used by infant formula producers, lactose manufacturers and in the production of whey protein concentrates. Whey has also been utilized as such or after lactose hydrolysis in canning of fruits, vegetables and beans. Sugar syrups based on hydrolysed whey fractions are commercially available. Dry whey is used in massive quantities as an ingredient in the manufacture of bread, biscuit, ice cream, cheese spreads and other dairy products.

Cheese is traditionally added to products as a spray dried preparation for flavour, appearance and texture enhancement. The amount of cheese used varies and the overall flavour and quality of the product depends on the type of cheese used.

High intensity cheese flavour concentrates such as enzyme modified cheeses (EMCs), cheese powders and cheese flavours may be alternative to the use of natural cheese in processed consumer foods requiring a cheese flavour.

2.0 PROCESS CHEESE PRODUCTS

2.1 Process cheese - Process cheese is the food prepared by comminuting and mixing, with the aid of heat, one or more cheese of the same or two or more varieties with an emulsifying agent into a plastic, homogeneous mass. Heating is not less than 65.5°C and for not less than 30 seconds. Moisture content shall not exceed 1% more than constituent natural cheese, but not exceeding 43%. Fat in dry matter is similar to natural cheese, not less than 47% in general. According to PFA the FDM in Process Cheese should not be less than 40%.

2.2 Process cheese spread - Process cheese spread is similar to process cheese but spreadable at 21°C and fat content is not less than 20%. It may contain optional dairy ingredients, emulsifying agents and gums (less than 0.8%). Acids may be added to get
pH not below 4.0. Sweetening agents may be used (sugar, dextrose, corn sugars). Sorbic acid (less than 0.2%) may be used as a preservative. Since its moisture content is high its cooking temperature is higher and pH lower than process cheese.

2.3 Process Cheese Food - Process cheese food is similar to process cheese, except it must contain moisture not exceeding 44% and fat content is not less than 23%. It contains optional dairy ingredients: cream, milk, skim milk, butter milk, cheese whey solids, anhydrous milk fat, skim milk cheese for manufacturing. pH is adjusted to not below 5.0 with vinegar, lactic acid, citric acid, phosphoric acid and acetic acid. It cannot contain more than 3% emulsifying agents and 0.2% sorbic acid. Since product contains more moisture than process cheese, its cooking temperature is slightly higher and its pH is slightly lower. The final product resembles process cheese, but it has softer body and milder flavour. The pH range of most processed cheese foods is usually 5.4-5.6, but it may go down up to pH 5.2.

2.4 Cold Pack Cheese (Club Cheese) - Cold pack cheese involves blending without heating various cheeses. Only cheese from pasteurized milk is used. Its moisture content is same as of individual cheese, and fat content in dry matter is not less than 47% in most cheeses. Cold pack cheese may contain acids to standardize pH to not below 4.5. Sorbic acid (less than 0.3%) can be used as preservative.

2.5 Cold Pack Cheese Food - Cold pack cheese food is prepared by comminuting and mixing (without heating) cheeses and other ingredients like cream, milk, skim milk, butter milk, whey solids, anhydrous milk fat. Acids may be added to standardize pH not less than 4.5. Sweetening agents (sugar, corn solids) may also be used. Sorbic acid (90.3%) may be used as a preservative. Guar gum or xanthan gum may be used (0.5%). Moisture content can not exceed 44% and fat content is not less than 23%.

3.0 COMPUTATION OF INGREDIENTS

Computation of ingredients is conducted on the basis of established fat and dry matter contents of natural cheese components. Formulation of the material balance of fat and dry matter, including all blend constituents, added water and condensate from live steam used during processing, must be made in such a way as to yield a finished product with the desired composition. In addition to natural cheeses, various other dairy and non-
dairy ingredients are used in the production of processed cheese spreads and processed cheese foods, as shown in Fig. 1. Since the quality of the final product is influenced considerably by all the components present in the blend, the non-cheese components must also fulfill certain qualitative and quantitative requirements. The most frequently used non-cheese ingredients are skim milk powder, casein, whey protein coprecipitates, various whey products and milk fat products.

3.1 Paneer- Paneer is an unripened cheese. It is used for preparation of number of culinary dishes. A significant demand for paneer in the urban areas of the country already exists. Packaging and extended shelf life would accelerate growth of this category. Value added products derived from paneer (pakouras, diced paneer, paneer snacks flavoured with popular seasoning, etc.) are likely to increase investment returns.

3.2 Ready-to-Eat Long-life Paneer Curry- A ready-to-eat, long life paneer curry has been developed at our institute. A paneer based curry (paneer cubes in gravy) packed in retort pouches/tin containers was developed using Hurdle Technology. A gravy mixture was prepared using tomatoes, onions, garlic, ginger, spices, salt, cream, dahi, skim milk powder and humectant like glycerol. The spiced mixture and fried paneer cubes were taken in a tin container or retort pouches in 5:1 proportion and heat treated at 104°C/20 min. The average composition of the product was total solids 40%, fat 25%, protein 6% and ash 3%, carbohydrate and glycerol constituted about 6%. The product had a shelf life of about a month at ambient temperature. The cost of production of 200 g of the product in a retort pouch worked out to be approximately Rs. 10.00.

4.0 IMITATION CHEESE PRODUCTS

An imitation product is a substitute, in which the general composition, appearance and characteristics intended to simulate milk or a milk product and the milk solid constituents are wholly or partly replaced with non-milk ingredients. They are produced either by blending, structurizing or shaping of mixture of ingredients (e.g. margarine, non-dairy whiteners), to substitute milk fat by non-milk fat in the raw material (e.g. filled milk, imitation cream and imitation cheese) or from milk like products obtained from
soybeans, groundnuts etc. (e.g. soy-paneer, soy-cheese, tofu, groundnut cheese and groundnut paneer). The advent of new technology has enabled manufacturers to develop imitation products that are fairly similar in appearance and performance to traditional dairy products. The products can be so tailored as to contain less of lactose or cholesterol.

Imitation cheese products are differentiated into “Cheese Analogues”, “Filled Cheese” and Tofu.

### 4.1 Cheese Analogs
This product, as manufactured from vegetable fat, milk protein, various additives and flavouring compounds using process cheese technology, has been a success, especially with regard to its capacity to replace genuine Mozzarella, in the Pizza industry. It is found to have better functional properties than genuine Mozzarella when used in frozen pizza.

### 4.2 Filled Cheese
Filled cheese is similar to genuine natural cheese and is suitable for eating with bread. Filled cheeses are usually cheeses in which milk fat is replaced by vegetable fat. In manufacturing filled cheese, “filled milk” or “filled reconstituted milk” is converted into cheese by normal cheese making procedures. The raw material is skimmed milk to which a vegetable fat has been added with the aid of emulsifying substances. A Cheddar type cheese made from a mixture of skim milk and vegetable oil, homogenised at 70 kg/cm$^2$, was found to be satisfactory in qualitative acceptance.

### 4.3 Tofu
Tofu was first introduced in Japan in 1183 and then subsequently spread to other Asian countries. Tofu has long been a very popular food in Eastern Asia. The method of manufacture of Tofu is simple. Soybean is converted into soymilk (5-6% TS), which in turn is coagulated by calcium sulphate. The coagulum is formed and whey is separated out. The curd is then pressed in perforated hoops. Thereafter, it is dipped in water and sliced into desired size pieces and consumed while fresh.

### 4.4 Pizza
Pizza is a nutritious fast food very popular all over the world. It provides less fat and cholesterol than other fast foods and more valuable protein. The calories are not usually high. The nutritive value of Pizza depends on (i) type of base used and its formualtion, (ii) toppings used and (iii) time-temperature of cooking/baking. Pizza crust comprises of about 50 per cent of the weight of Pizza. A typical serving of one-fourth of a 10 inch crisp crust Pizza made with the enclosed Pizza sauce and cheese provides 200 calories. With the additional toppings such as sausages, meat balls, tomato, onions, or
mushrooms, etc. increase the calorie count, but it is still not likely to exceed 250 or 300 calories per slice.

4.4.1 Classification- Pizza is a food of many variations and it has some major differences. Most people classify Pizzas by the variation in crust. These are (i) thick crust Pizza, (ii) thin crust pizza

Round Pizzas and square; rich (vegetable oil content) dough and lean dough. Typically, the thick crust or deep pan Pizza is known as Sicilian Pizza which is popular in Italy and the thin crust Pizza is called the neapolitans Pizza which is liked by Americans.

Pizza is further classified on the basis of toppings used:
(i) Vegetarian and
(ii) Non-vegetarian – the non-vegetarians items contribute about 10-15 per cent of the Pizza.

4.4.2 Preparation:

Pizza preparation is more of an art than science. The selection of suitable Pizza base is primarily according to the taste of consumers.

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maida</td>
<td>60.0</td>
</tr>
<tr>
<td>Water</td>
<td>34.0</td>
</tr>
<tr>
<td>Yeast</td>
<td>3.0</td>
</tr>
<tr>
<td>Salt</td>
<td>1.0</td>
</tr>
<tr>
<td>Sugar</td>
<td>1.0</td>
</tr>
<tr>
<td>Vegetable oil</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Another typical formulation is , 100 gm maida, 2 gm vegetable oil, 1 gm salt, 1 gm sugar and 2.5 gm yeast admixed with 60-65 ml of water. Sometimes calcium propionate is also used as preservative in the Pizza base.

The sugar and yeast is dissolved in the lukewarm water, let yeast bloom 10-20 min. The oil and salt is added in the maida and then yeast water mixed with it. The dough should be soft but not sticky. The content is mixed/kneaded for 10 min on low speed or by hand properly until the dough is very smooth and elastic. The dough is
covered well and set aside in warm place about 3 hrs or until dough has raised to double its size.

When dough has raised, spread in large well greased baking pan about ½ to ¾ inches thick. Dent here and there with finger- tips, pour generous layer of tomato sauce or Pizza sauce (made from tomato sauce, paste or puree or a combination thereof. Typical spices for Pizza sauce are oregano, basil, black pepper, garlic powder and ground Ramano etc., which is spread uniformly on the surface of the suitably selected base. The amount of sauce used varies with the size of the base. In general for 12 inch round Pizza 85 gm of sauce, for 14 inch 125 gm and for 16 inch Pizza 170 gm of sauce is used. The ground or shredded Mozzarella cheese is added in the following proportions: for a 12 inch round Pizza 110 gm cheese, for 14 inch 150 gm and for 16 inch Pizza 210 gm of cheese. For better flavour sometimes processed cheese or Parmesan cheese added up to 20 per cent of the total cheese. On the top finally the materials like onion, tomato, capsicum, mushrooms etc., non-vegetarian items and other spices are applied. After filling the dough, the content is baked on either hearth for about 20 min at 45°F or in oven at 220-230°C for about 15-20 min. No steam is used in the oven for proper and complete baking. The following observations are made:

(i) cheese should be melted
(ii) the tomato should have just started to brown and the dough should be brown and crisp around the edges. The hot Pizza is served with sauce and spices etc.

5.0 NATURAL CHEESE

These process cheese products are made from natural cheeses. Cheese connotes transformation of vital milk constituents from fluid to semi-solid or solid form. Natural cheese is made directly from milk (or whey). It is made by coagulating or curdling milk, stirring and heating the curd, draining off the whey and collecting or pressing the curd. Desirable flavours and textures are obtained in many cheese by curing process at a specified temperature, humidity and time period.

Butter and cheese have been part of people’s diet in Egypt and Asia since ancient times. Ancient Greeks included cheese in their offerings to their Gods and Mount Olympus. This practice is reminiscent of the use of ghee in Vedic offerings during traditional God worship. Aristotle evidently was aware of the composition of milk and referred to cheese making from mares’ and asses’ milk. The Aryans made their first efforts at cheese-making in Central Asia and carried their skills to Europe. The Romans picked up from Aryans the art of making butter and cheese.
Essentially, cheese is a preserved food. In cheese, the main milk components (proteins, fat and minerals) are concentrated and protected from rapid deterioration by spoilage microorganisms. Cheese is, therefore, a concentrated milk food.

Cheese making requires four basic raw materials: good quality milk, rennet or coagulating acids, culture and salt. Various combinations of heating and washing of curd and subsequent ripening at specific temperatures and humidity are needed in production of flavours and textures characterizing numerous natural cheese varieties.

Cheese represents a balanced food with concentrated form of energy and good quality protein. As such it is the only food which could prove to be an appropriate substitute to non-vegetarian diet. Cheese has high food and nutritive value. It is an excellent source of high quality protein, rich source of calcium and phosphorus, an excellent source of several water-soluble vitamins. To consumers, it provides good nutrition, variety, convenience for use, portability, food safety and novelty of flavour and texture.

6.0 THE WORLD MILK UTILIZATION PATTERN

The fact that cheese is a virtuous product can be further substantiated by the steady growth of cheese production in the world (Table 1)

Table 1 World Milk Utilization Pattern (%)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Butter</td>
<td>34.00</td>
<td>36.00</td>
<td>30.00</td>
<td>29.00</td>
</tr>
<tr>
<td>Cheese</td>
<td>13.00</td>
<td>28.00</td>
<td>40.00</td>
<td>42.00</td>
</tr>
<tr>
<td>Preserved milk</td>
<td>4.00</td>
<td>5.00</td>
<td>5.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Liquid milk &amp; others</td>
<td>49.00</td>
<td>31.00</td>
<td>245.00</td>
<td>24.00</td>
</tr>
</tbody>
</table>

7.0 CHEESE PRODUCTION

Whenever there is surplus milk production, the recourse is taken in the conversion of milk into cheese, which has excellent shelf-life. In general, majority of the dairy products have a shelf-life about a week at refrigeration temperature. In contrast the shelf-life of cheese ranges from one week to five–ten years depending upon the specific variety. Edible cheese about 2000 years old was found in 1948 in a tomb in Altai region of Siberia (Wilster, 1955). Thus, cheese is such a product which can travel to any part of the world without much problem. In fact, it should become a part of regular diet of our explorers in Antarctica, to our soldiers in Siachin. The steady increase in cheese production is shown in Table 2.
Table 2. Cheese production (‘000 tonnes)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>14,471</td>
<td>14,653</td>
<td>14,908</td>
</tr>
<tr>
<td>U.S.A.</td>
<td>2961.00</td>
<td>3053.00</td>
<td>3200.00</td>
</tr>
<tr>
<td>India</td>
<td>183.00</td>
<td>190.00</td>
<td>200.00</td>
</tr>
</tbody>
</table>

Growth rate – 4 per cent

In 1955, 14.9 million tonnes of cheese was produced in the world, of which the United State and the European Union accounted for more than 50%.

With the withdrawal of subsidy to milk producers following the GATT agreement, a restructuring in the international cheese trade is expected as the European cheese producers would find their product less competitive because of the rise in the milk price. This offers a unique opportunity for the Indian dairy Industry to get the desired breakthrough and take a place in the global cheese market.

In India’s rapidly expanding dairy industry, one product gaining importance is cheese. It has attracted the attention of entrepreneurs following delicensing of dairy industry in 1991. The next few years would see packed cheese slices and spreads on the shelves of retail outlets in metro cities, as also new varieties such as Gouda, Camembert, Edam and Cheddar would soon be making their debut in the market.

In India cheese production has been increasing quite steadily being 800 tonnes in 1977 and 1000 tonnes in 1980. It increased to about 3000 tonnes per annum in 1987. In 1994, the production has been estimated at 8,000 tonnes, against the installed capacity of 9000 tonnes, shared among 50 units in the organized sector. Of these, only three can be regarded as major players: Amul (40% of the market share), Verka (22%) and Vijaya (14%). In addition to the domestic production, another, 1000 tonnes was imported and largely included specialized cheese varieties.

Against this production, the total demand estimated by several market surveys was placed around 18,000 tonnes, which is projected to exceed 30,000 tonnes by 2000 AD. The projects, under implementation will see the capacity treble to over 25,000 tonnes.
8.0 ENZYME MODIFIED CHEESE

The demand for cheese flavours has increased due to consumer demand for a wider choice of convenience and low-fat products that possess cheese flavour. Cheese flavours can be produced by procedures such as synthesis or partial synthesis of individual components, isolation of individual components as flavour complexes from natural raw materials or the formation of flavour complexes by physical/chemical synthesis. However, the identification of all the compounds present in a given cheese flavour

8.1 Enzyme Modified Cheese Technology

EMC technology has evolved from curd slurry model system. The curd slurry technique is a very useful technique for assessing the capability of specific enzymes and starter cultures to generate good cheese flavours in an environment similar to that used during EMC production.

Essentially, the technology used to produce EMC involves incubating cheese/curd with exogenous enzymes (proteinases, peptidases, lipases and esterase) in a slurry system under controlled conditions until the required flavour is attained. The flavour profile of enzyme-modified cheese can be up to 30 times the intensity of natural cheese. Using EMC technology can produce a series of cheese flavours.

8.2 Use of EMC

EMCs are used in food recipes to fulfil several roles, e.g., as the sole source of cheese flavour in a product, to intensify an existing cheesy taste or to give a specific cheese character to a more bland-tasting cheese product. They have approximately 15-30 times the flavour intensity of natural cheese and are available as pastes or spray-dried powders. The addition of intense cheese flavours to these products creates the desired flavour without an increase in fat content, as the same can be added at levels of 0.1% (w/w) and contribute less than 0.07% fat (2.28 calories) per 100 g.
1.0 INTRODUCTION

A package is designed to protect and to sell the product it contains, and this generally requires a mechanical process on a packaging line selected to carry out efficiently those operations necessary to put the product into the package.

Formulated foods involve the packaging of water-like liquids, beverages, powders, granules etc. The nature of the product has more profound effect on the performance of the packaging line than any other factor.

2.0 PACKAGING SYSTEMS

The basic systems, which can be used for the packaging of formulated foods are:

2.1 BOTTLING

Earlier bottling lines handled only glass bottles, whereas today the containers can be not only of glass, but of, one of a variety of plastics with shape and stability as varied as marketing may demand. Different shaped containers need handling in different ways, and their contents are filled according to their characteristics.

A bottling line can be a collection of automatic machines connected by a conveyor belt, or a group of highly sophisticated, fully automatic units completely integrated by a synchronized drive arrangement. Semi-automatic lines depend to a large extent on the dexterity of individual machine operators for their maximum output, and operating speeds, on these vary from 30-60 units per minute. Above this speed, a fully automatic bottling line is usually necessary. The different bottling processes are:

- Bottle feeding
- Bottle cleaning
- Filling
- Closing
- Labelling
- Packing for transport.
2.2 CANNING

The canning of formulated foods can be divided into eight basic operations:

- Handling and storage of empty cans
- Cleaning empty cans
- Product preparation
- Filling
- Closing
- Processing
- Cooling
- Handling and storage of filled cans.

Tinplate containers do not have unlimited resistance to physical abuse or corrosion. Cans should therefore be transported in a manner that will avoid damage to the reims, denting or rupture of soldered laps.

2.3 CARTONING

A cartoning system combines a special carton with the machinery to erect it from a flat condition, fill it with the product, and close it. The machinery varies from simple hand-fed machines to automatic staticins coupled with means for packing the cartons directly into cases for dispatch. In cartoning three main operations are performed:

i) Forming or erecting the container.
ii) Loading or filling the container
iii) Closing or sealing

In addition to these main operations, cartoning systems may be required to carry out secondary operations such as handling paper liners, embossing codes, and inserting leaflets. All these can be performed along with the three main operations on manual, semi-automatic, or fully automatic lines. When forming, filling and closing must be carried out on one machine in a single operation, fully automatic machinery is used.

2.3.1 Cartons for liquid products

Requirements with respect to impermeability and hygiene are particularly stringent when packing liquid formulated foods. Sealing of cartons must be very tight and there are problems to be solved in connection with filling and how to seal or avoid open-cut edges. There are two main groups of machines, those which work from a reel, form the package and fill it in a continuous operation, and those which start from a pre-manufactured blank. "Tetra Pak" machine, utilizing the principle of forming from a reel, the different stages being combined in one machine. This machine permits carton-filling under fully aseptic conditions.
2.3.1.1 Selection of cartoning system

2.3.1.1.1 Machinery considerations

(i) The required production rate of the machine both immediately after installation and at the expected peak of production.

(ii) The number of package sizes which may be involved.

(iii) The frequency of size changes.

(iv) Whether the system will have to cater for alterations of the product type or number within the size variation anticipated.

(v) The availability of labour for the machine lines.

(vi) The space available for putting the machinery, bearing in mind a possible increase in production later on.

2.3.1.1.2 Product factors

(i) The variations likely to be expected in the product itself, how easy it will be to control the size of the product and within what limits.

(ii) The methods available for handling the cartons after they have been filled. For example, are they required to go into a deep freezer, or are they to be over-wrapped with a barrier material to provide protection from moisture in an export market? Such factors determine the nature of any protective barrier that may be required on the board itself.

(iii) Whether product itself requires protection from moisture, oxygen, outside odours etc. Is it greasy, or wet or otherwise able to affect the board from which the carton is made?

3.0 LABELLING

Labelling machines for packaging combine three components:

(i) The container to be labelled, the adhesive and the label.

(ii) They may be divided into two main categories based on the general nature of the adhesive system: machine using "wet" adhesive (provided separately from the labels) and those using pre-adhesed labels.
In selecting a machine one must consider which system is best suited to the particular application, i.e. wet adhesive, heat activated or pressure sensitive adhesive. While making selection, the following points need to be considered:

3.1 ECONOMIC

- basic label cost
- adhesive cost
- setting up, cleaning down and routine stoppages
- Inventory cost.

3.2 MARKETING

- label material and print requirements
- container material
- container shape
- container re-use
- security considerations.

3.3 HANDLING

- storage conditions
- transit hazards
- retail conditions
- in-use conditions.

4.0 CONCLUSION

Any packaging line starts a long way before the end of the production line for the product and only ends when the product and the package reach the consumer. All the operations between these two very important points have so important bearing on the packaging that they should be regarded as part of the packaging process.

5.0 SUGGESTED READING

ASTM D4169-82: Performance testing of shipping containers and systems.


1.0 INTRODUCTION

Fats and oils are obtained mainly from animals, vegetables, and marine sources and are mixture of triacylglycerols. Each fat has different fatty acids and characteristics distribution of these fatty acids in the triacylglycerol molecules. As a result the physical, functional and organoleptic properties of fat and oils differ from each other. In food industry fats and oils are widely used in the manufacture of variety of foods. The role of fats in the food ranges from providing energy to carrying fat-soluble vitamins and providing flavour, palatability and satiety. Fats and oils are used as a heat exchange medium such as in frying. Shortenings are used as lubricants in foods, contributing to mouth feel and texture and as a tenderize the baked food other fats such as margarine are used as spreads or the baking. They can be formulated into a coating or a moisture barrier. The physical properties of fats and oils lend them to the diverse factors like the emulsifiers, emulsion, autoxidation and lipolysis in the food. The specific requirements however, vary according to the type of product. Thus the use of one particular type of fat is sometime limited as it lacks the physical properties desired is: a specific food. Modification of fats and oils can bring about desired changes in their functional properties and play special role in imparting specific characteristics to the fats and oils and the resulting products.

2.0 MODIFIED FATS

Processes such as hydrogenation, interesterification; fractionation and blending either individually or in combination are generally adopted to improve one or more of the properties of naturally occurring fats and oils produce a "tailor made" fat 40 suit the requirements of a particular food. Such "tailor made" product is referred to as modified fat. The modification process bring about desired changes in the functional property and wider the range of alternative sources of fats and oils for the food industry.

3.0 MODIFICATION PROCESSES

Blending: Hard fats obtained by hydrogenation, and/or interesrification and fractionation of refined fats and oils are suitably blended to obtain products like margarine with desired characteristics. Additives such as lecithin, monoglycerides or other surface active or crystal modifying agents can be added to facilitate blending of oils and fats.

3.1 Fractionation

Fractionation by crystallization is used to separate a fat into harder and softer fractions. It is primarily a thermo-mechanical process of separation where fat is first nucleated and crystallized and then separated from the liquid phase using one of the several
techniques. Three methods of fractionation, namely, solvent fractionation, detergent fractionation and dry fractionation are in commercial use. Other processes like super critical carbon dioxide extraction process have not yet achieved commercial success.

3.2 Hydrogenation

Hydrogenation is especially used for converting liquid oils to semisolid fats. By means of hydrogen in the presence of a catalyst, hydrogenation saturates some (for occasionally all) of the double bonds of unsaturated fatty acids originally present in the liquid oil. Most commercial hydrogenation is not carried out to full completion as the resulting oil is enriched in trans fatty acid and depleted of natural cis fatty acids.

3.3 Interesterification

The aim of this process is to produce fats with desired physical properties. Under the influence of a suitable catalyst, the component fatty acids of a triacylglycerols i.e. fat may leave their original sites and redistribute and occupy new sites. Thus, it results in a rearrangement of fatty acids random or directed in an oil blend with new triacylglycerols. As a consequence of the process the newly formed glycerol esters will not necessarily have the same physical and functional characteristics as these present in the original fat.

3.4 Bio-modification

In recent years there has been much interest in the use 1,3 selective or 1,2,3 non-selective lipases for the modification of fats & oils. A process for the modification of palm oil using lipase enzymes to produce a fat similar to coca fat has been developed.

4.0 APPLICATION IN FOOD INDUSTRY

Confectionery and imitation dairy products seem to be the major outlets for modified fats. Foods like dairy spread, spreadable butter, icings, mayonnaise, margarine, chocolate, confectionery coating, limitation dairy products like coffee whitener, etc. possess qualities due to the fat that they contain. These fats are hard and brittle at and below room temperature and melt completely at body temperature. These fats are referred as hard butters and possess characteristics solid fat index profile. Hard butters may be produced from the fats and oils obtained from various sources, like palm Kernel, coconut, cottonseed, palm, soybean etc. using modification technique.

4.1 Fractionated Fat

Fractionation of milk fat changes it from a limited and variable commodity into a versatile food ingredient. Fractionated milk fat has been successfully used in the preparation of dairy spread, spreadable butter, pastry, biscuits and shortbread, cakes and chocolate and confectionery.
4.1.1 Pastry Products

Major benefits of fractionation are derived when plasticised milk fat hard fractions are used in layered pastry products such as puff pastry. Overseas, these products are currently the most important application for milk fat fractions.

Regular milk fat tends to have a low work tolerance. When cold, it tends to break during rolling of layered pastry products and as it warms during further rolling and folding it tends to melt and is absorbed into the dough. This results in a poor layering and variable lift. Although suitable cheap fats from other origin are available for pastry products, milk fat is much preferred because of its superior flavour.

The function of the fat in these products is to keep the layer separate enabling good and even lift during baking. In baking, the heat melts the fat and starts to denature the gluten in the dough, which begins to stiffen. The sater present in transformed to steam, the pressure of which forces the layer of dough to separate. The melted fat assists in this process by acting as lubricant.

4.1.2 Biscuits and Shortbread

Milk fat soft fractions are used on a large scale in the manufacture of shortbread and biscuits with improved quality. One of the advantages conferred is a better shelf-life, especially during winter months when the temperature cycling can cause fat bloom or surface discolouration of biscuits. It is interesting to know that in shortbread the soft fractions improve their shelf-life, whereas chocolate shelf life is improved with hard fractions, which result in better fat bloom stability.

4.1.3 Cakes

The use of butter in cakes is desirable as it gives a superior butter flavour, which remains throughout the whole cake after baking. However, in the cake production, the creaming properties are also very important. However, the traditionally churned butter leaves much to be desired. The creaming properties largely determine the specific volume and textural properties.

4.1.4 Chocolate and Confectionery

Milk chocolate contains both cocoa fat and milk fat. Cocoa is usually nearly twice the price of milk fat; therefore there is a strong economic incentive to utilize more milk fat. However, in milk chocolate, depending on the style of chocolate and other ingredients, no more than 20-30% milk fat can be used, otherwise the chocolate becomes too soft. Hard fractions of milk fat are more comparable with cocoa fat than regular milk fat. By using some of the hard fractions, it may be possible to increase the properties of milk fat. A blend of milk fat and milk fat hard fractions with cocoa butter gives uniform melting properties over a wide range of concentrations.

Other potential advantages of milk fat fractions include firmer milk chocolates for tropical areas and milk and dark chocolates of improved fat bloom stability. Milk fat may be added in low levels to dark chocolate as a natural fat boom inhibitor.
There are also opportunities to improve the quality of other confectionery products such as compound or substitute chocolates, fillings and ice cream coatings can also be improved by using fractionated milk fat. Some milk fat fractions have better compatibility with the lauric fats used in the substitutes than standard milk fat, which causes bloom and softening. For fillings or chocolate centers somewhat softer fats are often preferred. This also applies to ice cream coatings where chocolate tends to be hard and breaks off in large sheets. Consequently, substitute chocolate is frequently used for ice cream coatings. By incorporating milk fat soft fractions, the use of suitably textured real chocolate becomes a distinct possibility.

4.2 Spreadable Butters

The addition of milk fat soft fraction from a single step fractionation to butter makes a more spreadable product but their softening effect is not as great as that of vegetable oils. Milk fat soft fractions from multistep fractionation (with softening point 10°C or less) give a much better softening effect, nearly as good as vegetable oils. However these dairy blend type products cannot be made as easily spreadable as margarine at refrigerated temperatures without making them too soft at ambient temperatures. The product immediately melts on warm toast and it easily separates in the two phases; oil and water when left on the table on a warm day. This phase separation is irreversible without reprocessing. By blending a milk fat hard fraction with very soft fraction, a product with a better spreadability than a normal dairy blend (20-30% vegetable oil) is obtained. It has better characteristics at ambient temperatures, closer to that of butter. A blend of 30% milk fat hard fraction with 70% very soft fraction gives a spreadable butter of excellent physical properties.

Dairy blends of a type different from those discussed above can be made by blending vegetable oil with a milk fat hard fraction. The molten blend is crystallized with the aid of SHE. The use of the milk fat hard fraction negates the need for hard hydrogenated oil as used in margarine. The resulting products are more spreadable than any of the previously mentioned dairy blends and spreadable butters made with hard and very soft milk fat fractions. They can also be made firmer than butter at ambient temperatures. Such product consisting of milk fat hard fractions and rapeseed oil is marketed in Finland.

4.3 Dairy Spread

By blending higher, middle and lower melting fractions of milk fat with vegetable oils a wide range of spreads could be obtained. Blending of unmodified liquid vegetable oils with milk fat yields a dairy spread with good spreadability but the spread lacks standup quality. This problem could be overcome by using partly hydrogenated oils in the blend. The poor spreadability and texture of low fat dairy spread made from all milk fat could be improved by blending it with low melting fraction of milk fat. Fully hydrogenated milk fat can be used as the hard stock in the preparation of PUFA margarine by blending it with sunflower oil.
4.4 Shortenings

Although blended products have achieved some success in spreads, blended shortenings and other baking fats have achieved less success in food industry.

4.5 Hydrogenated Fat

In edible fat industries the hydrogenation process is employed for converting liquid oils to hard or plastic fats, for converting soft fats to firmer products and for improving the resistance of fats and oils to deterioration through oxidation or flavour reversion. Hydrogenated soya oil and palm kernel oil are known for confectionery coatings, imitation dairy toppings and as cocoa butter substitute. Hydrogenated cum interesterified product showing rapid melt down at the sharp melting range is used as cocoa butter substitute. Reesterification of hydrogenated coconut oil fatty acids after fractionation result into cocoa butter substitute. Such products could be used in the formulation of imitation dairy products.

4.6 Bio-modified Fat

Bio-modified palm oil can be used as a cocoa butter substitute. The 1-3 specific lipase enzyme from *Mucor miehei* and its immobilized use for the production of cocoa butter has been reported. The linoleic acid in olive oil can be increased when the oil is reacted with linoleic acid in presence of fatty acid specific enzyme produced by *Geotricum candidum*.

4.7 Interesterified Fat

Interesterification is widely applied in two areas of the food industry namely, (i) for changing or stabilizing the crystal habits and (ii) for changing the melting and crystallization behaviour of fats and oils. Edible fat are polymorphic and the most important crystal forms in the production of margarines and shortenings are a b and b, of which the last two are the stable forms. The desired, form for most margarines and shortenings is the b structure. Individual oils and fats show tendencies towards either the b or the b structure. Lard crystallizes naturally in the b form because of the high proportion (64%) of palmitic acid in the 2- position of its disaturated glycerides. On randomizing, this proportion is reduced to 24% and, in consequence the interesterified product crystallizes in the b form with resultant improvement in its shortenings performance. Similarly the crystal structures of margarine based on sunflower oil and canola oil are stabilized in b form by random interestification.

The fact that interesterification results in changes in the melting characteristics of fat has been used to produce dietary margarines high in PUFA and with low to zero trans fatty acids content and confectionery fats with rapid mouth melt down properties. By directed interesterification shortening of improved plastic range is obtained from lard and, after fractionation, a salad oil can be produced from palm oil.
4.8 Structured Lipid

A structured lipid-containing dairy fat has been made by transesterification of a mixture of fatty acids and triacylglycerols including milk fat, in the form of cream or butter. The product has nutritional applications and may also be used as an enteral or potential supplement.

Structured lipids (SL) can be synthesized to target specific metabolic effects or to improve physical characteristics of fats. An SL made from fish oil and medium chain triacylglycerols was compared with conventional low chain triacylglycerols and found to decrease tumor protein synthesis, reduce tumor growth, decrease body weight, and improve nitrogen maintenance. SL may be synthesized to provide the most desirable features of long chain fatty acid and medium chain fatty acid for use as nutrients in cases of pancreatic insufficiency. An SL made by reacting tripalmitin with unsaturated fatty acid using a Sn 1-3 specific lipase closely mimicked the fatty acid distribution of human milk and is under commercial development for application in infant formulas under the trade name of Betapol. High density lipoprotein cholesterol decreased by 14% when a diet containing a SL careening as 40% of total calories was fed to healthy men, compared to no change in levels when a long chain triacylglycerol diet was fed.

5.0 SUGGESTED READING

Timms, R.E. The possibilities of using modified milk fats in the production of confectionery fats, shortening and spreads fats for the future . 251-261
1.0 INTRODUCTION

It is estimated that more than 50% of milk production is utilized for the manufacture of various Indian milk products and delicacies by traditional sector i.e. Hulwais (Banerjee, 1977). The value of khoa and channa produced in India is probably twice the value of milk handled by the organized sector. Most of the traditional Indian dairy products are prepared normally in the small batches. Since no standard method are adopted for their manufacture, the chemical, sensory and rheological properties of traditional dairy products are invariably inconsistent. The small-scale entrepreneurs and confectioners, who are largely engaged in the manufacture of those products, are unaware of emerging trends in production, preservation and overall quality control. Thus most of the traditional dairy products have limited shelf life.

The ready-to-use traditional milk products have great scope because these offer several benefits. Some of these are as given below:

- Economic use of seasonal and regional milk surplus.
- Produce sweets of consistent quality at the convenience of users.
- Adaptable to medium and industrial scale dairy processing operation.
- Allow product diversification with manageable investments for improved productivity of the dairy industry.
- Enhanced shelf life at ambient storage
- The products offer good export potential.

Several long life ready-to-use traditional milk products have been formulated in recent years. The technologies of khoa powder, gulabjamun mix powder; rasogolla mix powder, kulfi mix and kheer mix have been discussed in this write up.

2.0 KHOA POWDER

Khoa is an important base material for several milk delicacies such as burfi, peda, gulabjamun, kalakand, milk cake, etc. It has limited shelf life of about 4-5 days at room temperature. Several attempts have been made in the past to develop khoa powder. (Patel and De, 1977; Thompkinson and De, 1978; Rizvi et al 1987). Ranganadham (1988) developed technologies for small scale and industrial production. The flow diagrams of the methods are depicted in Fig 1.
2.1 METHOD OF MANUFACTURE

Khoa, made from standardised buffalo milk in the traditional manners was grated and subjected to heat treatment to evaporate moisture before grinding (Fig.1). Grinding was accomplished in a laboratory grinder. The product was uniformly distributed in aluminium trays and dried separately in a vacuum and atmospheric hot air oven at 70°C. In another process, grated khoa was dried in a fluid bed drier with an inlet air temperature of 98°C. It took about 4 hours to dehydrate the product in a hot air oven and 30 min in a fluid bed drier.

![Diagram of the method of manufacture of khoa powder.](image)

The drum drying process was standardised for medium scale operation. Buffalo milk was adjusted to 6 percent fat and 9 percent SNF and heat treated to develop a typical cooked flavour in the final product. The heated and partly concentrated milk was drum dried after adjusting the steam pressure, flow rate of milk and speed of roller drums (Fig 1B). Spray drying technology was considered suitable for large scale production of khoa powder (Fig 1C). Concentrated milk with 30 percent T.S. was prepared from standardised buffalo milk followed by heat treatment to develop cooked flavour. The heated, concentrated milk was atomised and instantly dried in an Anhydro spray drier with an inlet temperature of 190°C and outlet temperature of 78°C.

The composition and physico chemical characteristics of khoa powder prepared by above three methods and that of spray dried whole milk have been shown in Table 1 below:
Table 1. Physico-chemical properties of khoa powder in comparison with whole milk powder.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Tray dried khoa (A)</th>
<th>Khoa powder (roller dried) (B)</th>
<th>Khoa powder (spray dried) (C)</th>
<th>Whole milk powder (spray)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td>3.98</td>
<td>3.75</td>
<td>2.40</td>
<td>2.20</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>31.17</td>
<td>37.07</td>
<td>38.21</td>
<td>27.01</td>
</tr>
<tr>
<td>Proteins (%)</td>
<td>26.73</td>
<td>24.28</td>
<td>23.96</td>
<td>27.08</td>
</tr>
<tr>
<td>Lactose (%)</td>
<td>32.98</td>
<td>30.07</td>
<td>30.38</td>
<td>36.85</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>5.14</td>
<td>4.90</td>
<td>5.05</td>
<td>6.15</td>
</tr>
<tr>
<td>Free fat (% on fat basis)</td>
<td>64.73</td>
<td>77.77</td>
<td>63.96</td>
<td>28.17</td>
</tr>
<tr>
<td>P-DMAB (reactivity absorbance at 545 nm)</td>
<td>0.14</td>
<td>0.19</td>
<td>0.31</td>
<td>0.09</td>
</tr>
<tr>
<td>Total HMF values</td>
<td>21.00</td>
<td>25.81</td>
<td>34.06</td>
<td>10.06</td>
</tr>
<tr>
<td>Loose bulk density (gm/cc)</td>
<td>0.45</td>
<td>0.23</td>
<td>0.29</td>
<td>0.37</td>
</tr>
<tr>
<td>Water activity (at 25°C)</td>
<td>0.42</td>
<td>0.38</td>
<td>0.25</td>
<td>0.30</td>
</tr>
</tbody>
</table>

2.2 SHELF LIFE OF KHOA POWDER

Tray, roller and spray dried khoa powders had a shelf life of 5, 6 and 7 months, respectively at room temperature (30°C). At refrigeration temperature (5°C), the shelf life was observed to be 7, 8 and 9 months respectively. Nitrogen gas packing and addition of BHA further enhanced shelf life to 11 months.

2.3 SUITABILITY OF KHOA POWDER FOR PREPARATION OF SWEETS

One Kg khoa powder on reconstitution yields 1.5 Kg of khoa. Sweets such as kalakand, milk cake and burfi were successfully prepared from the reconstituted khoa powder. Good quality gulabjamuns were also obtained from tray and roller dried khoa.

3.0 GULABJAMUN MIX POWDER

Few ready-made gulabjamun mixes on sale in the market are governed by the patent regulations and the general public are not aware about the composition of the mixes, and their cost is very high. Many of the ready made mixes being sold in the market do not produce sweets of desired quality. We have standardized the technique of formulating gulabjamun mix powder (GMP) from the roller as well as spray dried skim milk (SMP). The gross composition of different formulations is given in Table-2 (Ghosh et al, 1986).
Table 2. Gross Composition of Gulabjamun Mix Powders

<table>
<thead>
<tr>
<th>Constituent (%)</th>
<th>GMP (roller base)</th>
<th>GMP (spray base)</th>
<th>GMP (WMP base)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>8.44</td>
<td>6.07</td>
<td>8.2</td>
</tr>
<tr>
<td>Fat</td>
<td>15.03</td>
<td>20.5</td>
<td>15.1</td>
</tr>
<tr>
<td>Total proteins</td>
<td>19.45</td>
<td>17.12</td>
<td>19.07</td>
</tr>
<tr>
<td>Total ash</td>
<td>3.89</td>
<td>4.65</td>
<td>3.93</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>53.19</td>
<td>51.66</td>
<td>53.7</td>
</tr>
<tr>
<td>(by diff.)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.1 ROLLER SMP BASED GMP

The GMP, based on roller SMP, consists of SMP, maida, semolina (suji), dalda (vegetable fat), baking powder and cardamom in definite proportions. All the ingredients are mixed uniformly in a power driven mixer. Vegetable fat is added in molten state in instalments to ensure proper mixing. The mix is packaged in printed laminated pouches and stored in dry place. The shelf life of GMP is more than 6 months at room temperature. The method of making sweets from GMP has also been standardised. It involves preparation of dough of suitable consistency (50-55 ml water for 100g mix), making smooth balls of uniform size and shape and their deep fat frying in vegetable oil (Dalda) at about 125°C for 15-20 min. The dried brown coloured balls are transferred to hot sugar syrup. This formulation has found wide public acceptance and sold from the milk parlour of the Institute. It has also been observed that skim milk powder + veg. fat can be completely replaced with whole milk powder in the formulation of GMP.

3.2 SPRAY SMP BASED FORMULATION

Since spray dried skim milk is easily available in the market at reasonably low cost, its utilization in the formulation of GMP was also attempted. Use of spray SMP leads to case hardening of balls during deep fat frying and prevents the absorption of sugar syrup. The texture of resultant sweet becomes hard.

The use of high heat SMP, increase in fat content from 15% in roller SMP based formulation to about 18% in spray based SMP, use of additives such as CMC and sodium citrate and/or addition of dried whey protein concentrates (1-2% of SMP) to the mix, helped overcoming these problems and produced good quality sweets.

The process for making gulabjamuns from spray based GMP also requires some modification such as increasing the holding time of dough and frying at slightly lower temperature. The shelf life of spray SMP based formulation was equal to that of roller SMP based GMP (Rajorhia and Dharam Pal, 1989).

4.0 RASOGOLLA MIX POWDER

Manufacture of rasogolla is probably most difficult amongst all the milk-based delicacies. It requires lot of art and experience in addition to the right type of raw materials.
Cow milk is invariably used in the manufacture of good quality spongy rasogolla. Cold storage of chhana results into production of sweets of inferior quality. The use of ultrafiltration, a membrane process, has been made in our endeavour to produce base for the rasogolla mix powder (Dharam Pal et al., 1992).

4.1 PROCESSING TECHNIQUE

Cow skim milk was ultrafiltered to about 3 fold concentration to achieve a product containing all the milk proteins, part of the minerals and lactose as obtained in a chhana. To reduce the mineral and lactose level to almost the same level as in chhana, UF retentate was diafiltered. The pasteurized cream was added to diafiltered retentate followed by spray drying adopting standard conditions. The dried retentate was blended with selected additives to produce desired flavour and texture. The flow diagram of manufacturing rasogolla mix powder by this technique is given in Fig. 2.

**Fig: 2 Flow diagram of the manufacture of rasogolla mix powder**
4.2 COMPOSITION OF RASOGOLLA MIX POWDER

Both cow and buffalo, standardized milks were used for the manufacture of rasogolla mix powder. The composition is given in Table-3.

Table 3. Composition of UF Retentate Powder and Rasogolla Mix Powder

<table>
<thead>
<tr>
<th>Constituants</th>
<th>Cow milk rasogolla mix powder (%)</th>
<th>Buffalo milk rasogolla mix powder (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>4.6</td>
<td>4.15</td>
</tr>
<tr>
<td>Fat</td>
<td>31.7</td>
<td>30.9</td>
</tr>
<tr>
<td>Total protein</td>
<td>46.83</td>
<td>43.55</td>
</tr>
<tr>
<td>Ash</td>
<td>4.39</td>
<td>5.49</td>
</tr>
<tr>
<td>Lactose</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Free fat (% of total fat)</td>
<td>66.25</td>
<td>69.33</td>
</tr>
<tr>
<td>Carbohydrates including lactose (by diff.)</td>
<td>12.48</td>
<td>15.91</td>
</tr>
</tbody>
</table>

4.3 RASOGOLLA MAKING FROM DRIED MIX

The process of making good quality rasogolla involves adding equal quantity of water to the mix powder and holding for about 5 min for rehydration of proteins, followed by making circular balls of about 7 g size in a manner that no cracks appear on the surface. Balls are cooked in the boiling sugar syrup maintained at 60% consistency for 15 min with plenty of foam around the balls. The cooked balls are transferred into another hot sugar syrup of about 40% consistency.

4.4 PRODUCT YIELD AND SHELF LIFE

The average yield of mix powder from cow milk is 7% which can produce about 55Kg of sweet on drained weight basis. This yield is almost 20% higher than that obtained by traditional method. Dried rasogolla mix can be stored for about 5 months at 30°C.

5.0 INSTANT KULFI MIX POWDER

Kulfi is a very popular traditional frozen milk product of India. The chemical and organoleptic qualities of kulfi sold in markets vary to a great extent. Inferior microbial quality is another serious drawback of market kulfi. The existing small scale batch process of kulfi making is not suitable for industrial application. Despite all these deficiencies, kulfi is invariably sold at exorbitant price. A technology has been perfected in this Institute for the manufacture of kulfi mix powder by spray drying process (Ghosh, 1991). The brief details of the process are given here.
5.1 METHOD OF MANUFACTURE

Mix is formulated from milk fat (11%), MSNF (16%), sucrose (15%) and isabgol husk (0.2%). The concentration of solids is adjusted in the mix and only 25% of the total sugar required added before drying. The mix is homogenized at 6.83/3.43 MPa and heated at 100°C for 10 min in a tubular heat exchanger followed by cooling to 4°C. The mix is spray dried. The remaining sugar in ground form is dry blended with the powder and packaged in the tin cans.

5.2 COMPOSITION

The proximate chemical composition of kulfi mix powder is: fat 25.41% MSNF 36.98, isabgol 0.46%, sugar 34.65% and moisture 2.52%.

5.3 SHELF-LIFE

The product has a shelf-life of 7 months at 30°C in tin cans. The shelf-life can be extended upto 10 months with the addition of butylated hydroxy anisole and nitrogen gas flushing.

5.4 RECONSTITUTION OF KULFI MIX POWDER INTO KULFI

Kulfi mix powder can be instantly reconstituted and frozen to get kulfi of consistently good quality all the year round at an affordable price. It ensures the production of pathogens-free frozen product.

6.0 READ-MIX FOR KHEER (PAYASAM)

A ready mix for kheer has been formulated by blending 3 parts of roasted semolina, 3 parts of sugar and 4 parts of whole milk powder. The overall acceptability of the mix was improved by adding 5% pre-porocessed cashew nuts, 0.7% cardamom and 25ppm of edible sunset yellow colour. The composition of kheer mix was: moisture 4.2%, fat 11.5%, proteins 13.3%, total ash 3.01%, and carbohydrates (by difference) 68%. The receipe can be prepared by reconstituting 100 gms of the mix with 500 ml of water and boiling for 5 minutes.

7.0 SUGGESTED READING


1.0. INTRODUCTION

Gulabjamun is a popular sweetmeat of India. It is conventionally prepared from khoa, maida and baking powder. Khoa has low short life and is mostly in short supply throughout the year. Gulab jamun mix powder has been evolved using either SMP (Roller/spray) or WMP, butter fat/vegetable fat, maida, samolina (suji) and backing powder. The formulation using SMP (roller dried) has found wide acceptance for commercial production of gulabjamun but the production of SMP (Roller) is limited to a few small dairies. SMP (spray) and WMP are easily available. The use of SMP (spray) leads to case hardening of balls during deep fat frying and prevents absorption of sugar syrup. The texture of resulting sweet becomes hard. Some of these problems can be overcome by (a) varying the proportion of different ingredients (b) partial replacement of SMP with butter milk powder (c) exposure of mix powder to high temperature of heating (d) addition of texture improveres (e) modification in the method of making gulab jamun. The increase in the proportions of fat and baking powder and decrease in the contents of samolina gives soft product with increased absorption of sugar syrup. Partial replacement of SMP with butter milk powder improves the dough quality and texture of sweet but it adversely affect the colour. Heating of SMP and mixture of SMP and starch separately at 80°C for 15 min improves the texture but there is a problem of slight cake formation in the mixture. Use of texture improves such as sodium citrate is found to be beneficial.

The softness of sweet can be increased, by increasing the quantity of water for dough making. However, 50 ml water per 100 g of powder with few min holding time is optimum. Increasing the temperature of sugar syrup to 80°C improves its absorption in the balls. The shelf life of the formulated mix in flexible polyethylene or polypropylene containers at 30°C is 5-6 months.

2.0. THE COMPOSITION OF THE FORMULATION USING SMP

1. SMP (Roller dried)= 43.5%
2. Maida=25%
3. Semolina=15%
4. Butter fat/veg. fat=15%
5. Baking powder=1.5%
6. Cardomon powder=0.10%
The product contains almost whole of the fat in free form. The problem of free fat can be overcome by using WMP.

1. WMP (20% fat) = 58.5%
2. Maida = 25%
3. Semolina = 15%
4. Baking powder = 1.5%
5. Cardomom Powder = 0.10%

Generally, gulab jamun are prepared from khoa (300g), Maida (100g) and baking powder (1.5g).

In this first two formulations, all the ingredients are dry blended in the lab dry blender or manually. Molten butter fat is simultaneously sprayed while blending.

Maida as a single source of starch, results in a sweet with soft body but slightly sticky and gummy texture and doughy taste. This defect can be overcome by replacing part of maida with samolina in the mix powder. Samolina improves granularity, sponginess and softness of sweet which is also influenced by the fat content. Baking powder improves the textural properties of the sweet. Cardomom powder masks the powdery flavour in the balls from SMP.

3.0. CHEMICAL EVALUATION OF GULAB JAMUN MIX POWDER

Moisture, fat and Ash in GMP are determined gravimetrically according to the method described in AOAC (1970).

3.1. MOISTURE

A known quantity of sample is taken in an aluminium dish. Moisture is evaporated in an oven maintained at 102°C for one hr. From the loss in wt. due to evaporation of moisture, moisture content is calculated as follows:

\[
\% \text{ moisture} = \frac{\text{Loss in wt.}}{\text{wt. of sample}} \times 100
\]

3.2. Fat

There are two methods

• Gravimetric/Mojonnier method
• Modified Gerber Method

3.2.1. Gravimetric Method

About 2-3 g of the sample is digested with 3 ml of concd. HCl on the hot plate for about 30 minutes, contents are allowed to cool, transferred in the Mojonnier tube. 10ml of C₂H₅OH are added, followed by 25ml each of solvent either and petroleum ether and shaken for 1 min. Ethereal layer is decanted in a tared aluminium dish. Second and third extractions
are repeated using 15 ml each of solvent ether and petroleum ether. All the three extractions are combined and evaporated on a hot plate. Then dish is transferred to oven at 135°C for final removal of traces of ether, cooled and weighed.

\[
\text{% Fat} = \frac{\text{Wt. of residue}}{\text{Wt. of sample}} \times 100
\]

### 3.2.2. Modified Gerber Method

About 5-6 g of the sample is digested with 7 ml of concentrated HCl for 30 min on hot plate, contents are cooled and transferred quantitatively in milk butyrometer. The 3 ml of Gerber acid and 1 ml of amyl alcohol are added, followed by a few drops of distilled water and centrifuged.

\[
\text{B.R.} \quad \frac{\text{% Fat}}{\text{Wt. of the sample}} = \frac{\text{------------------------}}{x11.25}
\]

### 3.3. PROTEINS

The protein content can be determined by the Kjeldahl method as suggested by Menaffee and Overmann (1940).

About 0.1-0.2 g of the sample is digested with 8 ml of concd. H$_2$SO$_4$ in the presence of digestion mixture consisting of Na$_2$SO$_4$ and CuSO$_4$ in the ratio of 50:1. The contents are distilled off using 25 ml of 50% NaOH (W/W) absorbed in 25 ml of sat. boric acid soln. and titrated against N/50 HCL using 0.3 ml of mixed indicator (100 mg methyl red & 30 mg methylene blue in 100 ml of 60% alcohol).

Proteins are calculated as follows:

\[
\text{% Protein} = \frac{V \times 0.028 \times 6.38}{W} = 0.18Vx
\]

V= Volume of N/50 HCL used
W= Wt. of the sample

### 3.4. FREE FAT

Free fat content in GMP is determined by the method given by Hall and Hedrick (1966) for dried milk. About 10 g of the sample is taken into 250 ml conical flask and 100 ml of petroleum ether is added and mixture is shaken for 5 min. The contents are allowed to settle and filtered through Whatman filter paper No. 42 into a tared aluminium dish. The second extraction is repeated. The ether is evaporated and residue weighed.

\[
\text{% free fat} = \frac{\text{wt. of fat residue}}{\text{Wt. of sample}} \times 100
\]
3.5.  HMF VALUE

5-HMF value of GMP can be determined according to the method of Keeney and Bassette (1959).

100ml of water are added to 10g of the sample and mixed thoroughly. 5 ml of 0.3 N Oxalic acid are added to 10ml of the reconstituted sample and kept in boiling water bath for one hr. and then cooled. 5ml of 40% TCA are added, mixed and filtered through Whatman filter paper No. 42. One ml of 0.72 % TBA (aqueous soln) is added to 4 ml of the filterate, kept in water bath at 40°C for 20 min, cooled and absorbance measured at 443nm.

Total HMF (free+potential)= (Absorbance-0.055x87.5)  
(Moles of HMF/100g)

For determination of free HMF, the step of boiling is eliminated.

Free HMF = (Absorbance-0.015)x81  
(Moles of HMF/100g powder)

3.6.  PEROXIDE VALUE

Peroxide value of GMP is determined by the iodometric method of Smith (1939). 25 mls of glacial acetic acid are added to 5g of the sample in 100ml vol. flask and warmed the contents for 5 min at 35°C with intermittent shaking to facilitate dissolution. Then CHCl₃ is added to make up the volume to 100ml. The contents are filtered through an ordinary filter paper. To 25ml of the filterate. One ml of freshly prepared sat. soln. of K.I. and 100ml of d. water are added in an Iodine flask. The mixture is shaken for 1 min and titrated against 0.002 N Na₂S₂O₃ using starch indicator.

\[ \text{Peroxide value} = 4V \]  
(ml of 0.002 N Na₂S₂O₃ per gramW)

(b) Peroxide value,\( = 8V \)  
(Milli equivalent O₂ perW  
Kg. of the sample)

Where V= Volume of 0.002 N Na₂S₂O₃ used  
W= Wt. k of the sample in g

3.7.  ASH

About 5 g kof the sample in silica cucible is incinerated on a heater till smoke free. The contents of the crucible are ignited at 550°C in a muffle furnace for 3-4 hrs and cooled. The residue in the crucible is weighed.

\[ \% \text{ Ash} = \frac{\text{Wt. of residue} \times 100}{\text{Wt. of sample}} \]
4.0. SUGGESTED READING


1.0 INTRODUCTION

The word "tea" comes from the Chinese local 'Amoy' dialect word t'e, pronounced "tay". In Cantonese, it becomes ch'a pronounced "Chah". The name travelled in this form to Japan, India, Persia and the USSR. There is a Chinese legend which places the introduction of tea drinking in the reign of the mythological emperor Shen Nung about 2737 B.C., but the earliest credible mention is A.D. 350, where tea was described by Kuo P'o in the ancient Chinese dictionary "Erh Ya". The original area of production was in parts of south-east Asia bordering China, India, Thailand (Siam) and Burma. The cultivation and the use of beverage spread throughout the Japan and the China under the patronage of Buddhist priests, who sought it as a means of combating intemperance.

Tea grows best in tropical and sub-tropical areas where adequate rainfall, good drainage and slightly acid soil prevails. Major tea producing areas in India include Assam, West Bengal, Tamilnadu and Kerala. Tea has traditionally been one of the largest organised agricultural activities and industry in India. It has also been one of the largest foreign exchange earners for the country. Apart from providing large scale employment, it is perhaps the only product in which India has held a dominant share in the world market.

India is world's largest producer, consumer and exporter of black tea. During 1988-89, tea production was estimated at 702.00 million kg (World Production : 2287 million Kg); During the year 1988-89, India exported 209 million Kg of tea (World export ; 975 million kg) worth Rs. 905 crore. It is mainly a labour intensive industry providing employment to over 10 lakh people directly and another 10 lakh indirectly by way of ancillary occupations (Manorama Yearbook, 1990).

Increasing trend towards tea consumption has led to the introduction of a large number of tea brands at competitive rates in the consumer market, all of which employ the same technique for preparing the tea beverage. The technique adopted to make the tea beverage involves the addition of water, milk, tea leaves and sugar, boiling for a certain duration and then filtration. Since in our country, preparing tea is perhaps the most common practice-almost in every household, institutions, commercial and catering establishment and places of common utility and that too unlimited number of times a day, the above mentioned method is a long and cumbersome process and involves lot of time. In addition, the problem is confounded by the fact that there is no standardized product available in the market.
conforming to certain standards, which may even partially meet the large variation in tastes and preferences of the populace across the length and breadth of the country.

Looking to these facts, the importance of a product like tea complete powder can be well understood. It will be a product, which is ready for reconstitution into tea without the burden of assembling all the ingredients for brewing tea, and will also save a lot of precious time. Tea complete powder shall contain all the basic ingredients for brewing namely, milk, tea solids and sugar. This can be very easily reconstituted into tea beverage by the mere addition of hot water and gentle stirring.

Such a product will be highly suitable for use in large scale catering establishments and for meeting the demands of the travelling public. Increasing thrust towards urbanisation of the society has resulted into the introduction of a vast number of packaged foods and ready-to-eat convenience products in flexible packages at competitive rates. Therefore, it will be highly appropriate and timely, in keeping with the requirements of the consumers, that a product like tea complete powder, which is characterized by simplicity and convenience, is developed and technology for large scale manufacture of the product is standardized.

Though, India remains the largest producer of tea in the world, its share in the world market has significantly declined from 32 per cent in 1975 to only 20 percent in the year 1980-90, thereby, significantly reducing the foreign exchange earnings of the country on this account. This declining trend of Indian tea in the international market is attributed to increased domestic consumption as well as, to the lack of value added products. This problem can be effectively tackled in two ways: firstly, by increasing the yield per hectare by adopting improved agricultural practices and secondly, by manufacturing the value added products such as packaged tea, instant tea and tea complete powder. An appropriate low cost technology could be developed, so that a standard product is made available for western markets where convenience food are in great demand. This will certainly help tide the problem of foreign exchange by boosting the country's exports by way of value added products.

The origin of Coffee dates to about 575 A.D., when it was first cultivated by Arabians and was originally consumed as a food in Abyssinia. By the sixteenth century coffee became a popular drink in Egypt, Syria and Turkey. The word "Coffee" is derived from the Turkish pronunciation Kahveh of the Arabian word Gahweh, meaning a bean infusion. Early in the seventeenth century coffee became popular as a beverage and its use spread rapidly. The first coffee plant came up by 1725 in Martinique, West Indies. Later on, there was rapid increase in its cultivation and it gained wide acceptance.

The world production of coffee has reached 5.9 million tonnes for 1986 while in India the figures available for 1984-85 is 195,000 tonnes. Commercial coffee is grown in subtropical climates with altitudes upto 1800 metres. Coffees from different areas of production
possess their own characteristic flavour. Preferred flavours can be obtained by mixing the varieties before or after roasting. The two common varieties are 'Robusta' and 'Arabica'.

The acceptance of coffee is mainly for its stimulating properties due to Caffeine, though, it has no food value unless milk is added. The characteristic aroma of coffee prepared by extraction of soluble components of roasted coffee has its own appeal.

In our country, a large section of people with different income groups consume coffee and the general practice is to prepare a brew of coffee followed by addition of milk and sugar. Presently the use of instant soluble coffee has gained popularity. However, the ready availability of milk or sugar and the cumbersome process of preparing the drink advocates the need for developing instant ready-to-reconstitute formulations.

A ready-to-reconstitute product 'Coffee Complete' was developed at National Dairy Research Institute, Karnal using milk solids and sugar. It was prepared by incorporating soluble coffee in sweetened condensed milk base, but it has a limited shelf life unless stored under refrigeration. Since refrigeration facilities are expensive and inadequate and the cost of packaging in tins is higher, the scope of utilization of such product is limited in India. Manufacture of spray dried milk based coffee powder would drastically affect the intensity of coffee flavour. Moreover, the presence of sugar may also affect physical characteristics of the product.

The development of ready-to-reconstitute formulation in a dehydrated form, which exhibits characteristics as that of traditional coffee would be of great interest in India because of its inherent advantages. It was therefore, proposed to manufacture coffee complete powder by incorporating soluble instant coffee into sugar and whole milk powder. It is a convenient product for use in catering establishments, meeting the demand of the public in particular. The lower storage and transportation costs associated with reduction of weight and volume and longer shelf life of the product will provide additional economic incentives. Also it will serve the purpose of diversification of whole milk powder being produced in bulk.

2.0 SUGGESTED READING

Anon (1977) Food Engg. Int. 2: 44
BITTERNESS IN DAIRY PRODUCTS AND ITS REMOVAL

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1.0 INTRODUCTION

Problem of bitterness is normally encountered in protein rich foods, such as cheese to which proteolytic enzymes have been added as an aid to manufacture. For centuries, cheese making has been the only means of preserving the major constituents of milk. Although bitterness appears in all dairy products, it has been studied most extensively in Cheddar and Gouda cheeses. The cheese making procedure influences extensive bitterness and several other factors such as starter culture strain, rennet concentration, heat treatment given to milk, acidity or pH of cheese and salt concentration.

The native protein (casein as whole or its fractions) do not taste bitter. This is because native proteins possess a convoluted structure, which envelops the bitter portions within its folds. These hydrophobic or potentially bitter portions are inaccessible to the taste buds and hence do not taste bitter. But if proteolytic enzymes break down the same protein then bitterness is produced.

The appearance of bitter flavour during the ripening of cheese has long been found as being attributable to the accumulation of bitter compounds in the peptide fraction. The concentration of the bitter peptides in the cheese must exceed a certain threshold level before bitterness can be detected. The bitter peptides have special chemical properties, which enable them to interact with the taste buds at the back of the tongue to give the sensation of bitterness. Bitterness has long been recognised as a major defect in Gouda and Cheddar Cheeses; it also occurs in Camembert and similar types of cheeses. This defects has also been reported to Swiss mountain cheese, Japanese yeast-ripened cheese, Gorgonzola and Cottage cheese indicating the universality of this problem.

2.0 MECHANISM OF BITTERNESS

The formation of bitterness during hydrolysis of otherwise non-bitter protein molecules can be quantitatively described as follows: In the intact globular protein molecule, majority of the hydrophobic side chains are concealed in the interior and can not, therefore, interact with the taste buds. When the protein is degraded by proteolytic attack, peptides are still able to mask to some extent their hydrophobic side chains by hydrophobic interaction, whereby U-shaped peptides or clusters of peptides are formed. With further hydrolysis more and more hydrophobic side chains become exposed and bitterness increases. The bitterness reaches a maximum, however, because a hydrophobic amino acid exerts its strongest bitterness when both ends are blocked, e.g. by forming peptide linkages (Matoba and Hata, 1972). The bitterness is comparatively weaker when the amino acid is in a terminal position, and weakest when the amino acid is free. Consequently, an extensive hydrolysis usually results in a decreased overall bitterness, which is illustrated by the successful use of exo-
peptidases for debittering casein hydrolysates (Clegg and MacMilan, 1974; Umettsu et al., 1983). Also the initial increase in bitterness has been confirmed experimentally.

As early as in 1959, Czlak postulated a mechanism for the development of bitterness, which involves the combined action of rennet and bacterial proteolytic enzymes. Peptides released by rennet action are considered to be hydrolysed further by “non-bitter strains” of lactic streptococci, whereas “bitter” strains are unable to hydrolyse these peptides, which thus accumulate and cause bitter taste. He further said that accumulation of bitter tasting peptides might be due to increased activity of rennet at low pH levels. Stadhouders (1959) recorded higher bitterness levels with increasing concentrations of rennet employed. The proteolytic activity of starter cultures produce bitterness in cheese. This process breaks down caseins down into peptides of low molecular weight (~1.400 Daltons) with bulky hydrophobic groups towards the C-terminal end of the peptide (Matoba and Hata, 1972).

The key to understanding bitterness lies in the hydrophobicity of the amino acids and the peptides. On the hydrophobicity scale, tryptophan, isoleucine, proline and phenylalanine occupy the highest position while serine, glycine and aspartic acid are the least hydrophobic.

As a sort of thumb rule, Ney (1972) proposed the measurement of the hydrophobicity on the Q-value, which is the free energy required for the transfer of amino acids side chain from ethanol to water. He observed that peptides with a Q-value of +1400 cal/mole or more are bitter while those with a value of +1300 cal/mole or less are non-bitter, while those which lie in the area in between could be either bitter or non-bitter. This was designated as Q-role. This rule could also predict the possibility of a protein hydrolysate being bitter from its amino acid make up.

Amino acids are capable of existing in two enantiomorphic form, viz., the D and L form, of these two the L-form are bitter while D-form are sweet by the same intensity but unfortunately all proteins contain the naturally occurring L form which is bitter.

3.0 SOURCE OF BITTER PEPTIDES IN DAIRY PRODUCTS

The casein fractions and whey proteins, e.g., β -lactoglobulin and α-lactalbumin are the major protein components of bovine milk while the minor protein components consist largely of serum albumin, immunoglobulins and fat globule proteins (McKenzie, 1967). The casein and fat globule proteins are concentrated in curd while whey proteins and other minor protein components are largely lost in whey during the manufacture of cheese. The caseins not only are the major proteins of cheese but they are also more susceptible than the highly structured whey proteins to enzymatic hydrolysis during ripening. Thus, proteolysis in cheese and in most other casein derived peptides can be considered to be synonymous with the degradation of the casein to peptides and amino acids.

αs and k-caseins undergo extensive degradation during cheese ripening. However, the degradation of β -casein appears variable.

3.1 k-casein

The structure of k-casein has not as yet been fully elucidated but its relatively low concentration and amino acid composition (Mckenzie, 1967) would suggest that it would not be an important source of bitter peptides in dairy products.
3.2 $\beta$-casein

The higher content of hydrophobic amino acids in $\beta$-casein would make it a potential source of bitter peptides than $\alpha s$ -casein. Also the higher content of proline in $\beta$-casein would make the peptides more resistant to enzymic degradation. As the C-terminal of $\beta$-casein is known to satisfy the C-terminal requirements for bitterness in a peptide, a single cleavage at any point, say within 20 residues of the C-terminal and of $\beta$-casein would release a bitter peptide. Three bitter peptides, which may have been derived from the C-terminal of $\beta$-casein, are shown in Table 1. It seems reasonable that $\alpha s$, $\beta$-casein and para-k-casein with high average hydrophobicities of 1.17, 1.33 and 1.31 kcal/residue are potential sources of bitter peptides and hydrolysis (Visser, 1977). The C-terminal portion of $\beta$-casein has an extremely bitter taste (Visser et al., 1983; Shinoda et al., 1986) and is a principal source of bitter peptides in Gouda cheese.

<table>
<thead>
<tr>
<th>Probable source</th>
<th>Amino acid sequence</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>s-casein</td>
<td>Phe-Phe-Val-Ala-Pro-Phe-Pro-Glu-Val-Phe-Gly-Lys</td>
<td>Matoba et al., (1970)</td>
</tr>
<tr>
<td>s-casein</td>
<td>Phe-Tyr-Pro-Glu-Leu-Phe</td>
<td>Belitz and Sparrer (1971)</td>
</tr>
<tr>
<td>$\beta$-casein</td>
<td>Gly-Pro-Phe-Pro-Val-lieu</td>
<td>Maloba et al. (1972)</td>
</tr>
<tr>
<td>$\beta$-casein</td>
<td>Arg-Gly-Pro-Phe-lieu-Val</td>
<td>Minumuiira et al. 91972)</td>
</tr>
<tr>
<td>$\beta$-casein</td>
<td>PcA-Gln-Pro-Val-Leu-Gly-Pro-Val-Arg-Gly-Pro-Phe-Pro-lieu-lieu-Val</td>
<td>Gordon and Speck (1965)</td>
</tr>
</tbody>
</table>

Table 1: The amino acid sequence of some bitter peptides isolated from hydrolysates of casein

In a Cheddar cheese, $\beta$-casein is highly resistant to proteolysis, while $\alpha s$, casein is extensively degrade. The main reason for this resistance to proteolysis if the formation of $\beta$-casein polymers that are not readily hydrolyzed (Creamer, 1975). Strains, which produce bitterness in cheese, degrade $\beta$-casein at a faster rate than non-bitter strains (Sullivan and Jago, 1972). Additional evidence favouring $\beta$-casein as the major source of bitter peptides in cheese is the correlation between the effect of salt in inhibiting enzymic hydrolysis of $\beta$-casein but not $\alpha s$ -casein (Fox and Walley, 1971) and in preventing the development of bitterness in cheese (Lawrence and Gillies, 1969). By contrast, the terminals of $\alpha s$, -casein are not conducive to the formation of bitter peptide by a single cleavage and thus cleavage of a bond next to a potentially bitter terminal, involving more extensive hydrolysis of $\alpha s$, -casein, would be required before a bitter peptide could be release.

4.0 STRUCTURE OF BITTER PEPTIDES

All peptides are not bitter, there appears to be a structural requirement for bitterness. Bitterness has been found in peptides ranging in size from 2 to 23 residues. All bitter peptides are lipid soluble or are hydrophobic as shown by their solubility in organic solvents. It was found out by Kirimura et al., (1969) that the most bitter peptides were those which contained lysine or arginine and any other amino acid except glutamate or asparatate. Tryptophane, tyrosine and phenylalanine produced bitterness when combined with other amino acids except themselves, aspartate or glutamate. Valine, leucine or isoleucine produced bitterness when combined both with themselves and with the other residues except aspartate and glutamate.
The frequency distribution of terminal amino acids in bitter peptides isolated from casein has been shown in Fig.3. The total height of histogram gives the relative frequency with which an amino acid appears in a terminal position. The shaded area gave the frequencies as N-terminal and the unshaded as C-terminal. The C-terminal residues illustrated in Fig.3 have the common property of high hydrophobicity while the N-terminal residues show a wide range of hydrophobicity.

5.0 FACTORS LIKELY TO INFLUENCE BITTER OFF-FLAVOUR DEVELOPMENT IN DAIRY PRODUCTS

5.1 Milk quality
Dairy products possessing good flavour and shelf life cannot be made from raw milk of poor organoleptic and bacteriological quality (White et al., 1978). Flavour defects, such as bitterness resulting from the microbial contamination in raw and pasteurized milk can occur at any stage of production and processing (Barbette et al., 1986).

5.2 Psychrotrophic bacteria
These are present in most raw milk supplies and can grow at refrigerated temperature, producing proteolytic and lipolytic enzymes. Lipase acts on triglycerides and produces mono and diglycerides, which give bitter flavour that occasionally accompanies lipolysis. Proteolytic enzymes hydrolyse casein in raw and processed milk and thus cause bitterness problems e.g. *Ps. fluorescens*.

5.3 Pasteurisation treatment
Cheese made from pasteurised milk developed more readily a bitter flavour, a defect more pronounced (in flash pasteurised at 85°C than at 74°C/20-30 S), as by this process more rennet is retained and cheese has greater chances of becoming bitter (Stadhouders and Hup, 1975). The pattern of proteolysis is altered during maturation, consequently there is more intensive breakdown of \( \alpha \) -casein and increased bitterness in Cheddar cheese (Creamer et al., 1985).

5.4 Effect of salt
The average “salt in moisture” level of the non-bitter cheese was considerably greater than that in bitter cheese. Rennet activity is optimal at a salt concentration of 3 per cent. Rennet activity decreased sharply as the concentration of salt was increased to 5 percent (Lawrence and Gilles, 1969).

5.5 Effect of rate of acid production
When the rate of acid production is fat, high acid level is attained rapidly, the pH of cheese becomes low and flavour is sour and bitter (Czulak et al., 1969).

5.6 Effect of moisture
The average moisture level of bitter cheeses was significantly higher than that in non-bitter cheeses at all pH levels. The increased moisture level (free water) might facilitate the proteolytic activity of both the rennet and the starter.

5.7 Effect of rennet
A decrease in rennet concentration caused a significant decrease in the intensity of bitterness but low amounts of rennet resulted in softer coagulum from which the whey was hard to expel. According to Stadhouders (1962), three main factors control the concentration of rennet in cheese.

- Quantity of rennet used in cheese making.
- The manner in which curd is washed and dried (with short drying and washing times, more rennet remains in cheese).
- pH of milk and curd during cheese making when the pH of curd is much below the normal pH of milk (6.5-6.6), the casein contains more rennet which is then found in larger quantity in the cheese.

5.8 Bitter and non-bitter strains

The starter plays the most important role in bitterness. Cheese was seldom bitter when non-bitter strains were used as starter, regardless of the amount of rennet, salt or moisture present or the rate of acid production in curd or final pH of cheese. However, when bitter strains were used, the cheese was invariably bitter except when salt to moisture (S/M) level and the pH of cheese were relatively high. Bitterness of cheese manufactured with bitter strains was directly proportional to the among of rennet used. Bitter strains grow rapidly under normal cheese making conditions and reach high populations in cheese curd prior to salting. On the other hand, the multiplication of non-bitter strains is inhibited at the normal cooking temperature in cheese making. Strains that produced bitter cheese hydrolysed bitter-tasting peptides less extensively than strains that produced non-bitter cheese. Gordonand Speck (1965) showed that bitter starters produce bitter compounds from casein in absence of rennet but that non-bitter strains cannot.

5.9 Acidity or pH of cheese

Excessive acid production by cultures used as starters is associated with bitterness. Czulak (1959) found bitter flavour most frequently in Cheddar cheese having a pH value of less than 5.0 in first week, Cheese from “fast acid” vats have a low pH, a sour and bitter flavour, a crumbly body and pale colour.

6.0 REDUCTION OF BITTERNESS IN CHEESE DEBITTERING

6.1 Starter pairing

Pairing off “bitter” starters with”non-bitter” starters markedly reduces bitterness in Cheddar (Lawrence and Pearce, 1968) and Gouda (Visser, 1977) Cheese making. Level of bitterness decreased as the proportion of non-bitter strains in the starter culture increased. Combining a bitter and a non-bitter strain made non-bitter cheese in suitable proportions as starter in the vat. this can be explained by the dilution effect on the bitter starter by the non-bitter starter.

6.2 Exopeptides

Incidence of bitterness was also noticed when rennet substitutes were used. The action of exopetidase from microbial rennets may help in preventing the occurrence of bitterness and in accelerating cheese ripening process (Malkki et al., 1978). Bitterness was absent and ripening process enhanced when peptidases from Pseudomonas fluorescens VTTE 87 was used in cheddar cheeses made with calf rennet. Wheat carboxypeptidase can also be used for de-bittering purposes. It acts on the bitter peptides and releases hydrophobic amino acids from
their carboxyl terminal followed by a decrease in bitterness. Wheat carboxypeptidase may be useful for debittering protein hydrolysates in food application (Umetsu et al., 1983).

6.3 Controls during production

Control of bitterness in cheese, therefore, hinges on keeping the concentration of bitter peptides below threshold level for bitter taste either by decreasing the rate of formation of bitter peptides, and/or by increasing the rate of their degradation to non-bitter products (Jago, 1974). In practice, control of bitterness in cheese can be achieved by combination of methods which include:

- Limitation of the starter cell population
- Maintenance of high S/M levels
- Starter pairing
- Alteration of the starter culture
- Avoidance of the use of excess rennet

6.4 Debittering by addition of chemicals

This method was tried by Tamura et al. (1990) on some model peptides, e.g. Argenyl-prolyl-phenylalanine (Arg-Pro-Phe-Phe), Phenylalanyl-phenylalanine (Phe-Phe) and valyl-valyl-valine (val-val-val) also have different bitter potency. Several substances for effective debittering were used, most of them being commonly used for nutrition.

6.4.1 α-Cyclodextrin: Cyclodextrin was selected to wrap the hydrophobic functions of bitter amino acids and reduce bitterness. They are also reported to be useful in removing the bitterness of citrus fruit juice. A large excess of α-cyclodextrin was necessary to reduce bitterness of the peptides.

6.4.2 Starch: Starch was selected as another sugar polymer because it covers the bitter compounds with its “net structure” and to prevent them from reaching the bitter taste receptor sites but for this the mixture of starch and the bitter samples is to be heated at 100°C overnight before the resultant solids were re-dissolved in water and tasted.

6.4.3 Skim milk, protein and casein hydrolysate: These materials are composed of amino acids or in other words are “peptide compounds”. Due to the affinity between proteins and amino acids or peptides, these proteins and protein hydrolysates were effective to decrease the bitterness as expected.

6.4.4 Fatty substances: creaming powder, margarine, vegetable oil: Creaming powder is the most effective. They are effective to reduce the bitterness because of their affinity to hydrophobic compounds and thus forms an emulsion to wrap bitter amino acids or peptides.

6.4.5 Acidic amino acids: Acidic amino acids like Aspartic acid, glutamic acid and taurine were used to mask bitterness. An excess quantity of these, are to be used to reduce bitterness.
These debittering methods might be applicable to the practical debittering of fermented products and additives for nutrition and medication.

7.0 CONCLUSION

- Bitter peptides have certain characteristic properties of which hydrophobicity and the nature of the terminal residues (particularly the C-terminal residue) appear to be most important.
- β-casein (particularly the C-terminal sequence of β-casein) appears to be major source of the bitter peptides formed in dairy products by the action of rennet and bacterial proteinases. The degradation of β-casein appears to be greater in the presence of bitter than in non-bitter strains.
- Salt concentration, pH, type of coagulating enzyme and strain of starter are important factors in controlling the release of bitter peptides from β-casein.
- The level of bitterness in cultured dairy products would be determined finally by the relative activities of the proteinases and peptidases present.
- The production of bitter compounds during enzymatic hydrolysis could be reduced by changing the enzymes and/or conditions of the reactions, removing the bitter peptides by extraction or absorption, by modifying the structure of bitter peptides, mixing with additive.

8.0 SUGGESTED READING

1.0 INTRODUCTION

Last century witnessed a wide array of development in the area of food science. Although, during initial stages focus of attention was towards developing the effective preservation technologies or systems. In the later part, there were revitalised interests among consumers about the nutritional and therapeutic aspects of food they eat. This led to shifted attention to explore the missing linkage between the food we eat and our health. Besides moving towards a world of medicine for every little disturbance related to health, there is a basic temptation in human being towards the nature and the products that are natural. All these developments have resulted in the increasing number of potential nutritional products with medicinal and health benefits, termed as “functional foods”.

Functional foods, designer foods, pharmafoods and neutraceuticals are synonyms for foods that can prevent and treat diseases. Moreover, nutritional significance of plant molecules is well documented and increasing cases of cancers, coronary heart diseases, diabetes and many other chronic diseases, have been attributed to under consumption of fruits and vegetables in our diet. But beyond these known nutrients i.e. vitamins, fibers, plants have clearly more to offer. And scientists are scurrying to discover exactly which plant components might fend off specific diseases. An ever-expanding array of previously unknown plant molecules with hard to pronounce names is being uncovered. But there exact metabolic role and how these can be utilized in designer food, need to be clarified.

All over world there has been growing demand for functional foods. Currently Japan leads the world in the production, with more than 100 production and consumption of such products.

2.1 Defining Functional foods and Photochemical

The term functional foods was first introduced in Japan in the mid-1980s and refers to processed foods containing ingredients that aid specifically bodily functions in addition to being nutritious. To date, Japan is the only country that has formulated a specific regulatory approval for functional foods, known as foods for specific health use (FOSHU). Currently 100 products are licensed as FOSHU foods in Japan. In US, the Functional foods category is not recognized legally. However, The Institute of Medicine's Food and Nutrition Board (IOM/FNB, 1994), defined functional foods as “any food or food ingredient that may provide a health benefit beyond the traditional nutrients it contains”. To qualify as functional food, it should meet following three highlighted conditions:-
• It is a food (not capsule, tablet or powder) derived from naturally occurring ingredients.
• It can and should be consumed as part of daily diet.
• It has particular when ingested, serving to regulate a particular body process. Such as
  - Improvement of biological defence mechanisms
  - Prevention of specific disease.
  - Recovery from specific disease
  - Control of mental and physical conditions
  - Retarding the ageing process

“Phytochemicals”- phyto from Greek word for plants, denoting their plant origins. Most likely phytochemicals developed as a part of the plants own defense mechanism against environmental insult and only fortuitously provide benefits to man.

The number of identified physiologically has increased dramatically in the last decades and overwhelming evidence from epidemiological, in vivo, in vitro and clinical trial indicate that plant rich diet can reduce the risk of certain chronic diseases (Hasler, 1998) Health professionals are gradually recognizing the role of phytochemicals in health improvement.

2.0 POTENTIAL PHYTO-NUTRIENTS

Some phytochemicals with proven health benefits can be grouped under following categories.

2.1 Isoflavones

Soy has been in the spotlight as “wonder bean”, not only for its quality protein, but also because of recently identified preventive and therapeutic molecules that can prevent cancer, coronary vascular diseases(CVD), osteoporosis and certain other disorders. Besides isoflavones, soybean also contains saponins, phytic acid, phytosterol. Among all these molecules isoflavones have been thoroughly studied and it contain genestein and diadzein, which are heterrocyclic phenols structurally similar to oestrogenic steroids and are termed as phytooestrogens. These compounds either compete with or antagonize estrdiol action. Exact biochemical mechanism involving CYP3A monoxygenase activity in presence of phase I enzyme inducers such as dimexamethane, on carcinogens was explained by Ronis et al. In another study dietary soy products, showed antitumer activity, by directly affecting the tumor cell proliferation and reduction in tumor angiogenesis (microvesSEL density). This activity may prevent prostrate cancer.

Research has shown that diets rich in soya help to reduce blood levels of LDL (bad) cholesterol by an estimate of 12-15%. The isoflavones in soy foods are converted in the gut to phytoestrogens that may reduce LDL blood cholesterol. The health effect of these compounds depend upon the exposure level of phytoestrogens, the binding constant relative to estradiol and the selectivity of different tissue receptors.

3.0 ORGANOSULFUR COMPOUDS

Termed as “promise of garlic” and most widely quoted herb in the literature. Besides its popularity as a recipe seasoning, garlic has long been promoted as a medicinal agent. Garlic and
other allium vegetables – onions, chives, leeks and scallions contain allylic sulphides. The purported health benefits of alliums are numerous including cancer, chemopreventive, antibiotic, antihypertensive and cholesterol lowering properties (Srivstava et al., 1995). Active components identified is a family of thioallyll compounds and the intact garlic bulb contain an odorless amino acid called alliin, which is converted enzymatically by allinase into allicin, when the garlic cloves are crushed. Formation of allicin is responsible for characteristic garlic flavour. Allicin then immediately decomposes to form numerous sulphur-containing compounds. These organosulphur compounds exhibit anti-oxidative function, decrease metabolic activation of carcinogens and adduct binding to DNA, and thus prevent cancer of gastrointenal tract. It has role in prevention of CVD possibly through antihypertensive properties. Animal feeding studies demonstrated the regulation of fatty acid and cholesterol synthesis via modulating. The role of certain enzymes, by garlic components. However, it is still unclear which component of garlic is responsible for cholesterol lowering effect.

Organosulphur compounds also show antithrombosis, anti-adhesion and antiprolific effects as well. Aged garlic extract and its active compounds SAC (S-allyl cysteine) and SAMC (S-allyl mercaptocysteine) have been demonstrated to have an antiplatelet adhesion effect and ultimately it prevents initiation of atherosclerotic process.

4.0 GLUCOSINOLATES

Cruciferous vegetables comprising cauliflower, broccoli, cabbage, Brussels sprout contain relatively high content of glucosinolates, a potent anticarcinogen. Glucosinolates are a group of glycosides stored within cell vacuoles of all cruciferous vegetables. Myrosinase, an enzyme found in plant cell, catalyze these compounds to a variety of hydrolysis products, including isothiocynates and in doles. Diindolylmethane (DIM), indole-3-carbinol (I3C), phenethly isothiocynate (PEITC) and sulphoraphane seems to be promising chemo preventive molecules, in brassica plants (Zeligs, M.A.). In addition to the induction of phase I and II xenobiotic metabolizing enzymes resulting in the inhibition of the oxidative activation of carcinogens. I3C may reduce cancer risk by modulating estrogen metabolism. The C-16 and C-2 hydroxylations of estrogens involve competing cytochrome P-450-dependent pathways, each sharing a common estrogen substrate pool. Studies indicate that the increased formation of 2-hydroxylated estrogen metabolites relative to 16-hydroxylated forms, may protect against cancer. Another isothiocynate isolated from broccoli and termed as sulforphane has been shown to be the principal inducers of a particular type of phase-II enzyme, quinone reductage.

Delaquis and Mazza (1995) have reviewed the antimicrobial properties of isothiocynates and their potential application in processed foods.

5.0 CAROTENOIDS AND FLAVONOIDS

Consumption of B-carotene rich fruits and vegetables, has since long been known to prevent certain diseases like cataract. More recent studies have promoted their role in caner, and CVD prevention primarily owing to their anti-oxidative properties.
Carotenoids, C-40 polyisoprenoid structure with an extensive conjugated double bond system. Of the 600 or so carotenoids that have been identified, about 50 serve as precursors for vitamin A. The most researched among them are B-carotene & lycopene. These carotenoids inhibit the oxidation of LDL to its atherogenic form. Lycopene’s ability to act as an anti-oxidant and scavenger of free radicals that are often associated with carcinogenesis is potentially a key for mechanism for its beneficial effects on human health. (Khachik et al., 1995). Lycopene may prevent carcinogenesis and athrogenesis by interfering passively with oxidative damage to DNA & lipoproteins. Lycopene is the most effective quencher of singlet oxygen in biological system.

Flavonoids are polyphenolic compounds and originally regarded as nutritionally inert, these is new increasing interest in the apparent anticarcinogenic properties of certain flavonoids, although exact biochemical mechanisms is not clear. A great deal of attention has been directed to the polyphenolic constituents of tea, particularly green tea. Catechins are the predominant and most significant of all tea polyphenols. The four major green tea catchins are epigallocatechin-3-gallate, epigallocatechin, epicatechin-3-gallate and epicatechin.

However, epidemiological studies are inconclusive, on the other side research findings in laboratory animals clearly support a cancer chemopreventive effect of tea components. Other flavonoids, with promising health stimulating effects include quercetin, kaempferol, myricetin, apigenin and luteolin. Source of these compounds are choclate, coca, fruit juices, nuts, red wine, raspberry, blackberry and citrus fruits.

6.0 B-GLUCAN

B-glucan is an water soluble fibre, found in oat, legumes and some other grains and may be helpful in diabetes control by delaying stomach emptying and slowing glucose absorption in small intestine. There is now significant scientific agreement at consumption of this particular plant food can reduce total and low density lipoprotein (LDL) cholesterol, thereby reducting the risk of CHD. B-glucan like water soluble fibers, increase the excretion of sterol and bind bile salts and neutral sterols and thus enhance their removal from the body. Consumption of these fibers relive many gastrointestinal problems like constipation. Correlation between high fiber diet and reduce risk of colon cancer is well known.

7.0 OLIGOSACCHARIDES

Oligosaccharides were initially developed to replace sucrose from various processed foods, but the physiological effect of these sugars on human being, differ considerably from sucrose. Now these oligsaccharides are designated as ‘Prebiotics’. Oligosaccharides being non digestable escape the action of enzymes present in stomach and small intestine and reach to large intestenine. Native microflora of large intestine, metabolize these carbohydrates and produce short chain fatty acids, resulting in decrease in the pH. Low pH of intestine adversely affect the growth of harmful bacteria, where as favours the proliferation of beneficial microflora including Bifidobacterium and lactic acid bacteria. These bacteria produce certain nitrogenous compounds that help in the elimination of carcinogens. Oligosaccharides also improve immune response and regulate serum cholesterol level. Oligosacchride include, fructo-oligosaccharides,
Phytochemicals

Soyoligosaccharides consisting of raffinose & stachyose, xylooligosaccharides, are commercially available.

8.0 OTHER PHYTOCHEMICALS

There are certain other compounds present in plant foods, with significant health promoting effect include plant fatty acids, tocotrienols, phenolic derivatives and dietary fibers etc. Docosahexaenoic acid (DHA), which is one of the most important structural component of brain and retina, and denovosynthesis of this compound is very rare. The decline in DHA intake could have serious implications for public health, since low plasma, DHA concentrations have been correlated with increased incidence of number of important chronic diseases such as depression, attention deficit disorders and Alzheimer’s dementia. Cryptothecodium cohmii strain of marine algae is used for the commercial production of DHA rich oil. Spirulina, termed as wonder alga is one of riches source of omeg-3-fatty acids, quality protein and many other therapeutic molecules.

9.0 PROMISING FUNCTIONAL FOODS WITH PHYTOCHEMICALS

Nutrients dense foods that provides benefits beyond basic nutrition have been already developed and commercially available. Such foods can be defined as “An accepted and tolerable food that has natural, naturally concentrated photochemical derived from fruits and vegetables or related food ingredients that a) indicated to be epidemiologically important in disease prevention, b) have shown to be useful in preventing cancer or other chronic diseases in animal bioassays, c)are unique in structure, class, pattern and metabolism. The concept of fortification is not new and some new formulations based on phytochemicals are discussed here:

10.0 FUNCTIONAL DRINKS

Most energy drinks fall into the functional foods or nutraceutical – classification. They got their start in U.S., but they are rapidly moving into the mainstream as a result of growing consumer interest in natural remedies (Hollingsworth, 1997). In fact, the beverage market is on the cutting edge in functional food development. Energy drinks, isotonic (spare) beverages, herbal and green teas, fortified waters, smart drugs, caffeinated drinks and fringe.

Beverages are relatively cheap to blend, fortified, bottle and distribute. These beverages are making inroads in the conventional drink market, currently dominated by aerated synthetic beverages. Soluble fiber containing beverages are already available. Tea and coffee, constituents can be incorporated into new formulations with other phytochemical to develop herbal drinks.

Recently the anti-oxidants or free radical scavenging ability of ascorbic acid, B-carotene lycopene, trocalnenols has been promoted (Giese, 1995). Free radicals are formed by autoxidation, photosensitization, enzymatic reactions and due to pollutants.

Some of the fruits and vegetables more important ones from beverage formulation standpoint include licorice, ginger, tea, citrus, carrots, tomatoes berries, mint and other herbs and
spices. These have been much interest in developing beverages, which contain these types of compounds.

11.0 DAIRY PRODUCTS

Probiotic cultures in fermented dairy products, have multifunctional role. In recent years, yogurts with oligosaccharides have been developed. These cultured dairy products may also incorporate, isoflavones of soy protein, B-glucan of oat, carotenoids and flavoroids of certain fruits in their formulation. Blackberry and raspberry as fruits or their extracts added in ice creams, dairy drinks, frozen desserts, not only as flavouring component, but also as source of anthocyanins and other phenotic derivatives. Similarly imitation dairy products may also include omega-3-fatty acids from flax seed oil and DHA from algae. Some infant formula have already available in market containing DHA. Dairy analogue, primarily based on soy milk, may be modified to increase the level of phytoestrogens, particularly isoflavones.

12.0 CONFECTIONARY ITEMS

Bars either based on fruits or on cereals may serve as vehicle of phytonutrients. Commercially wide variety of nutritional bars has been developed for specific purpose. These bars can be enriched with fibers, anti-oxidants, phenolic substances, ant proteins, glucosinolates, in them. Oat bar, based on soluble oat fibers. Also contain omega-3-fatty acids to further strengthen its heart health image. Fruit preserves, fruit spreads, have been developed, using traditional herbs and products were further enriched by adding other phytonutrients. Encapsulation technology offers the product developer a new tool in protecting sensitive and expensive nutrients. A coated candy confectionary was patented in USA. The product has a soft candy center with 5-40% (w/w) water. Two coating was applied to the product, first one as moisture barrier and second one was used as a carrier for a number of additional ingredients, including vitamins, enzymes, phytochemicals and vegetable extracts.

Chocolate considered as a culprit for CHD, obesity and dental problems, also moves into healthy arena. The chocolate has neutral effect on cholesterol levels, low level of coiffein, as compared to beverages, anti-oxidant activity of polyphenols, potential benefit of procyanidins and epicatechins on CVD. Replacement of a part of cocoa butter with PUFA; may further improve nutritional quality of chocolates.

13.0 BREAKFAST CEREALS

Shukla (1993) has discussed the possibility of developing high nutrition breakfast cereals containing disease preventing phytochemicals e.g. flavonoids and antioxidants etc. Raspberries and blackberries, reservoir of phytonutrients are considered as good option available for cereal product formulations. Initial studies conducted with DHA in bread are encouraging. Likewise, breads with garlic compounds and isothiocynates of cruciferous vegetables are prospective options. Soy flour is already important ingredient in bread, not only because of its nutritional significance, but excellent functional properties it impart.
14.0 MEAT PRODUCTS

Soy based meat analogues, had clicked the market in early 70’s. Texturizing properties of soy proteins, has offered the opportunity to develop a number of meat analogues. Addition of oat gum to meat patties resulted in decreased cooking loss. A comminuted beef product was developed that would have nutraceutical properties, exhibit resistance to rancidity and possess improved water holding capacity and cooking yield.

15.0 SAFETY ISSUES

The optimal levels of the majority of the biologically active components currently under investigation have yet to be determined. In addition, a number of animal studies show that some of the same phytochemicals (e.g. allyl isothiocynate) highlighted in this review for their cancer-preventing properties have been shown to be carcinogenic at high concentrations (Ames et al., 1990).

The benefits and risks to individuals and populations as a whole must be weighed carefully when considering the widespread use of physiologically-active functional foods. For example, what are the risks of recommending the increased intake of compounds (e.g. isoflavones) that may modulate estrogen metabolism? Soy phytoestrogens may represent a “double-edged sword” because of reports that genistein may actually promote certain types of tumors in animals (Rao et al., 1997). Knowledge of toxicity of functional food components is crucial to decrease the risk:benefit ratio.

16.0 CONCLUSION

Mounting evidence supports the observation that functional foods containing physiologically-active components, either from plant or animal sources, may enhance health. It should be stressed, however, that functional foods are not a magic bullet or universal panacea for poor health habits. There are no “good” or “bad” foods, but there are good or bad diets. Moreover, diet is only one component of an overall life-style that can have an impact on health; other components include smoking, physical activity, and stress.

Health-conscious consumers are increasingly seeking functional foods in an effort to control their own health and well-being. The field of functional food, however, is in its infancy. Claims about health benefits of functional foods must be based on sound scientific criteria.
ROLE OF STABILIZERS AND EMULSIFIERS IN FORMULATED FOODS

J.S. Sindhu,
Sr. Scientist
Dairy Chemistry Division
NDRI, Karnal 132 001

1.0 INTRODUCTION

The majority of formulated foods are complex, multiphase systems, which consists water, oil or fat, proteins and both simple and complex carbohydrates. Additionally, they may be frozen or whipped and therefore, contain ice crystals and air or other gases. Not only these foods are complex from a physico-chemical point of view, but also the degree of abuse they undergo during processing, shipping and storage. The shelf life expectations for these products add greatly to their complexity and to the difficult job of holding them together. The ingredients, which are used to perform this task, are called stabilizers and emulsifiers. Although their combined usages level is often less than 0.5 percent of the products weight, the function they perform, make them more important than ingredients at ten or even twenty times this level.

2.0 STABILIZERS

The term as it applies to the food industry, refers to a group of substances all of colloidal dimensions, having a great affinity for water and hence, called hydrocolloids or emulsoids. In the widest sense, a food stabilizer is any material that extends the useful storage life of a food product to which it has been added or a food stabilizer is a material, which reduces the rate at which a few types of physical changes occur within the food during storage, transport and normal handling. Stabilizers in this context are materials, which prevent or retard any of the following processes.

- Crystallization, usually of water or sugar.
- Gravitational sedimentation of suspended particles, including creaming of emulsion droplets and rise of gas bubbles.
- Encounter between particle droplets or bubbles in a fluid medium.
- Flocculation, coagulation or coalescence of dispersed moieties, which do happen to encounter each other.
- Disaggregation of aggregates.
- Uptake or loss of small molecules or ions, either via., changes in the chemical potential of the dissolved ion or molecule or by forming an impermeable film.
- Synersis in gels.

2.1 FUNCTIONS OF STABILIZERS IN FOODS

In addition to the following functions which the food formulator has uppermost in his mind when he decides to add a stabilizer to his formulations) listed in Table 1., the addition of a stabilizer will have other more subtle effects on the consumer's preception and these may be significant enough to determine the choice of an optimum stabilizer. Some of these functions are inhibition of oxidation, controlled flavour release, enhancement of flavour...
through increasing the vapour pressure of water-soluble aroma volatiles by immobilization of water, reduction of sweetness by decreasing the diffusion rate of the sugar as a function of viscosity. In a similar manner, stabilizer inhibits the diffusion rate of salts acids and buffering agents leading to an improvement in flavour profile.

**Table 1. Functions of stabilizers in Food Products.**

<table>
<thead>
<tr>
<th>Function</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adhesive</td>
<td>bakery Glaze</td>
</tr>
<tr>
<td>Binding Agent</td>
<td>Sausage</td>
</tr>
<tr>
<td>Bulking agent</td>
<td>Dietetic foods</td>
</tr>
<tr>
<td>Crystallization inhibition</td>
<td>Ice-cream, sugar syrups</td>
</tr>
<tr>
<td>Clarifying agent</td>
<td>Beer, Wine</td>
</tr>
<tr>
<td>Clouding agent</td>
<td>Fruit Juice</td>
</tr>
<tr>
<td>Coating agent</td>
<td>Confectionery</td>
</tr>
<tr>
<td>Emulsifier</td>
<td>Salad dressings</td>
</tr>
<tr>
<td>Encapsulating agent</td>
<td>Powder-fixed flavours</td>
</tr>
<tr>
<td>Film former</td>
<td>Sausage, Protective coatings</td>
</tr>
<tr>
<td>Flocculating agent</td>
<td>Wine</td>
</tr>
<tr>
<td>Foam stabilizer</td>
<td>Whipped Toppings</td>
</tr>
<tr>
<td>Gelling agent</td>
<td>Puddings, deserts, aspics mouses</td>
</tr>
<tr>
<td>Mold release agent</td>
<td>Gum drops, Jelly candies</td>
</tr>
<tr>
<td>Protective colloid</td>
<td>Flavour emulsions</td>
</tr>
<tr>
<td>Stabilizer</td>
<td>Beer, mayonnaise</td>
</tr>
<tr>
<td>Suspending agent</td>
<td>Chocolate milk</td>
</tr>
<tr>
<td>Swelling agent</td>
<td>Processed meats</td>
</tr>
<tr>
<td>Synersis inhibition</td>
<td>Cheese, Frozen meats</td>
</tr>
<tr>
<td>Thickening agent</td>
<td>Jams, Pie Fillings, sauces, gravies</td>
</tr>
<tr>
<td>Whipping agent</td>
<td>Topping, icings</td>
</tr>
</tbody>
</table>

**2.2 CLASSIFICATION OF STABILIZERS**

Stabilizers can be classified on the basis of:

i) Source (natural/ semi synthetic/ synthetic).
ii) Chemical nature (polysaccharides/ Proteins)
iii) Ionisation (anionic/ cationic/ non-ionic)
iv) Gelling behaviour (Gelling/ thickening agent)
v) Stabilization (Whether stabilize the protein or not)

A general type of classification of stabilizer is given below.

I. Natural stabilizers

<table>
<thead>
<tr>
<th>Origin</th>
<th>Plant origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural</td>
<td>d) Cereal Gum</td>
</tr>
<tr>
<td></td>
<td>Starch</td>
</tr>
<tr>
<td></td>
<td>Corn Hull</td>
</tr>
<tr>
<td></td>
<td>e) Plant extract</td>
</tr>
<tr>
<td></td>
<td>Pectin</td>
</tr>
<tr>
<td></td>
<td>Arabinogalactan</td>
</tr>
<tr>
<td></td>
<td>d) Plant Exud</td>
</tr>
<tr>
<td></td>
<td>Gum arabic</td>
</tr>
<tr>
<td></td>
<td>Gum Tragacanth</td>
</tr>
<tr>
<td></td>
<td>Gum Karaya</td>
</tr>
<tr>
<td></td>
<td>Gum Ghatti</td>
</tr>
<tr>
<td></td>
<td>b) Sea Weed Extracts</td>
</tr>
<tr>
<td></td>
<td>Agar</td>
</tr>
<tr>
<td></td>
<td>Alginate</td>
</tr>
<tr>
<td></td>
<td>Carrageenan</td>
</tr>
<tr>
<td></td>
<td>Furcellaran</td>
</tr>
<tr>
<td></td>
<td>c) Plant Seed Gums</td>
</tr>
<tr>
<td></td>
<td>Guar gum</td>
</tr>
<tr>
<td></td>
<td>Locust bean gum</td>
</tr>
<tr>
<td></td>
<td>Psyllium gum</td>
</tr>
<tr>
<td></td>
<td>Quince gum</td>
</tr>
<tr>
<td></td>
<td>Tamarind gum</td>
</tr>
<tr>
<td></td>
<td>(ii) Microbial origin</td>
</tr>
<tr>
<td></td>
<td>Dextran</td>
</tr>
<tr>
<td></td>
<td>Xanthan</td>
</tr>
<tr>
<td></td>
<td>Curdlan</td>
</tr>
<tr>
<td></td>
<td>Gellan</td>
</tr>
<tr>
<td></td>
<td>(iii) Animal Origin</td>
</tr>
<tr>
<td></td>
<td>Gelatin</td>
</tr>
<tr>
<td></td>
<td>Caseins</td>
</tr>
<tr>
<td></td>
<td>Albumins</td>
</tr>
</tbody>
</table>

II. Semi-synthetic or Modified stabilizers

<table>
<thead>
<tr>
<th>Derivative</th>
<th>Cellulose derivatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microcrystalline</td>
<td>Microcrystalline cellulose (Avicel)</td>
</tr>
<tr>
<td></td>
<td>Methyl cellulose (Methocel-MC)</td>
</tr>
<tr>
<td></td>
<td>Hydroxy methyl cellulose (Methocel-HG)</td>
</tr>
<tr>
<td></td>
<td>Sodium carboxymethyl cellulose (CMC)</td>
</tr>
<tr>
<td></td>
<td>Hydroxy ethyl cellulose (Natsol-250)</td>
</tr>
<tr>
<td></td>
<td>Ethyl hydroxyethyl cellulose (Natrosol-25)</td>
</tr>
<tr>
<td></td>
<td>Carboxy methyl hydroxy ethyl cellulose (CMHEC)</td>
</tr>
</tbody>
</table>

(ii) Modified starch

(iii) Low methoxyl pectin

(iv) Propylene glycol alginate

III. Synthetic or Man made stabilizers

<table>
<thead>
<tr>
<th>Stabilizer</th>
<th>Polyvinyl pyrrolidone (PVP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(ii)</td>
<td>Carboxy vinyl polymer (corbopol)</td>
</tr>
<tr>
<td>(iii)</td>
<td>Ethylene oxide polymer (Polyox)</td>
</tr>
</tbody>
</table>
2.3 CRITERIA FOR SELECTION OF AN APPROPRIATE STABILIZER FOR FOOD PRODUCTS

While selecting an appropriate type of stabilizer or a blend of stabilizers, the following criteria should be considered:

(i) *Ease of incorporation*: For ease of incorporation the stabilizer must dissolve quickly and completely in the cold water or in the aqueous food system. It may be added at any stage of processing, it must not cause to much increase in the viscosity to make the handling of the product difficult and should not require any preliminary processing and must enable the preparation of a concentrate solution (10-12 %).

(ii) *Ease of availability*: The stabilizers must be easily available in the local market.

(iii) *Cost effectiveness*: The stabilizer must not add too much to the cost of production, therefore, it must be cheaper.

(iv) *Higher efficiency*: On weight/weight basis lesser amount of the stabilizer must give the same desired effect.

(v) It must not impart cloudy appearance, off-flavour or undesired colour to the product and should not induce undesirable effects such as, oxidation of fat or microbial load.

(vi) The legal position on the use of a stabilizer must be kept in mind.

(vii) Ionic strength, pH and conditions of the food system must be kept in mind while selecting a stabilizer.

(viii) Objective of addition of the stabilizer to a particular food must be considered before selecting the appropriate stabilizer.

Table 2. Cost of various stabilizers

<table>
<thead>
<tr>
<th>Stabilizer</th>
<th>Cost (in $)</th>
<th>Stabilizer</th>
<th>Cost (in $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agar</td>
<td>6.80-7.00</td>
<td>Karaya gum</td>
<td>2.1</td>
</tr>
<tr>
<td>Alginate</td>
<td>3.50-4.50</td>
<td>Locust bean gum</td>
<td>2.1</td>
</tr>
<tr>
<td>Arabic</td>
<td>1.2</td>
<td>Pectin</td>
<td>3.3</td>
</tr>
<tr>
<td>Carrageenan</td>
<td>2.30-6.0</td>
<td>Low methoxyl pectin</td>
<td>4.75-5.0</td>
</tr>
<tr>
<td>CMC</td>
<td>1.60-2.0</td>
<td>Propylene glycol alginate</td>
<td>4.90-5.40</td>
</tr>
<tr>
<td>HPC</td>
<td>3.00-3.75</td>
<td>Starch</td>
<td>0.21</td>
</tr>
<tr>
<td>MC</td>
<td>3</td>
<td>Modified Starch</td>
<td>0.6</td>
</tr>
<tr>
<td>Avicel</td>
<td>1.75-1.95</td>
<td>Tragacanth</td>
<td>12.0-16.0</td>
</tr>
<tr>
<td>Gelatin</td>
<td>2</td>
<td>Xanthan</td>
<td>6</td>
</tr>
<tr>
<td>Guargum</td>
<td>0.45-0.50</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 2.4 CHARACTERISTICS OF SOME COMMON STABILIZERS

<table>
<thead>
<tr>
<th>Stabilizer</th>
<th>Source</th>
<th>Properties</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gum Arabic</td>
<td>A gummy exudation obtained from various species of trees of <em>Accacia sp</em> distributed over Africa, India and Australia</td>
<td>A neutral or slightly acidic salt of a complex polysaccharide and Ca(^{2+}), Mg(^{2+}) or K(^{+}) ions, not suitable, where high viscosity or great thickening properties are required. There is one exception that its use in dietetic foods where the bulk and texture of sugar could be reduced very effectively.</td>
<td>Caramels, toffees, chewing gums and cough drops, &amp; dietetic foods.</td>
</tr>
<tr>
<td>Gum Karaya</td>
<td>A dried exudate of the <em>Stercul urens</em> tree, which is widespread in India.</td>
<td>Does not dissolve in water to give a clear solution, but absorb water rapidly to form viscous colloidal solutions. On heating, its dispersions lead to a decrease in its viscosity but an increase in solubility, the pH of its dispersion is 4.5-4.7.</td>
<td>Cheese spread, whipped cream, breakfast cream &amp; meat products.</td>
</tr>
<tr>
<td>Agar</td>
<td>Extracted from a seaweed <em>Gelidium cartilaginum</em>, mostly found in Japan.</td>
<td>Insoluble in cold water, but soluble in boiling water to give a clear solution. A 1.5 percent solution on cooling to 32-39°C forms a firm, rigid gel that does not melt below 85°C, its gel withstand a very high temperature.</td>
<td>Salad dressings, dietetic foods, bakery products and beer.</td>
</tr>
<tr>
<td>Alginate</td>
<td>Extracted and isolated from brown algae <em>(Macrosystis pyrifera, Laminaria digitata, Asphophyllum sps.)</em></td>
<td>Possesses good water holding capacity, produces excellent texture, requires no preliminary processing, economical compared to other stabilizers, prevents the churning or clumping of fat globules during freezing and whipping.</td>
<td>Milk puddings, toppings, ice-cream, processed cheese, whipping cream, chocolate milk.</td>
</tr>
<tr>
<td>Carrageenan</td>
<td>Extract of the red algal seaweed sp. <em>(Condruis crispus, Gigartina manilosa, Gigartina stellata)</em></td>
<td>Small amount is required to give the same desired effect, tabilizes the protein hence, prevent the separation of curd and whey during freezing and whipping of the product, repeated freezing and thawing have no adverse effect, rather its efficiency is increased, hence is capable in preventing the heat shock, affected by pH and ionic strength of the system.</td>
<td>Ice-cream, milk custards, pie filling, puddings, cheese, meat, fish and poultry products.</td>
</tr>
<tr>
<td>Locust bean gum</td>
<td>Derived from the seeds of <em>Certonia siliqua</em> Linn.</td>
<td>Excellent thickener, not affected by pH or ionic strength, Wt/wt efficiency is very high, produces uniform viscosity, does not stabilize protein.</td>
<td>Icecream, iceshertbets, salad dressings, bakery &amp;confectionery products.</td>
</tr>
<tr>
<td>Guar gum</td>
<td>Obtained from the seeds of guar plant <em>(Cyamopsis</em></td>
<td>Cold water soluble, thickening power is high. Compared to other stabilizer its cost is very low, making it the cheapest.</td>
<td>Icecream, cheese spreads bakery products, meat</td>
</tr>
<tr>
<td><strong>Stabilizer</strong></td>
<td><strong>Description</strong></td>
<td><strong>Uses</strong></td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td>-----------------</td>
<td>---------</td>
<td></td>
</tr>
<tr>
<td>Tetragonolobus</td>
<td>Widely grown in India and Pakistan.</td>
<td>Stabilizer, due to its non-ionic nature, it is not affected by pH or ionic strength, has all the good qualities of locust bean gum, but no demerits of it except it is not a protein stabilizer. Products, beverages, salad dressings, sauces, icings &amp; instant puddings.</td>
<td></td>
</tr>
<tr>
<td>Modified Starch</td>
<td>Produced by acid or alkali treatment on amylopectin causing the aggregate of the molecule to split into smaller fragments, preserving the structure of linear chain.</td>
<td>Compared to other stabilizer it is easily available and is cheaper with very good excellent water holding capacity and gelling properties. Does not produce too high viscosity hence, handling and processing is easier, to obtain the same desired effect a higher amount has to be used. Baby foods, cake mixes, baked beans, baking powder, butter mix, jams and gelatins, milk products, soups and toppings.</td>
<td></td>
</tr>
<tr>
<td>Avicel</td>
<td>Prepared by the acid treatment of α-cellulose.</td>
<td>High water holding capacity hence, is very effective in preventing the ice crystal growth in frozen products, not affected by acidity or ionic strength of the medium and is not influenced by repeated freezing and thawing. Icecream &amp; other low calorie products as a fat replacer, and bulking agent.</td>
<td></td>
</tr>
<tr>
<td>Gelatin</td>
<td>Obtained by acid or alkali treatment of bones, cow hides or pig skin.</td>
<td>Dissolves readily in hot water and gets cooking to about 14°C give a smooth, tender, shiny firm gel that melt at body temperature, not affected by pH or ionic strength of the system but disadvantage is that it requires 3-4 hours time for hydration. Deserts, ice cream, dry dairy mixes, meat loaves, sausages, hard cheese, cakes and icings.</td>
<td></td>
</tr>
<tr>
<td>CMC</td>
<td>Prepared by the introduction of a controlled number of Na carboxy methyl groups into α-cellulose.</td>
<td>Excellent water hydration capacity, imparts chewy body and smooth texture to the product, improves the whipping ability, stabilizing fat in high fat products. Cheese spreads, milk beverages, ice cream, sherbets and frozen foods.</td>
<td></td>
</tr>
<tr>
<td>Pectin</td>
<td>A by-product of citrus fruit industry.</td>
<td>Depends greatly on the molecular weight and degree of methylation as well as concentration, temperature, pH and presence of salts. High methoxyl pectin requires sugar for gel formation while low methoxyl pectin requires calcium salt for gel formation. Jams, jellies, preserves, milk gels, puddings, and frozen foods.</td>
<td></td>
</tr>
<tr>
<td>Xanthan gum</td>
<td>Product of microbial fermentation using plant pathogen (Xanthomonas campestris)</td>
<td>Soluble in hot and cold water, give high viscosity at low concentration, no change in viscosity with variation in temperature, freeze thaw stability, high heat stability in the presence of salts. Salad dressings, malt beverages and beer.</td>
<td></td>
</tr>
</tbody>
</table>
3.0 EMULSIFIERS

Emulsifiers are surface active substances. Due to the presence of both hydrophilic (polar) and lipophilic (non-polar) groups they form a film at the interface between the oil and aqueous phase and aid in the formation and stabilization of the emulsion by decreasing the interfacial tension between the two phases.

3.1 CLASSIFICATION OF EMULSIFIERS

Emulsifiers can be classified on the basis of source, solubility, conic strength, HLB value and functional groups (Table 3).

Table 3. Classification of emulsifiers.

<table>
<thead>
<tr>
<th>Source</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proteins</td>
<td>Caseins, albumins</td>
</tr>
<tr>
<td>Phospholipids</td>
<td>Lecithin, phosphotidyl ethanolamine</td>
</tr>
<tr>
<td>Mono- &amp; di-glycerides</td>
<td>Glycerol mono stearate</td>
</tr>
<tr>
<td>Monoglyceride derivatives</td>
<td>Ethylated mono glycerides</td>
</tr>
<tr>
<td>Fatty acid derivatives</td>
<td>Sucrose esters</td>
</tr>
<tr>
<td>Fatty acid esters</td>
<td>Spans</td>
</tr>
<tr>
<td>Fatty acid ester derivatives</td>
<td>Tweens</td>
</tr>
<tr>
<td><strong>Solubility</strong></td>
<td></td>
</tr>
<tr>
<td>Hydrophilic</td>
<td>soaps, lecithin</td>
</tr>
<tr>
<td>Lipophilic</td>
<td>Monoglycerides, Propylene glycol esters</td>
</tr>
<tr>
<td>Amphiphilic</td>
<td>Spans, Tweens, Sucrose esters</td>
</tr>
<tr>
<td><strong>Ionic nature</strong></td>
<td></td>
</tr>
<tr>
<td>Anionic</td>
<td>Forms negatively charged ions and are effective at neutral and alkaline pH)</td>
</tr>
<tr>
<td>Cationic</td>
<td>Forms positively charged ions and are effective at acidic pH</td>
</tr>
<tr>
<td>Amphoteric</td>
<td>Forms both type of ions and are effective at all pH but some are ineffective at</td>
</tr>
<tr>
<td>Non-ionic</td>
<td>Forms no ions and are independent of pH</td>
</tr>
<tr>
<td><strong>HLB value</strong></td>
<td></td>
</tr>
<tr>
<td>Low HLB</td>
<td>Monoglycerides</td>
</tr>
<tr>
<td>Medium HLB</td>
<td>Spans</td>
</tr>
<tr>
<td>High HLB</td>
<td>Tweens</td>
</tr>
<tr>
<td><strong>Functional groups</strong></td>
<td></td>
</tr>
<tr>
<td>Mono and diglycerides</td>
<td></td>
</tr>
<tr>
<td>Propylene glycol esters</td>
<td></td>
</tr>
<tr>
<td>Sorption esters</td>
<td></td>
</tr>
<tr>
<td>Polyoxyethylene sorbitan esters</td>
<td></td>
</tr>
<tr>
<td>Polyglycerol esters</td>
<td></td>
</tr>
<tr>
<td>Ethoxylated esters</td>
<td></td>
</tr>
<tr>
<td>Lactylated esters</td>
<td></td>
</tr>
<tr>
<td>Lactic acid derivatives</td>
<td></td>
</tr>
<tr>
<td>Lecithin and its derivatives</td>
<td></td>
</tr>
</tbody>
</table>
3.2 Functions of Emulsifiers

Emulsifiers perform several functions in food products as described in Table 4.

**Table 4. Functions of emulsifiers in food products.**

<table>
<thead>
<tr>
<th>Functions</th>
<th>Food products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emulsion stabilizer</td>
<td>Beverages, meat emulsions</td>
</tr>
<tr>
<td>Destabilizing agent</td>
<td>Ice cream</td>
</tr>
<tr>
<td>Whipping agent</td>
<td>Whipped toppings</td>
</tr>
<tr>
<td>Dispersant</td>
<td>Flavours, vitamins</td>
</tr>
<tr>
<td>Dough conditioner</td>
<td>Bread, Buns, rolls</td>
</tr>
<tr>
<td>Defoamer</td>
<td>Yeast, sugar manufacturing</td>
</tr>
<tr>
<td>Starch complex</td>
<td>Macroni pasta</td>
</tr>
<tr>
<td>Crystalization inhibitor</td>
<td>Salad oil</td>
</tr>
<tr>
<td>Antistaling agent</td>
<td>Yeast mixed foods</td>
</tr>
<tr>
<td>Antispattering agent</td>
<td>Margarine,</td>
</tr>
<tr>
<td>Anti sticking agent</td>
<td>Candy, chewing gum</td>
</tr>
<tr>
<td>Freeze thaw stabilizer</td>
<td>Frozen toppings, coffee whitener</td>
</tr>
<tr>
<td>Gloss enhancer</td>
<td>Confectionery coatings</td>
</tr>
</tbody>
</table>

3.2.1 ROLE OF EMULSIFIER IN DAIRY PRODUCTS

<table>
<thead>
<tr>
<th>Product</th>
<th>Emulsifier</th>
<th>Function</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice cream</td>
<td>Mono- &amp; di-glycerides, Polysorbates</td>
<td>Foaming agent, destabilizing agent</td>
<td>Improved whipping ability, dried body, stiffer &amp; smooth texture, slower meltdown, Prevention of shrinkage</td>
</tr>
<tr>
<td>Whipped cream</td>
<td>GMS, Tween</td>
<td>Partial coalescence</td>
<td>Stable product</td>
</tr>
<tr>
<td>Whipped toppings</td>
<td>PGMS, GMO</td>
<td>Protein dispersion, Crystallization of fat at air bubble surface</td>
<td>Drier body</td>
</tr>
<tr>
<td>Cream liquors</td>
<td>GMS</td>
<td>Interaction with protein to form weak gel</td>
<td>Improved creaminess, better mouthfeel</td>
</tr>
<tr>
<td>Coffee whiteners</td>
<td>GMS, Tween-60</td>
<td>Improve dispersibility, Solubility, whitening ability,</td>
<td>Stable and more effective whitener</td>
</tr>
<tr>
<td>Processed cheese</td>
<td>SDS, CTAB, Lecithin</td>
<td>Improve softness and spreadability</td>
<td>Better body and texture</td>
</tr>
<tr>
<td>Recombined butter</td>
<td>Phospholipids, Monoglycerides</td>
<td>Antispattering agent, Strengthen</td>
<td>No fat spattering during cooking, better shelf life</td>
</tr>
<tr>
<td>Yoghurt</td>
<td>Sucrose esters, Monoglycerides</td>
<td>Lubricating agent, Antimicrobial agent</td>
<td>Better mouthfeel, Longer shelf life</td>
</tr>
</tbody>
</table>
### 3.2.2 ROLE OF EMULSIFIERS IN BAKERY PRODUCTS

<table>
<thead>
<tr>
<th>Product</th>
<th>Emulsifier</th>
<th>Function</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shortening</td>
<td>Mono- &amp; di-glycerides, PGMS, Polysorbates</td>
<td>Whipping, emulsifying, lubricating &amp; anticrystallization agent</td>
<td>Supplement and improve functionality, improved keeping quality, loaf volume and texture</td>
</tr>
<tr>
<td>Yeast raised products</td>
<td>Lecithin, DATEM</td>
<td>Antistaling, conditioning &amp; crumb softening agent</td>
<td>Improved texture through larger volume and fine grains</td>
</tr>
<tr>
<td>Cakes</td>
<td>PGME, Polysorbate-60, Na stearoyl lactylate, Sorbitan monostearate</td>
<td>Whipping, emulsifying &amp; crumb softening agent</td>
<td>Improved texture through larger volume and fine grains</td>
</tr>
<tr>
<td>Cookies and crackers</td>
<td>SSL, Lecithin</td>
<td>Gelatinization &amp; release agent</td>
<td>Drier dough, better release from rotary dies</td>
</tr>
<tr>
<td>Extruded cereals/snacks</td>
<td>SSL, Monoglycerides</td>
<td>Energy reducing agent, whipping agent</td>
<td>Smooth texture and fine pore structure</td>
</tr>
<tr>
<td>Cream icings</td>
<td>Polyoxyethylene monosorbate, Monoglycerides</td>
<td>Whipping agent</td>
<td>Better texture, improved and stable gloss</td>
</tr>
<tr>
<td>Fat free products</td>
<td>Mono- &amp; di-glycerides, Polysorbates, Polyglycerol esters</td>
<td>Dispersing, fat stabilizing &amp; fat sparing action</td>
<td>Improved body and texture, better mouthfeel</td>
</tr>
</tbody>
</table>

### 3.2.3 ROLE OF EMULSIFIERS IN CONFECTIONERY, MARGARINE AND LOW SPREADS

<table>
<thead>
<tr>
<th>Product</th>
<th>Emulsifier</th>
<th>Function</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chocolate &amp; compound coatings</td>
<td>Lecithin, Polyglycerol polyricinoleate, Srbiton tristearate, SMS, Polysorbates</td>
<td>Thinning, antiblooming, antimicrobial agent</td>
<td>Thin &amp; fine coating, longer shelf life, better appearance</td>
</tr>
<tr>
<td>Chewing gum</td>
<td>Polysorbate-60, 65, 80, Lecithin</td>
<td>Softening, carrier (colour&amp; flavour) agent, protective coatings</td>
<td>Improved consistency</td>
</tr>
<tr>
<td>Margarine</td>
<td>Mono- &amp; di-glycerides of long chain FAs (Lipophilic)</td>
<td>Emulsifying, stabilizing &amp; antimicrobial agent</td>
<td>Improved shelf life, texture &amp; flavour release</td>
</tr>
<tr>
<td>Low fat spreads</td>
<td>Polyglycerol esters of Interesterified ricinoleic acid, Distilled monoglycerides (IV 80)</td>
<td>Emulsion stabilizers</td>
<td>Improved shelf life &amp; mouthfeel</td>
</tr>
<tr>
<td>Oil-in-water spreads</td>
<td>Tweens</td>
<td>Emulsion stabilizers</td>
<td>Improved shelf life &amp; mouthfeel</td>
</tr>
<tr>
<td>Liquid margarine</td>
<td>Citrem esters of monoglycerides, Lecithin</td>
<td>Stabilizing &amp; antispattering agent</td>
<td>Stable emulsion with no spattering during frying</td>
</tr>
</tbody>
</table>
4.0 SUGGESTED READINGS

Krog, N. (1997) In: Food grade emulsifiers and their chemical and physical properties in food emulsions. (Eds. S.E. Frieberg and K. Larsson), Marcel Dekker Inc., New York, USA.


1.0 INTRODUCTION

‘Dairy analogs’ or ‘imitation dairy products’ have gained currency in the past 2-3 decades as milk or milk products substitutes offering one or more advantages in terms of reduced allergenicity, low or no cholesterol content, low saturated fat content and often a low cost. Thus, these products represent partial or complete replacement of milk constituents with non-dairy ingredients. Although it may not always be possible for dairy analogs to have the same flavour and texture attributes as those of genuine milk products, mimicking the ‘eating’ (or, sensory) quality of the product without adversely affecting their nutritional value is the major objective of the dairy analog development. Therefore, selecting the right kind of ingredients is key to the success of these products whose popularity is steadily increasing. It should be noted that while dairy analogs may not and need not replace dairy products from people’s diet, there seems to be a definite scope for these products for certain target groups seeking the specific advantages mentioned above, as also for the general population simply to add variety to their diet which is believed to be nutritionally as important as the nutritive value of a particular food product.

Soybean has been found to be unique as an ingredient for dairy analogs. Its protein quality as well as polyunsaturated fat and crude fibre contents make it highly desirable from the nutritional standpoint. While in several applications whole soyabean, suitably processed, have been used, often soya products such as full-fat flour, fat-free flour, soybean meal or grits, soya oil etc. have been effectively used in dairy analogs for the reason of improved palatability without loss of nutritional quality. Proper processing of soybean cannot be overemphasised if the full benefit from it is to be realized in dairy analogs. An attempt is therefore, made in this presentation to assess soybean as an ingredient for dairy analogs.

2.0 SOYBEAN AS A FOOD

2.1 The early soya products

Having originated in China nearly 5000 years ago, soybean has for centuries served the Chinese, Japanese, Korean and South-east Asian peoples as a valuable food item. In the beginning i.e. some 3000 years back, soybean is believed to have been used as fermented products such as ‘tempeh’, ‘natto’, ‘miso’ and ‘shoyu’. Later, it also acquired the form of bean curd or ‘tofu’ obtained by precipitation of cooked bean slurry (or, soymilk) with calcium sulphate or magnesium sulphate. All these soya preparations have been traditionally consumed in the Far East as well as in China. The fermented soya products have a characteristic flavour associated with each of them, and so, have remained largely confined to those Oriental countries. However, the relatively bland tofu has been gaining popularity in the West. Of course, soya sauce or shoyu is also consumed in many non-Oriental countries.
The starting material for tofu-making i.e. soymilk was traditionally prepared in China by grinding soaked soybeans in water (1:8-10) followed by filtration and boiling for a few minutes. Heating the slurry before filtration as practiced in the Japanese method results in improved yields. The soymilk obtained by either of these methods as also tofu obtained therefrom has a characteristic ‘beany’ flavour which, though acceptable to the Oriental people, is not desirable for consumers in other parts of the world. The off-flavour is known to originate from peroxidation of polyunsaturated fatty acids especially linoleic acid by the native enzyme lipoxygenase in the presence of water. Thus the technology of soybean processing for non-traditional consumption concerns preventing the off-flavour development by inactivating the enzyme before it is able to act on the substrate, or removing the compounds responsible for the off-flavour.

2.2 Improved methods of soymilk preparation

Soymilk has been generally considered as a milk analog, but in the form of a flavoured drink rather than as plain beverage. In order to overcome the problem of ‘beany’ flavour in soymilk, attempts have been made to modify the method of preparation. These new methods include the ‘hot-grind’ or Cornell process (involving grinding of unsoaked, dehulled soybeans in hot water, boiling the slurry for 10 min. and sterilizing at 121°C for 12 min), the Illinois process (consisting in boil-blanching presoaked soybeans in water containing 0.25-0.50% sodium bicarbonate for 10 min or unsoaked soybeans for 20 min, followed by homogenization, pasteurization and bottling), and the ‘rapid hydration hydrothermal cooking’ process (which involves grinding of soybeans into flour, mixing it with hot water, and then rapidly heating it at 154 °C for 30s by direct steam infusion, followed by centrifugation). Soymilk thus obtained has been claimed to have little or no off-flavour and its yield is high.

The Illinois process and its modification (starting material dehulled soybeans instead of whole beans for soaking) have been used at this Institute to produce flavoured milk-like beverages based on water or whey. Whey protein being rich in sulphur-containing amino acids, the protein quality of a whey - soy beverage is superior to that of water-based soy beverages. In order to extend the shelf life these beverages are sterilized usually in bottles or processed aseptically.

Soymilk has been prepared using other forms of soy materials such as defatted soy flour, soy protein isolate etc. but the flavour of the resulting product would necessarily depend on that of the starting material. In many cases, soymilk flavour improvement is sought through deodorization employing a high-temperature, vacuum flash process so as to eliminate the volatiles responsible for the off-flavour. This method is used in conjunction with other techniques by some Japanese soymilk manufacturers. Commercial soymilk processes either employ the Illinois technique or the Cornell process with certain modifications. The Tetra Alwin Soy process line of Tetra Pak (Sweden) involves feeding of cleaned soybeans into the grinder funnel where hot water is added (sodium bicarbonate optionally being dosed into the funnel), pumping of the resulting slurry to a decanter centrifuge for fibre separation, direct steam heating of the extract followed by flash cooling in a vacuum chamber. The resulting product serves as a soybase for a range of products including soymilk.
2.2 Soybean as an oilseed

While it is a traditional food crop in the East, soybean legume crop has spread to other parts of the world essentially as an oilseed crop. USA accounts for about half of the total world soybean production (approx. 140 million tonnes) and nearly 85-90% of it is used for edible oil manufacture. Although soybean cultivation in India has been practiced for the past 1000 years, the present production level is just about 5 million tonnes, 85% of which goes for oil production, 10% for seed and 5% for food and feed purpose. Soybean oil extraction results in production of 82% (of the beans) soymeal as a byproduct. While practically all oil is used for edible purposes, soymeal is largely diverted feed uses including exports. Therefore, effective utilization of soymeal for food purposes is warranted for making the soybean industry more profitable, and soybean production more remmunerative to the farmer.

2.3 Soy protein products

For non-traditional food purposes, soybean has been used in the form of defatted flour or grits equivalent to soymeal, full fat flour, protein concentrates and protein isolates, in addition to the soy slurries or suspensions i.e. soymilk. Of these, protein concentrates and isolates are by far the most commonly used soy products for non-conventional food applications.

Soy protein concentrates are obtained by removal of soybean carbohydrates and some flavour compounds from defatted meal. This is achieved by isoelectric leaching, alcohol (60-80%) extraction, or moist-heat water leaching, which results into concentration of the insolubilized protein. The solids including insoluble carbohydrates are then dispersed in water, neutralized to pH 7.0 and spray-dried to produce a soy concentrate. Depending on the extent of leaching out of the solubles, soy protein concentrates may contain 65-72% protein, 0.5-1.0% fat, 3.5-5.0% crude fibre, 4.0-6.5% ash and 20-22% carbohydrates in dry matter (moisture, 4-6%).

Soy protein isolates containing 90-92% protein and 0.1-0.2% crude fibre in dry matter (moisture, 4-6%) are prepared from defatted soy meal using aqueous or alkali extraction of proteins and soluble carbohydrates, followed by isoelectric precipitation of protein from the extract before neutralization and spray drying of the precipitate. Other less frequently used methods of isolate manufacture include separation by molecular weight (ultracentrifugation or sucrose density gradient centrifugation), ultrafiltration or salt extraction. The methods of alkali or salt extraction may be combined with membrane processing.

3.0 FUNCTIONAL PROPERTIES OF SOY PROTEIN PRODUCTS

The functional properties of soy protein products depend on pH, ionic strength and interaction with other food components. While protein is the principal functional component soy flours and concentrates, the carbohydrates and other constituents considerably influence their functional properties. Heat treatment is also an important factor affecting the functional behaviour of soy protein products. Structural changes such as decrease in α-helix content, exposure of tryptophan and tyrosine, and exposure of disulphide groups caused by protein denaturation are generally associated with decreased solubility, increased viscosity, reduced hydrophillicity, etc. The isoelectric point of soy protein is 4.2-4.6, above and below which solubility increases sharply. Solubility of soy protein in a salt solution depends on the type of
salt and its concentration. In chlorides, bromides and iodides of monovalent cations, solubility decreases with increasing salt concentration up to 0.1 M above which it increases, albeit less rapidly. Sulphates of monovalent cations decrease the solubility as their concentration goes up. Soy protein solubility in solutions of divalent or polyvalent cation salts is far less. Heat treatment used during preparation of the soy protein appreciably decreases its solubility in salt solutions. A lipid fraction, essentially a phospholipid, in soybean causes, through protein oxidation, decreased solubility. Either removal of this polar lipid from soy flour before isolate preparation, or addition of antioxidants to defatted soy flour increases the solubility of isolated soy protein.

The emulsifying capacity of soy protein products increases with increasing protein solubility. Although emulsion stability increases with protein concentration, the emulsifying capacity usually decreases. Further, the emulsifying properties are good in the alkaline pH range but poor under acidic conditions. The emulsion capacity of soy protein is decreased above 50°C.

The foaming properties of soy protein are also related to its solubility. Soy isolates are superior to soy flours and concentrates in their foaming properties. Extraction of lipids improves the foaming behaviour. Heating to 75-80°C as also enzymatic hydrolysis has been found to enhance the foaming properties of soy protein. Succinylation and other chemical modifications have also been reported to be effective in this regard.

The nature of soy protein gel varies with type of soy protein product, protein concentration, rate and duration of heating, and cooling conditions. While soy flour and concentrates form soft, fragile gels, soy isolates form firm, resilient gels. Chemical modification such as treatment with a disulphide cleaving agent promotes the gel forming characteristics of soy protein.

Among soy protein products, isolates have the highest water-binding capacity (approx. 35 g/100 g). Heat treatment generally decreases the extent to which water can be bound by the protein molecules. The water-holding capacity, which includes both bound and hydrodynamic water has been reported to be 2.60, 2.75 and 6.25 g/g of solids for soy flour, concentrate and isolate, respectively. Heat treatment of soybean material adversely affects the water holding capacity.

4.0 NUTRITIONAL VALUE OF SOY PROTEIN PRODUCTS

Whole soybean seeds, comprising 8% cotyledon (or, seed-coat), 2% hypocotyl and 90% cotyledon contain 40% protein, 20% lipid, 35% carbohydrate and 5% ash in dry matter, the moisture content usually being 13%. While soybeans are a good source of polyunsaturated oil, it is soy protein that is valued for its nutritional significance. Soybean protein, essentially globulin (soluble in salt solution) is made of several fractions viz. 2S, 7S, 11S and 15S (based on ultracentrifugation behaviour), accounting for about 20, 35, 35 and 10% of the total extractable protein. The 2S and 7S fractions include the anti-nutritional factors viz. trypsin inhibitors and haemagglutinin as also the enzyme lipoxygenase. Most of these proteins exist as more or less spherical organelles called ‘protein bodies’.

The amino acid profile of a protein is the major determinant of its nutritional quality. Soy protein contains all essential amino acids in sufficient quantities except sulphur-containing amino acids viz., methionine and cysteine. Thus, these essential amino acids are
the limiting ones, methionine being the most significant limiting amino acid i.e. its fortification would result in an increased nutritional quality of soy protein. On the other hand, soy protein is rich in lysine, another essential amino acid. This implies that cereal proteins, which are generally deficient in lysine but contain fair amounts of methionine can be combined for complementary effects in terms of protein quality.

The protein efficiency ratio (PER), an index of protein quality determined by animal (rat) feeding assays is 2.3 for well-processed soy protein as against 2.5 for casein. The nutritive value of protein also depends on its digestibility or amino acid bioavailability. Depending on the type of soy protein product and processing that it has undergone, protein digestibility ranges from 65 (steamed or toasted whole soybeans) to 93-97 (soy protein isolates). Further, it is interesting to note that the new parameter of protein quality, PDCAAS (Protein Digestibility Corrected Amino Acid Score) indicates that soy protein in its purified form is nearly equivalent in quality to animal protein, the parametric values being 1.00, 0.99, 0.92 and 0.73 for egg white, soy protein concentrate, soy protein isolate, beef and pea protein concentrate, respectively.

Bioassays involving human subjects based on measures of growth, nitrogen balance, and dietary nitrogen utilisation have conclusively revealed that properly processed soy protein products i.e. concentrates and isolates can serve as the major or even sole, source of protein intake, and that their nutritional value is essentially equivalent to that of animal proteins.

5.0 ANTINUTRITIONAL FACTORS IN SOY PRODUCTS

Trypsin inhibitors (TIs), lectin (or, haemagglutinin), phytate (calcium-magnesium-potassium salt of phytic acid), isoflavones (or, flavonoids) and flatulence factors are the major antinutritional constituents of soybeans. TIs are known to inhibit protein digestion by trypsin and thereby suppress growth in experimental animals. About 40% of growth inhibition is ascribed to the TIs. It is also associated with pancreatic enlargement mediated by formation of a trypsin-TI complex. Heat treatment of soybeans or soy products by steaming, boiling in water, dry roasting, dielectric, microwave or infra-red radiation, or extrusion cooking can effectively inactivate TIs. Wet heat is usually more effective than dry heat.

Soy lectin, which agglutinates erythrocytes and other types of cells, have been shown to account for about 25% of growth inhibition in rats caused by raw soybeans. It has also been associated with pancreatic enlargement, lowering of blood insulin level, inhibition of digestive enzymes, degenerative changes in liver and kidneys, and interference with absorption of iron and lipid from the diet. However, lectin can be completely inactivated by adequate heat treatment.

Raffinose (a trisaccharide) and stachyose (a tetrasaccharide) are soluble carbohydrates found in soybeans. These non-reducing sugars have their monosaccharide units linked by fructosidic and α-galactosidic linkages. On account of the absence of α-galactosidase in humans, these oligosaccharides are not digested in the small intestine but pass onto the large intestine where microorganisms degrade them and result in production of carbon dioxide, hydrogen, nitrogen, methane etc. which, in turn, cause flatulence and related problems. These sugars are not destroyed by heat, but can be substantially leached out in water during soaking and blanching of soybeans, or can be extracted from soy flour by aqueous alcohol. Enzymatic
degradation by means of exogenous enzymes, lactic acid fermentation or germination is also effective in eliminating the flatulence factors.

Phytate (or, phytin) bind di- and tri-valent metal ions such as Ca\(^{2+}\), Mg\(^{2+}\), Zn\(^{2+}\) and Fe\(^{3+}\) and thereby reduce their bioavailability in human food. It also forms complexes with protein molecules and thus reduce protein digestibility and also affects its functional properties. Heat treatment is not effective in phytate elimination. Soaking in hot water (50 \(^{\circ}\)C for 16 h) has been found to reduce phytin by 26% through the action of endogenous phytase and/or through leaching into soak water. Germination or use of exogenous phytase has also been found to reduce the soy phytate content considerably.

Isoflavones, the C\(_6\)-C\(_3\)-C\(_6\) cyclic compounds have been reported to exhibit estrogenic activity, cause interference with mineral metabolism and growth inhibition. They have also been associated with a certain after-taste, usually bitter or astringent, in soy products. However, recent research has shown that isoflavones not only have antioxidant and antifungal activity, but also are anti-carcinogenic. An apparent relationship between increased soyfood consumption and reduced cancer risk has been attributed to the presence of isoflavones.

6.0 HEALTH ASPECTS OF SOY PRODUCTS/CONSTITUENTS

Besides isoflavones, trypsin inhibitors found in soybeans have been shown to be anticarcinogenic at extremely low levels. Similarly, dietary oligosaccharides have been reported to display several beneficial effects including blood pressure-decreasing and anticarcinogenic effects. Also, considerable evidence is available from studies on animals and human beings to show that the total and low-density lipoprotein (LDL) cholesterol in plasma or serum are reduced by replacing animal protein in diet with soya protein. Recently, the Food and Drug Administration (FDA) of the USA has allowed soya products to bear the claim that so proteins lowers blood cholesterol levels, but to qualify for this health claim, the product must contain at least 6.25 g soy protein per serving, which is 25% of the 25g daily intake that studies have shown to be needed for a significant cholesterol-lowering effect. The polysaccharides present in soybean are believed to be useful as dietary fibre, although no beneficial effects have been demonstrated. Soybean oil contains large amounts or omega-3 fatty acids, which are beneficial for human health.

It should be pointed out that, not withstanding the above-mentioned potential and actual positive health effects of soy constituents, some studies indicate that the health properties associated with soy products may not be actually present. For example, isoflavone aglycones found in traditionally fermented soya products are anticarcinogenic, but in non-fermented products such as tofu and soymilk, these isoflavones are present in an altered form, as beta-glycoside conjugates which have no anticarcinogenic effect.

7.0 SOYA-BASED DAIRY ANALOGS

Soy protein products, most frequently isolates, have been used for production of imitation milk, imitation cheese products, imitation ice cream, imitation spreads, soyghurt, soya paneer etc. Soy products have often been combined with milk ingredients or dairy by-products such as skim milk, whey, whey protein concentrate etc. in order to enhance the sensory characteristics of the products. Combination of whey protein, which is rich in sulphur amino acids with soya protein, has a unique advantage of balancing the essential amino acid composition and thereby raising the nutritional status of the soya-based dairy analogs.
Sweetened flavoured products such as soya drink and frozen desserts have generally greater consumer acceptability than that of non-flavoured or mildly flavoured products. Obtaining ripened cheese-type products from soya or other vegetable products poses the biggest challenge to the dairy-food technologist primarily because of the characteristic flavour which is difficult to duplicate even in a bland base material.

8.0 CONCLUSION

Soya-based dairy analogs are important because both the soy products and dairy products have their unique features – for the populations to whom soya is a foreign food, it is its nutritional status among vegetable proteins that makes it valuable, and as regards the dairy products it is their ‘eating’ or sensory quality and nutritive value that matter. Various soya products viz., soymilk, soy curd, flours, protein concentrates and soy isolates have been used for various dairy analogs, but isolates have the largest applicability owing to their high protein content, functionality, and bland flavour. Properly processed, soy products are highly nutritive. Often concern has been raised against certain anti-nutritional factors in soya products but appropriate processing can effectively eliminate such undesirable components. Recent research showing several soy constituents to have healthful effects such as anti-carcinogenicity, cholesterol-reducing effect etc. has led to rejuvenated attempts to market soya products especially of analog type in the Western countries. Although soy-based analogs may not be ideal substitutes for dairy products, as supplementary products in human diet as also in the form of dairy-blended products they seem to have a definite future in countries where soy is not a traditional food item.

9.0 SUGGESTED READING