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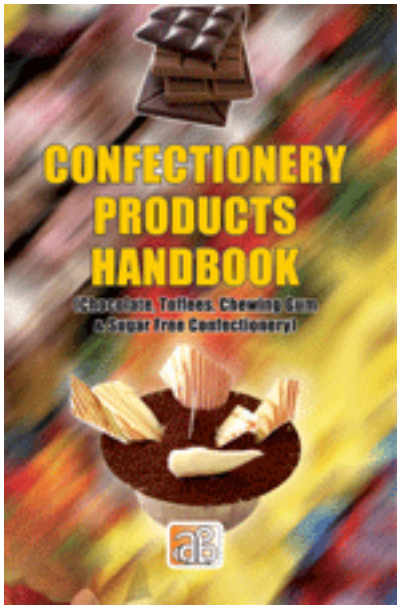
Confectionery Products Handbook (Chocolate, Toffees, Chewing Gum & Sugar Free Confectionery)



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Confectionery manufacture has been dominated by large scale industrial processing for several decades. Confectionery implies the food items that are rich in sugar and often referred to as a confection and refers to the art of creating sugar based dessert forms, or subtleties (subtlety or sotelty), often with pastillage. The simplest and earliest confection used by man was honey, dating back over 3000 years ago. Traditional confectionery goes back to ancient times, and continued to be eaten through the Middle Ages into the modern era.

Sugar confectionery has developed around the properties of one ingredient – Sucrose. It is a non- reducing disaccharide. The principal ingredient in all confectionery is sucrose, which in its refined form has little flavour apart from its inherent sweetness.

This handbook contains Packaging in the confectionery industry, Structure of sugar confectionery, Flavouring of confectionery, Confectionery plant, Ingredients, Quality control and chemical analysis, Medicated confectionery and chewing Gum, Chocolate flow properties, General technical aspects of industrial sugar confectionery manufacture, Manufacture of liquorice paste, Extrusion cooking technology, Manufacture of invert sugar, Marzipan and crystallized confectionery.

The manufacture of confectionery is not a science based industry, as these products have traditionally been created by skilled confectioners working empirically. The aim of this handbook is to give the reader a perspective on several processes and techniques which are generally followed in the confectionery industry. The texture and technological properties of confectionery products are to a large extent controlled by its structure.

The book is aimed for food engineers, scientists, technologists in research and industry, as well as for new entrepreneurs and those who are engaged in this industry.

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INTRODUCTION

History

Egyptian records describe that art of confectionery over 3000 years ago. Excavations of Herculaneum, buried under volcanic dust in A.D. 79, revealed a confectioner's workshop. The sweets of those ancient times were often based on honey, but sugar cane juices, boiled to concentrate, were also used in China and India.

Corn Syrup, Glucose Syrup, and Liquid Glucose. Corn syrup is the name given in the United States to the product obtained by the hydrolysis of starch. Because different starches, e.g., potato, are used in other countries, glucose syrup seems to be a more appropriate and general name.

In 1811 the Russian chemist G.S.C. KIRCHHOFF discovered that a sweet substance could be made from starch by treatment with acid. Since then, many syrups of different viscosity, sweetness, and saccharide content, have been produced. Originally glucose syrup was made entirely by acid hydrolysis under pressure, but now the process has been extended to a combination of acid and enzyme treatment. This has resulted in considerable variation in the proportions of dextrose, maltose, and the higher saccharides, known as oligosaccharides. A more recent development has been the isomerization of the dextrose to fructose by further enzyme treatment (-Glucose and Glucose-containing Syrups).

Function of Sugars in Confectionery. The main reasons for the use of sugars in confectionery are (1) their ability to preserve food, (2) their contribution to body, flavor, and texture, and (3) their ability to enhance the flavor of other ingredients. However, in the technology of confectionery, the combination of these sugars is the important factor. The presence of glucose syrup, for example, will retard sucrose crystallization, increase viscosity, and provide a syrup concentration that resists microbiological action.

Properties and Microbiology of Confectionery

Solubility and Syrup Concentration. The solubility of substances in water varies considerably and generally increases with temperature. Some materials are capable of forming supersaturated solutions; i.e., more substance is present in solution that would normally be present in a fully saturated solution at the same temperature. A supersaturated solution is formed by first heating the solid and solvent (sugar and water) until a concentrated solution is obtained. If this solution is then cooled without agitation and no solid is precipitated, a supersaturated solution is formed. Such solutions are unstable, and agitation will lead to precipitation.

Types of Confectionery

Some indication of the different types of confectionery has been given in the previous section. The solubility and crystallization properties of sucrose and its combination with other sugars are largely responsible for the physical differences in confectionery products. The major ingredients of all confectionery are sugars. In combination with fats, milk, gelatinizing agents, and minor substances such as emulsifiers and flavors, an extensive variety of confections is possible. The principal types are hard candies, fondants, caramels, jellies, and nougats. These are discussed in detail in the following section.

Marshmallows and Nougat

Modern methods use pressure beating, in either a batch or a continuous machine. The syrup and the aerating agent are beaten under pressure in a closed container that is controlled in time and pressure. Release of pressure is used as a means of discharge. With the continuous method, the syrup, air, and egg - gelatin solution are each metered to a rotor - stator mixer against a back-pressure valve through which the foam is continuously discharged.

Marshmallows can be made with a variety of textures. Some may be deposited into starch as fondant; others are extruded into ropes onto a moving bed of starch and subsequently cut into pieces. Because of their lower moisture content, nougats need more powerful mixers, but the first process is similar to the

atmospheric or pressure beating used for marshmallows. In the final process, fat is included together with other ingredients such as cocoa power, milk powder, flavor, preserved fruits, and icing sugar. This mixing must be as short as necessary to completely disperse the fat because the fat acts as an antifoam and tends to reduce aeration.

Packaging in the Confectionery industry

TRENDS AND DEVELOPMENTS

Since World War II, developments in packaging generally have been phenomenal and this applies to both materials and machinery. Changes have occurred with all commodities, large and small, edible and non-edible.

In the food industry, which includes chocolate and confectionery, special factors arise. The package and packaging operation must conform to rigid standards of sanitation, toxicity, and odor, and must provide protection of the contents. Also, modern distribution and sales methods have influenced the type of package. Supermarkets and garage areas, for example, require unit packs to encourage impulse buying as well as ease of display. Examples include candy bars, which now mostly have heat-sealed films or laminates giving adequate protection in what are often hostile atmospheric conditions.

MATERIALS

Metal Cans

Most chocolate and confectionery products are not perishable and therefore sterile packs are not required except, perhaps, for chocolate syrups and similar low-concentration mixtures. However, metal cans are often used for cocoa and food drink powders.

Types of Paper

Glassine and Greaseproof (G&G) Papers. Glassine is a heavily calendered paper with a shiny smooth surface and is transparent. Greaseproof is similar but is less calendered. These papers are produced by processes that beat the pulp until the cellulose fibers become highly hydrated and this has the effect of rendering them resistant to the penetration goil and grease. Glassine is used extensively for wrapping confectionery bars. Its greaseproof properties are very valuable in this respect and it prints well. Because of its dense structure, it gives a measure of protection against extraneous flavors. When special protection against moisture is required, glassine may be coated or laminate using wax, lacquer, polythene and other plastic films. With plastic films it may be heat sealable.

The Type of Wrap

The method of wrapping a confectionery product is determined by:

1. Appearance required.
2. Degree of protection.
3. Economy of wrapping material.
4. Speed of wrapping, which is related to the size of unit to be wrapped.

Printing Odors in Food Wrappers

All food manufacturers receive occcasional deliveries of printed wrappers that smell of printing ink, which, if used in that condition, will contaminate the food wrapped in them. chocolate and fatty foods are particularly prone to pick up these odors.

Testing of Wrappers for Various Other Properties

Many detailed publications are concerned with the testing of wrapping materials and the reader is referred particularly to British Standard Packaging Code BS 1133 Section 7 - Paper and Board Wrappers, Bags and Containers Appendices A to W, which cover most of the methods required by a food technologist and to appropriate U.S. agencies.

DESSICANT POUCHES

Some reference should be made to methods of retention of low humidity inside packs. This is used for

the bulk packing of dehydrated fruits, vegetables, and egg and milk powders. The packages are usually cans or drums.

In addition to the food, a pouch made of moisture-permeable material containing a desiccant is included in the container. By this means dehydration of the occluded air and the food continues after closure and the moisture content is reduced below that obtained by commercial drying.

The common desiccants used are calcium oxide, silica gel, or calcined alumina, which retain their "dry" conditions after absorbing moisture.

Sugar, syrup, confectionery and sweeteners

THE PRODUCTION OF BEET SUGAR

The sugar beet is a biennial plant. In the first year, only leaves and roots are formed. In this period much sugar is formed (about 17 percent) which is stored in the root as a reserve food for the second year. However the beet is harvested in the first year. The harvest time is from September until the end of December (the sugar beet harvest). The sugar beet factories work continuously during the harvest to process the beet as quickly as possible into sugar. This is necessary because during storage the sugar content decreases as a result of the continuing metabolism. From I kg beet, about 130 gram crystal sugar are obtained.

The production process for beet sugar

The beet arrive by lorry, train or ship. Each consignment is weighed and sampled. The sample is analysed for sugar content and its tare (this is the attached soil). The farmer is paid on the basis of weight and sugar content. The beet are then sprayed clean with water cannons. Stones and leaves are removed.

CONFECTIONERY, LIQUOrICE AND WINE GUMS

Confectionery

Confectionery can be divided according to ingredients and method of production.

- **Hard confectionery,** also called acid drops, consist of sugar and glucose syrup, which are dissolved in water and boiled down to a final moisture content of 2 per cent. Then flavour and colour are added and the warm mass is poured into moulds and cooled.
- **Soft confectionery,** such as fondant and marzipan are products based on sugar, glucose syrup, cream, milk and / or butter.
- **Peppermint** is produced from a mixture consisting of sugars, a gelling aid, starch and peppermint oil. The mixture can be rolled into a layer from which tablets are cut (hard peppermint). The mixture is also shape into granules of which tablets are pressed (soft or digestive peppermint).
- **Dragees,** or sugar-coated products, are finished with a layer of sugar, which contributes towards the taste, and beautifies the exterior, adding for instance gloss and colour or protection against the absorption of moisture.

SWEETENERS

Among sweeteners are numbered products which because of their sweetening ability are used instead of sugar, syrup or honey. There are several reasons for replacing sugar or sugar-containing products.

- Sugar can be detrimental to certain users, for instance diabetics.
- Some sweeteners supply little or no energy.
- In the foodstuff industry the processing of sweeteners offers technological advantages over the use of sugar.
- Some sweeteners are less harmful to the teeth than sugar.

QUALITY DETERIORATION, SPOILAGE AND STORAGE

Sugar, syrup and confectionery scarcely spoil because of their high sugar content.

Sugar will clump together if stored in a moist place; especially icing sugar and caster sugar.

Syrup can start to ferment in warm moist surroundings. Syrup which is stored too cool and too long

eventually crystallizes.

Confectionery can start to run (become sticky) under the influence of moisture.

In unopened packaging the above-mentioned products can be stored for years. In opened packaging, stored cool and dry they can be kept for a maximum of one year.

Food Value of Chocolate and Confectionery

FOOD VALUES OF CHOCOLATE AND CONFECTIONERY

Table 3 gives the food values of a selection of chocolate and confectionery products. Items 1 through 8 are from McCance and Widdowson (1960) and 9-12 are the author's figures. McCance and Widdowson's figures for chocolate and cocoa show high fat contents compared with present-day recipes. Chocolate and cocoa may have added alkali or salt, hence the figures in brackets.

Food factories get regular requests from hospitals, nutritionists, general practitioners, the general public, and food faddists to give details of the composition of their products. It is as well to build up a file of information on all lines sold so that inquiries may be answered promptly.

Calculation of Caloric Value of a Food

Often it is necessary to calculate the caloric value of a food. This is a relatively simple matter and is based on the fact that foods consumed in the body are burned up in the same way as they would be in a physical calorimeter. Allowing for small losses due to indigestibility, the caloric equivalents are as follows:

Carbohydrates	4.0 calories per gram
Fat	9.0 calories per gram
Protein	4.0 calories per gram

Thus, if the composition of a food is known or obtained by analysis, the caloric value may be calculated.

As an example, consider liquid milk consisting of protein, 3.3 percent; fat, 4.0 percent; carbohydrate, 5.0 percent; and water, 87.7 percent. It is found that 100 g of milk will provide:

Protein	3.3 x 4.0 = 13.2 calories
Fat	4.0 x 9.0 = 36.0 calories
Carbohydrate	5.0 x 4.0 = 20.0 calories
Total	69.2 calories per 100 g

The water is merely a "carrier" and provides no fuel.

THE VIRTUES OF CONFECTIONERY

Chocolate particularly, is much in demand for survival rations or as a constituent of food packs for use during feats of endurance such as mountain climbing and rescue.

The role of confectionery as a gift is not to be overlooked. There is great pleasure in receiving a box of chocolates. Holidays such as Easter and Christmas are enhanced by gifts of attractive foil-wrapped candies-Easter eggs, rabbits, and Santa Clauses.

Structure of Sugar Confectionery

Toffee

In a normal toffee product using condensed milk or skimmed milk powder as the protein source the degree of emulsification is controlled by the interactions between the whey protein fraction and the casein micelles. During cooking the whey protein appears to form a membrane at the edge of the fat droplets and the casein micelles attach themselves to this membrane. The casein micelles make the membranes brittle, which leads to breakdown of fat droplets during cooking and stirring. this process is illustrated in Figure 1, which shows the premix, half-cooked and final product stages of a normal toffee. The extent to which the fat droplets break down during cooking is seen to be related to the size of the casein micelles in the milk. If the calcium content of the milk is reduced by ion exchange then the result is small casein micelles in the milk, and this in turn results in a finer emulsion in the finished toffee. In some cases various sources of milk can

give rise to variation in the properties of the final toffee, and here the variation may be linked to the casein micelle size in the condensed milk. If a whey protein fraction is used with no casein fraction, then once again a very fine emulsion is formed in the finished product. The resulting toffee has a lower viscosity than normal and also shows some tendency to cold flow.

Boiled sweets and pulled sweets

In microscopical terms boiled sweets represent the simplest confectionery product. When properly made and stored they consist of a glassy matrix with occasional flavour / colour and air inclusions. Graining can occur due to either poor formulation or storage, and this is seen as crystals growing out of one another. In some jelly products (e.g. jelly babies) it is desirable for a small amount of graining to occur at the surface of the sweet whilst the centre remains glassy. In these products small changes in ingredients or recipe can lead to the graining developing too quickly through the body of the sweet.

Liquorice paste, cream paste and aerated confectionery

Liquorice paste: Introduction

Liquorice paste, or liquorice is manufactured for the production of pontefract cakes, count lines, pan centres and as sheets, tubes and rods for liquorice allsorts.

The texture of liquorice paste varies from the relative shortness and softness of pontefract cakes to the brittle hardness of some count lines, but most liquorice lines are smooth and firm and exhibit a chewy toughness; the texture of liquorice is mainly due to the ‘nature' of the ingredients and the method of treatment.

The manufacture of cream paste

Cream paste is manufactured by mixing together icing sugar and a mucilage in a heavy-duty Z-arm mixer, in which a homogeneous mix can be achieved repeatedly; it is essential that the viscosity of the cream paste is constant so that a uniform cross-section can be obtained when extruded through a die-plate.

There are two main processes by which cream paste is made: either with a non-boiled mucilage or with a boiled mucilage. The method adopted depends on the equipment available and the type of texture required. The current most usual method for the production of cream paste, and the one most suited to a continuous process, is the non-boiled system.

The extrusion of cream paste

Most cream paste is not used alone, but is layered with other colours of cream paste, or with pectin jelly, or with liquorice paste.

The cream paste is passed through brake rollers and /or extrusion heads to give the required thickness of sheet. The first extrusion is made onto a cold stainless-steel band, and a second layer is added. Other layers can be added to give the required effect, but once layering is complete cooling should be effected as quickly as possible by the use of a cooling tunnel. To avoid the possibility of condensation, the product emerging from the tunnel should be above the dew point, and so be in an ideal condition for cutting using rotary slitters and guillotine cross-cutters.

Aerated confectionery: introduction

The most cost-effective food ingredient is the one that is obtained free of charge, irrespective of the quantity used; such an ingredient is air. Air is a safe ingredient that adds bulk to a product without increasing weight, giving a ‘perceived value' benefit, an improved texture and an enhanced flavour.

Aerated food products can exhibit a whole range of textures depending on type of product, formulation, method of production and final density.

Nougat

Nougat is basically an aerated high-boiled syrup containing fat that has been stabilised by the addition of a whipping agent. Typical whipping agents used in the manufacture of nougat are egg albumen, gelatin, milk protein or soya protein, which can be used in combination with starch or gum arabic.

The production of nougat can be adjusted to give a range of textures that can vary between a long-eating, chewy, non-grained product and a short-eating, soft, fine-grained product.

Quality nougat of the white Montelimar type is made with egg albumen as the whipping agent. Honey is added to the syrup, and the additions include almonds, cherries and angelica. Other nougats, equally satisfactory but not of the same quality, are those based on a mixture of gelatin and egg albumen as the whipping agent, where the honey is replaced by invert sugar syrup and where the additions often comprise of hazelnuts, coconut, red and green jellies and honey flavour.

Nougat can be produced by either a batch or continuous method, but the batch method is considered to be a far superior system in terms of flexibility of production, textural consistency, the ability to absorb rework and the appearance after cutting.

The batch process consists of boiling a water, sugar and glucose syrup mix under vacuum to a moisture content of 8% at a temperature of 1200C. The vacuum cooker is used not only to reduce the time of boiling but also to produce a cooked syrup at a lower temperature - the higher the temperature, the longer the beating time.

The vacuum-cooked syrup is transferred to a robust and powerful atmospheric whipping machine that can operate on two speeds, low for mixing and blending and high for aerating. A gelatin solution is blended into the cooked mass before being aerated at high speed, when the density is reduced to 0.85 g/ml; fat, nuts, fruit and, if required, a small quantity of icing sugar to induce graining are then blended into the aerated product at low speed.

The nougat is discharged from the whipping machine into metal trays lined with rice paper and allowed to condition overnight. Here the induced fine grain can be developed in the product prior to cutting into the required shapes at a final water content ranging from 9.5 to 10.5%.

Chemistry of Flavour Development in Chocolate

Fermentation

The problems of defining the flavour mechanisms which occur during fermentation are difficult and as yet have not been definitively elaborated due to the many variations in fermentation methods. There are undoubtedly as many different methods of fermentation as there are countries that produce cocoa beans. It can be said that the beans undergo an anaerobic hydrolytic phase followed intermittently with an aerobic phase. The timing, sequence of events and degree of hydrolysis and oxidation may be highly variable from fermentation to fermentation. The presence and concentration of the many flavour precursors which occur during this stage are dependent on enzymatic mechanisms. A summary of enzyme-catalysed reactions and their products is presented in Table 1. Not only are flavour precursors produced, but colour changes also occur.

Drying

Following the fermentation process the beans are dried. This drying process is also instrumental in flavour precursor development. Indicators of good drying practices relating to flavour quality of the beans are good brown colour and low astringency and bitterness. Freedom from off-flavours such as excessive acidity and hammy/smoky flavour are also indicative of proper drying.

It is during the drying phase of cocoa curing that the characteristic brown colour of chocolate develops. Major oxidizing reactions occur with polyphenols catalysed by the enzyme polyphenol oxidase. The death of the bean, with loss of membrane integrity, allows previously restricted enzymatic reactions and results in brow colour formation.

Modern technology has changed the dependence on the sun for drying and includes artificial or mechanical drying processes which are not without drawbacks. With mechanical driers, where high temperatures may be used, case-hardening may result. Excessive heat and rapid drying may not allow for adequate loss of the volatile acids, e.g. acetic acid, and therefore are detrimental to quality. There also may

be situations where the water activity within the bean in such that the drying process is merely a continuation of the fermentation process and many reactions can proceed. A high level of water activity, as a result of incomplete drying or rain soaking, may also result in mould contamination, particularly noticeable for beans in transit.

The isomerization products formed during the initial phase are primarily addition compounds formed from amino acids and sugars. During the intermediate stage they are then dehydrated, fragmented and transaminated, forming complex compounds, depending on temperature and pH. On the acid side, generally hydroxymethylfurfural and other furfural products are formed. If the pH is neutral, the result of the reaction is reductones. All of the intermediates are very complex, and little is known about their structure and the exact nature of their formation in food systems. In the end, however, a host of compounds, depending on the substrates and the pH, will polymerize and in turn contribute to the final chocolate flavour. Some of the most important compounds are pyrazines, pyrroles, pyridines, imidazoles, thiazoles, and oxazoles.

An important interaction in the intermediate stage of the Maillard scheme is a specific type of amino acid degradation called Strecker degradation. Amino acids are tasteless and odourless: even the sulphur-containing ones have no flavour unless they are contaminated. An example of Strecker degradation is the interaction of the amino acid glycine with glyoxal. Glyoxal is a 1,2-dioxo compound and acts as an acceptor during transamination. Dioxo compounds may result from the formation of the dehydroreductones, sugar fragmentation and dehydration reactions. With Strecker degradation, glyoxal forms a nitrogen-containing moiety needed to form ringed compounds after reacting with glycine. The amino acid is decarboxylated and deaminated, producing an aldehyde which, in this example, is formaldehyde. This nitrogen-substituted 1,2-dioxo compound (now 2-amino-ethanal) could combine with a duplicate molecule. When the two compounds react and one further oxidized, pyrazine is formed. This is one of the major pathways for pyrazine formation during the browning reaction.

Conching

Conching can be described as the working of chocolate flake and crumb into a fluid paste. Before the invention of roller refiners, chocolate paste was coarse and gritty. The use of a machine called a ‘conche', so named because of its resemblance to the conche shell, changed the texture. After, pounding for days in a conche, the chocolate and sugar particles were thought to be reduced in size, giving the conched chocolate a smooth mouth feel. Thus, the conche was initially used to refine the texture. Since preconche chocolate can now be adequately refined without this time-consuming process, the question must be asked, ‘why do we continue to conche?'

Although conching allows the chocolate mass to be further mixed, it is the modification in flavour that becomes important. Typically, conched chocolae is described as mellow compared to unconched. The bitterness is reduced, perhaps allowing other flavour notes to be more pronounced. The nature of the flavour change during conching has not been completely explained at the chemical level even though much has been learned about the total volatiles, free fatty acids, pyrazines and sulphur compound concentrations.

Confectionery Coatings, Chocolate Replacers, Dietetic Compounds

CONFECTIONERY COATINGS

The manufacture of vegetable fat coatings has developed into an industry almost as large as that of chocolate itself. These coatings are of many types. Some closely resemble true chocolate, dark or milk. Others-made from cocoa powder, nonfat-milk powder, sugar, and one of the many vegetable fats - may have an appearance resembling dark or milk chocolate but a texture that is quite different. Then there are the pastel coatings that usually consist of milk powder, sugar, and a vegetable fat, with added flavors and colors.

Conditions to Be Observed During Production

Tempering and cooling. With compound coatings, for best results, the conditions for molding, enrobing, and cooling should be adjusted according to the properties of the fat phase in the coating.

The three basic groups of fats (i.e., cocoa butter equivalents, lauric and nonlauric replacers) are responsible for influencing the fat crystallization in the coating.

Cocoa Butter Equivalents. These require the same tempering and cooling procedures as chocolate. They are polymorphic.

Lauric Replacers. These are based mainly on coconut and palm kernel oils and are not polymorphic. They crystallize spontaneously, on cooling, in one stable form, and this takes place with in a narrow temperature range and is very quick. These coatings do not need tempering. Molding of thin bars and the enrobing of confectionary. centers can be done with fully liquid coatings at 40 to 45°C (140 to 113°F). Preferably there should be quick cooling with maximum air velocities and this gives good contraction. With large blocks, some tempering, by reduction of the temperature of the coating during mixing until seed is formed, is preferable. In these circumstances, rapid depositing is necessary.

Nonlauric Replacers. These fats are also not polymorphic and crystallize in stable form on cooling. Generally, they crystallize more slowly and their contraction is less pronounced. Coatings prepared from these fats do not need tempering and can be used at 40 to 45°C (104 to 113°F). They do, however, need to be cooled slowly with lower air velocities.

Condition of Centers, Molds. Molds should be warmed to about the temperature of the deposited coating, and centers to 75 to 85°F, but if large cakes, cookies or aerated centers are being coated, temperature of these centers will be higher.

Cooling. It is necessary to emphasize the differences in cooling procedure between chocolate, cocoa-butter equivalent fat coatings, and lauric and nonlauric fat coatings.

Sanitation of Machinery, Tanks, Pipelines. Because of the incompatibility of lauric fats and cocoa butter, enrobers and other equipment used for chocolate should not be used for lauric fat coatings unless they are completely cleaned of chocolate residue.

With enrobers, this is an exceptionally difficult task, and it is best, if possible, to used separate enrobers for each type of coating.

Storage. Storage conditions for lauric-compound-covered confectionery are different from those for chocolate or cocoa-butter-equivalent coatings. It is best to store dark chocolates at a temperature of about 12°C (54°F) or below but lauric coatings should be stored at 20 to 22°C (68 to 72°F). Nonlauric coatings are generally best under conditions similar to those for chocolate.

Whatever the conditions are, they should be fairly constant. Wide fluctuations are bad and the relative humidity should be 50 to 55 percent.

Colored Coatings and Pastel Coatings

The fats mentioned previously can be used for colored coatings and the processes for manufacture are similar to those for light and dark coatings.

Flavor. The fat and milk powder should not impart any significant amount of flavor of their own to the product, but with some coatings caramelization may be derived from the milk powder by the use of high mixing temperatures. Spray process powder is preferred for these coatings.

There is a variety of flavors that can be added and these are preferably oil soluble. Fruit flavors combined with citric acid (0.1 percent) help to reduce sickliness, in fact, some slight acid addition is desirable with most flavors. Flavors should generally be added in the last stage of processing.

Diabetic Chocolate

For persons suffering from diabetes, the forbidden ingredients in chocolate and confectionery are obviously sugar, dextrose, invert sugar, and starch-conversion products.

Manufacture of Diabetic Chocolate. The ingredients-cocoa liquor, sorbitol, artificial sweetener (Saccharin), nuts, and fats-are mixed to a suitable paste for refining.

The refining stage presents some unusual features since the sorbitol crystals are different from sugar, being elongated in shape and relatively soft, and tend to grind into flat plates instead of roughly rounded particles. This fact, together with the hygroscopic nature of sorbitol, can result in moisture absorption from the air under conditions of high humidity, and this can cause trouble at the conching stage.

Medicated Chocolates

Chocolate and cocoa, and to a lesser extent cocoa butter, are often an ingredient of tablets and pills used for therapeutic purposes. Chocolate is a suitable and pleasant carrier for many medicines with an objectionable flavour, and is particularly applicable to children's medicines. It can also be used for coating capsules.

Chocolate Bars and Covered Confectionery

Chocolate Drops (Chips)

Chocolate drops or chips are made in very large quantities. They are sold in small bags for household use and in bulk for inclusion in cookies and other flour confectionery products.

A necessary precaution with bulk packing is to see that the drops are completely cooled. If they are not, latent heat evolved in the bulk pack will raise the temperature of the drops well above ambient and ultimately severe fat bloom will form.

Drops are produced usually in small pyramid shapes but also may be deposited as small flat domes. These can be coated with colored nonpareils before the chocolate is set. Packed in attractive colored transparent bags, they make a popular children's product.

Roller Depositing

This production system has been designed for the manufacture of small solid articles using chocolate or other fat-based compounds. The articles may be "lentil" centers, coffee beans, small eggs, balls, and so on, and they are formed in a pair of stainless-steel rollers in which the two halves of the article have been engraved.

The hollow rollers are equipped with a special coolant circulation system. This cools the rollers in such a way that when the liquid tempered mass is fed between them, it forms a partly cooled continuous belt containing the shaped articles. This continuous belt is then passed through a cooling tunnel for the final cooling process. The cooling tunnel length can be designed to suit requirements, that is, if space is a problem, then a multipass cooler can be arranged that will reduce the length of the cooling tunnel.

After cooling, the web is transferred by conveyor to a rotating perforated drum. The speed of rotation and the angle of inclination of the drum are adjusted to separate the shaped articles from the flanges connecting the articles during forming. This process also smooths the surfaces for further processing, such as sugar or chocolate panning or polishing. The pieces passing the drum perforations are reprocessed.

The capacity of the roller line will depend on the width of the rollers and the number of pairs installed and can vary between 275 and 1,300 lb per hour.

Design of the roller assembly facilitates complete replacement and change of product.

Aerated Chocolate

Aerated chocolate in bar or tablet form has been a very popular product for many years. The basic method of preparation is to subject well-beaten tempered chocolate to vacuum. The small bubbles will expand, producing a cellular product, and in this form it must be set by cooling. If the vacuum is released while the chocolate is still warm, the aeration will collapse.

A similar product may be made by mixing chocolate with carbon dioxide under pressure. Under these conditions, the gas is partially soluble in cocoa butter.

This chocolate may be released through nozzles to normal atmospheric pressure where upon a

cellular product, very similar to that formed by vacuum, is produced.

A third method relies on the addition of certain fatty substances and vigorous mixing. This gives a fine aeration that is not prone to collapse under normal chocolate handling processes.

Measurement of Degree of Temper

Well-tempered chocolate contains approximately 3 to 8 percent cocoa butter crystals.

It is necessary with large molding machines and enrobers to know quickly whether chocolate being used is properly tempered. Experienced chocolate workers can assess the degree of temper fairly well from touch and by setting a small sample on metal foil. Temperature recording gives some confirmation. However, the precise degree of temper needs rapid scientific confirmation if large machines are to work consistently.

One instrument developed to accomplish this is called the Tempermeter. It is based on the principle that under controlled conditions of cooling chocolate there is a relationship between the cooling curve and the degree of temper.

The instrument consists of a temperature recording probe that is immersed in the sample of chocolate contained in a narrow tube. The tube is immersed in ice water and the probe is connected to an automatic recorder that prints the temperature on a moving chart at equally spaced intervals of time. Thus, a cooling curve is formed and the shape and slope of the curve depend on the degree of temper. The curve is produced in about 4 min.

The latest instrument by Sollich uses a transparent inclinometer, which greatly facilitates the measurement of the slope of the cooling curve.

The Westal SCB Process

This process is for the production of filled items in one depositing sequence.

The basic principle of operation has been used for over fifty years by, notably, Cadbury and Toms of Denmark. The machine was developed and made commercially available in 1978 by Westal Ltd., now a division of Baker Perkins.

The principle of the process is the simultaneous depositing of liquid chocolate and confectionery into a mold. Deposits are shaken down into the mold impression and, after cooling, a complete shell with filling is formed.

MOLDING AND SHELL PLANT COOLERS

Problems arise in the cooling of chocolate in molds and shells that differ from those in enrobers. The following are important points.

GOOD MANUFACTURING PRACTICE

In all molding plants, efficiency depends on obtaining 100 percent ejection of units from the molds because, if some of the molds become blocked, they have to be removed from the cycle. The chocolate that has stuck to the mold must be removed by hand and the mold cleaned. With equipment for shells and filled articles, this can be a very expensive operation and the disposal of the rejected material poses another problem.

Good demolding depends on proper tempering of the chocolate, adequate and even cooling, and starting with clean molds. Good tempering will result in good contraction, but milk chocolate is more difficult to demold than dark chocolate because of the soft milk fat it contains; this applies particularly to small shell chocolates, for which it is often desirable to use a chocolate with reduced milk or milk fat content.

Mold cleaning is done periodically. Special washing equipment is used for this purpose.

High-pressure hot-water jets with some detergent are used, followed by a rinse, preferably with soft water, and hot-air drying.

Care must be taken in the washing of plastic molds and information should be obtained from the manufacturers regarding suitable detergents.

CHOCOLATE ENROBING

Chocolate assortments, confectionery bars coated with chocolate, and chocolate cookies and cakes are all manufactured by the coating process known as chocolate enrobing. Reference has been made to hand covering, but the coating of chocolates by this process is reserved for the very expensive assortments mostly sold in exclusive shops.

Confectionery and extrusion cooking technology

The chemical polymer industry started using extruder equipment in the forties with the so-called melting extruders based on design concepts of mixer compounders. The food industry discovered the cooking extruder in the fifties, and in the beginning used the equipment for the production of cooked and expanded snacks based on corngrits and other cereals. Most of the equipment used employed the so-called single-screw extruder concept. Twin-screw extruder equipment dates back to the sixties. A technological reason for the use of twin-screw extruders is the need for equipment capable of handling high viscosities, as they are known in confectionery, or to process low and high viscosities in a single recipe at the same time in one piece of equipment. Although most confectionery articles are unique, it is clear that the basic components are sugar (sucrose), starch syrups (treacle) and starch or flours. At the same time water is always part of the recipe, and this is a reason for the selection of extruder equipment as an innovative tool in this area, since drying costs are responsible for a great deal of the price of the goods. Cooking extruders offer the possibility of processing confectionery goods at lower process moisture conditions compared with conventional processing, thus leading to attractive savings.

Problem description

In conventional confectionery processes, water is used to dissolve sucrose crystals at preset temperatures, as described by Honig. The products are cast in corn starch and the water is removed to equilibrium conditions in order to give as long a shelf life as possible. For this operation careful and time consuming drying is necessary at temperatures between 45 and 700C. The low diffusivity constants for water in sugar-like materials determine the rate of drying.

It is clear that these methods are energy-consuming. It would be more attractive to develop a cooking method at which the water percentage is as close as possible to the moisture level of the end product.

Sugar confectionery in the diet

Confectionery is a food which provides pleasure, the popularity of which is demonstrated by the large number of people who regularly purchase these food items.

Confectionery in society

Confectionery is often given as a gift because of the pleasure it bestows and because its ready portability makes it easy to send long distances. Confectionery in one form or another has been given as presents for many years, and carries with it connotations of luxury and indulgence. It also makes a pleasurable experience more pleasurable (e.g. a visit to the cinema or a trip to the seaside).

For children, confectionery is an important part of games, in part because of the interesting colours and shapes and partly as it is something that can be shared as a gesture of affection, which of course is not only limited to children. In order for the confection to be shared, it needs to either be in individual pieces or able to be broken up easily.

With changes in eating patterns and the move away from formalised eating regimes, meals are more often consumed ‘on the way', so the portability and long shelf life of confectionery makes it a useful adjunct to this style of eating.

What is a healthy diet?

As noted above, a healthy diet contains all of the necessary nutrients, without harmful excesses, from a wide variety of foods. The healthy majority of people eat the foods which suit them and which, as individuals, they prefer. Their diet provides sufficient nutrients for their needs.

The flavouring of confectionery

Other ingredients such as gums, pectin, gelatine, starch, milk, butter, other fats and cocoa, do most to give special textures, although it must not be forgotten that air and water probably have the greatest effect in confectionery. Other ingredients which also play a apart include liquorice, honey, nuts, coconut, raw sugar (molasses), malt extract, dried fruit, fruit, and fruit juices. These ingredients are added usually for their flavouring properties, or for their contribution to the eating quality, mouthfeel or nutritional value of a confection. Some products owe their total appeal to these added ingredients. The flavour industry also provide extracts, concentrates and flavourings to suit requirements for all these confectionery types.

Temperature and cooking (or heating) times also play an important role in determining final taste and texture as they have a significant effect on flavour and flavour development.

Figure 1 shows temperature bands for producing various confectionery types. The apparently large range is normal, and takes into account recipe differences and texture required. Lower boiling temperatures enable crystallisation to occur and a variation even as small as 0.5°C can make a significant difference to the texture of most types of confectionery.

Basic Confectionery Types, Recipes, Inherent Flavours

1. High Boilings (Hard Candy)

Candy is collective U.S. name for sugar confectionery, whereas in the United Kingdom it describes a special crystallised type.

Manufacturing method: Sugars and corn syrup are dissolved and boiled together until a temperature of about 145°C is reached. Butter is then added and gently incorporated to preserve as much of its flavour as possible. The batch is then boiled to the final temperature of 145-160°C. Where higher temperatures are preferred, special arrangements for direct heating (gas) may have to be made, since they are often too high for steam heated equipment. The mass is then cooled and flavouring incorporated, before the product is cut and wrapped. Generally lemon, usually in the form of lemon oil is added, since it is said to neutralise the greasy effect of fat. Vanilla flavourings are often used to enhance the character of the product and butter flavourings are popular too, as they increase the overall buttery taste. Flavourings of commerce intended for this confection generally contain all these components in carefully balanced amounts.

Emulsifiers, colours and flavours

EMULSIFIERS

An emulsion is a disperse system of two immiscible liquids, typically an aqueous phase and a lipid phase, and occurs commonly in food systems. Emulsifiers are a class of substances that help to form or stabilise an emulsion (figure 1). Some natural products, particularly gums and proteins, act as emulsifiers. Such natural products often escape being defined legally as emulsifiers even though they are undoubtedly emulsifiers in practice. Substances capable of acting as emulsifiers tend to have one part of the molecule that is best suited to oily surroundings, i.e. it is said to be lipophilic, while the other end of the molecule is best in an aqueous environment, i.e. it is hydrophilic. The two opposite terms hydrophobic (meaning water-heating) and lipophobic (meaning fat-heating) - are also in use. Emulsifiers are classified by a system of HLB numbers which refer to the ratio of hydrophilic to lipophilic groups present. Molecules with both hydrophilic and lipophilic groups are referred to as amphiphilic, and emulsifiers, whether natural or synthetic in origin, tend to be amphiphilic.

Technical Requirements of Colours in Sugar Confectionery

To be used successfully in sugar confectionery a food colour needs the following attributes as well as complying, with the appropriate legislation: it should be stable to heat and light; it should be stable to reducing sugars; and resistance to sulfur dioxide is also useful. Most of the colours used in sugar confectionery are water soluble. This is simply convenient as most sugar confectionery products contain very little fat anyway.

Flavours

Chemically, flavours are complex substances,1 and it is convenient to divide them into three groups: natural, nature-identical and synthetic.

Nature-identical Flavourings

These are ingredients that are identical to those that occur in Nature, but which are synthetically derived. From time to time it emerges that one substance produces a given flavour; for example, most chemists know that benzaldehyde has a smell of almonds. If a natural flavouring can be represented by a single substance, and if that substance can be synthesised, then the flavour is likely to be available as a nature-identical flavour. Vanilla flavour is a good example. Vanilla flavour can be all natural and derived from vanilla pods, nature-identical or artificial. The nature-identical product is based on vanillin, which is present in vanilla pods and has a flavour of vanilla. The artificial vanilla flavour will most likely be ethyl vanillin, which is not present in vanilla pods but has a flavour two and a half times stronger on a weight basis that vanillin. The claim ‘nature-identical' does not seem to be much appreciated in the English speaking countries whereas in some other countries it is an important claim for marketing purposes.

Confectionery Plant

Confectionery Plant

Most sugar confectionery is made by a process of dissolving sugar in water and boiling the sugar syrup with glucose syrup in order to concentrate the resulting mixture, and originally this was done in a saucepan on a stove. Small quantities of confectionery are usually made in this way although industrially the only products now normally made by this sort of process are those that require a temperature that is too hot for steam cooking.

In the confectionery factory the saucepan has been replaced by the steam heated pan. Steam heat provides a controllable way of heating food products - one advantage is that the maximum obtainable temperature is restricted to that of the steam. The use of steam implies a steam boiler and a system of pipes are needed to distribute the steam but the use of a central steam boiler can be avoided by using self-generating steam pans. In these devices, steam is generated in situ either from electric or gas heating, and using a self-generating pan avoids the capital cost of a boiler and the necessary boiler inspections and insurance.

The alternative to a central boiler is to use steam generators near to where the steam is needed. These devices, fired by gas, use a steam coil rather than a water or fire tube boiler - an advantage is that the losses in distributing steam are avoided; also, the cost of keeping a large boiler running at times of low steam consumption are avoided. Another advantage of the steam generator is that it can operate with a much higher level of dissolved solids in the feed water since dissolved solids in steam boilers tend to be deposited on the heating surfaces. This type of deposition creates problems since the boiler scale is a poor conductor of heat. This can lead not only to loss of efficiency but also to buckled boiler plates caused by thermal distortions. Dissolved solids in boilers can also cause problems with priming, i.e. liquid water carrying over into the steam.

Continuous Plant

Many process industries have converted from batch to continuous plant; Using a continuous plant is not as easy in the food industry as it is in the chemical industry since considerations of hygiene must now be added. The plant, therefore, will have to stop periodically for cleaning although continuous plants do tend to produce a more consistent product than batch processes. The most general problems with a continuous plant normally occur in setting up.

A particular confectionery industry problem is the long product life. A long-established product, initially made by a batch process, must retain the same qualities when prepared by a more modern continuous plant process, and a great deal of work can go into making the two products exactly the same.

In general, however, the continuous plants are more effective at heating the product and produce less sucrose inversion, although, even after the recipe has been adjusted to account for this, textural differences sometimes persist.

Ingredients

Ingredients

Sucrose is extracted either from sugar beet or sugar cane. Normally, the two sources are equivalent even though the trace impurities are different. There is one area where the two sources are not equivalent and that is regarding brown sugars. Cane sugar that has not been completely purified has a pleasant taste and can be used as an ingredient. Beet sugar, however, is not acceptable unless it is completely white. In some products, brown sugars or even molasses (the material left after sugar refining - see below) are used to add colour and flavour. Alternatively, in some products a less than completely white product is used simply to save money. Beet sugar refiners do produce brown sugars which are produced by adding cane sugar molasses to refined beet sugar, some specifications of which are given in Table 1. Brown sugars used in confectionery are carefully controlled products: they are not refined to a high degree of purity but they are produced with carefully controlled levels of impurity. Raw sugar is not normally used in confectionery, although there is one exception where very small tonnages of health food confectionery are made using raw sugar.

Butter Oil (Anhydrous Milk Fat)

Butter oil is covered by an International Dairy Federation specification for anhydrous milk fat. Butter oil is milk fat with the water content reduced to 0.1% or less. It can be made by concentrating cream to 75% followed by treatment in a phase inverter before centrifugal separation, although it is more common to make butter oil by melting the butter and removing the water with a centrifugal separator. At one time, butter oil was being made from butter that had been held in intervention stores. Owing to its low water content, butter oil has a very long shelf life and avoids the problems normally associated with butter storage. In some countries with no milk production, butter oil is combined with skim milk powder to produce milk products such as sweetened condensed milk, evaporated milk, ice cream and UHT milk.

Gums and Gelling Agents or Hydrocolloids

Legally speaking, another title which some of these ingredients fall under is that of thickeners and stabilisers. Some are only minor components of confectionery and can properly be regarded as additives; others are used in quantities which make them ingredients.

Gelling agents under appropriate conditions self-associate to produce a three-dimensional structure. Some gelling, as with gelatine, is thermoreversible; other gelling, such as with high methoxyl pectin, is irreversible. Apart from the effects on the texture of the product, an irreversible gelling agent is more of a problem in the factory since it cannot readily be recycled.

As the setting conditions for high methoxyl pectins require high soluble solids and a low pH, high methoxyl pectins are used for making low pH products such as fruit jellies. Th high methoxyl pectins are further subdivided by their speed of gelation. The speed of gelation is controlled by the DM. A DM around 72% gives a rapid set while a DM below 64%. In confectionery products the soluble solids are so high that only slow set pectins are used since a rapid set pectin would pre-gel under these conditions.

Low methoxyl pectins have radically different properties to those of the high methoxyl forms - the small chemical modification has totally altered the way in which the pectins behave. The gelling conditions for low methoxyl pectin require a pH of 2.8-6.5 (outside of which range the product would be inedible) and between 10 and 80% soluble solids in the presence of calcium.

Practical Forms of Egg Albumen

Fresh egg white is not normally used in confectionery as it is too unstable and could have bacteriological problems. In practice, various forms of dried albumen are used - these have the advantage

that they can be thoroughly tested bacteriologically before use. The form most commonly used in confectionery is dried egg white which is typically made by pouring egg white into shallow trays and drying it. The resulting sheets are then ground to final size. This type of product is a low technology product although it is possible to apply sophisticated drying methods, e.g. spray drying, to produce egg albumen that will reconstitute to a product similar to fresh egg white. ‘Fluff dried' albumen is made by whipping the albumen followed by rapid drying of the resulting foam.

Chewing Gum Ingredients

Chewing gum of necessity needs an ingredient that is scientifically a rubber. This does not mean that it is made from the sort of natural rubber that household gloves and similar products are made from. The specialised materials concerned are considered below.

Chewing gum

Different gum bases are used for chewing gum and bubble gum. Bubble gum base contains either higher levels of polymers or polymers with a higher molecular weight. Both of these foundations make the gum base more extensile and hence able to form bubbles.

Special non-sticking gum bases have been developed in order to avoid the problem of discarded gum becoming a nuisance. These products are very different to ordinary gum bases.

Gum Base Characteristics

The characteristics of the chosen gum base that is used depends not only upon the chewing properties of the finished product but also upon the type of gum being made. For example, chewing gum that is being pan coated has to be more rigid that gum that is being presented as a stick. If too soft a gum base is used on a pan-coated gum, instead of the product being presented as a neat pillow shape it will be distorted.

Texturisers

Texturisers are substances that are added to the gum base to modify the mouth feel and facilitate processing. Common texturisers are calcium carbonate or talc - both substances obviously have to be of food grade. As both talc and calcium carbonate are less expensive that the other ingredients in gum base, not surprisingly, this leads to low cost chewing gum bases containing 45-55% texturisers whereas for a high quality chewing gum base the texturiser levels are 18-20%. Similarly, bubble gum bases have a texturiser level varying between 30 and 60%, the higher levels being found in the most economical grades. As can probably be expected, gum bases with the higher levels of texturiser place more constraints on the rest of the formulation if a satisfactory product is to be made.

Dextrose

Dextrose monohydrate is sometimes used as an alternative to sucrose in chewing gum, and in some countries this substitution is economically advantageous. The endothermic heat of solution of dextrose gives a cooling sensation in the mouth, a property that goes well with mint flavours but not with others.

Glucose Syrup

The glucose syrup used in chewing gum is normally confectioner's glucose of about 38 DE, the only special requirement being that the sulfur dioxide level of the syrup should be less than 40 ppm. Glucose syrups intended for use in confectionery can contain up to 300-400 ppm SO_2; although in most other sugar confectionery products, e.g. boiled sweets, the glucose syrup is boiled, during which any SO_2 is boiled off. Obviously, these syrup are not suitable for use in chewing gum. The 40 ppm limit for the syrup arises because a chewing gum can contain 25% glucose syrup and the finished product should not contain more than 10 ppm of SO_2.

Traditional Chocolate making

A mixture of the ground cocoa beans and sugar would not by itself produce the solid chocolate so familiar to the modern consumer. Instead it would give a very hard substance which would not be pleasant

in the mouth. In order to enable it to melt easily it is necessary to add extra fat. This can be obtained by pressing the cocoa beans and removing some of the fat content, known as cocoa butter. The ability to extract this fat was developed in 1828 by Van Houten of Holland, and had a double advantage: the expressed fat was used to make the solid chocolate bars, while the remaining lower-fat cocoa powder could still be incorporated into a drink. This ‘drinking chocolate' was in fact usually preferred as it was less rich than the original high fat mixture.

Outline of Process

The processing of chocolate is related to obtaining these two criteria, and is therefore devoted either to developing the flavour of the product - using a raw bean would produce a very unpleasant taste - or treating it so that it will flow properly and be free from large gritty material.

Although many different methods of chocolate-making exist, most traditional ones are based on the process outlined in Figure 1 and briefly described below. Further details are given in the relevant chapters of the book.

1. Preparation of cocoa nib - flavour development

The cocoa tree produces pods containing a pulp and the raw beans. The outer pod is removed together with some of the pulp and the beans are fermented. This enables chemical compounds to develop inside the beans, which are the precursors of the flavour in the final chocolate. Failure to carry out this stage properly cannot be rectified by processing at a later date.

2. Grinding-particle size reduction

Up to this stage the cocoa is in discrete pieces, several millimetres in diameter. Subsequent processing may take several forms, but all require the solid cocoa particles, sugar and any milk solids to be broken so that they are small enough not to be detected on the tongue. The actual size depends upon the type of chocolate and the market in which it is sold, but in general the vast majority of particles must be smaller than 40 m (1.5 ×10-3 inch).

3. Conching-flavour and texture development

Although the fermentation, drying and roasting are able to develop the precursors of chocolate flavour, there are also many undesirable chemical compounds present. These give rise to acidic and astringent tastes in the mouth. The object of conching is to remove the undesirable flavours, while developing the pleasant ones. In addition, the previous grinding process will have created many new surfaces, particularly of sugar, which are not coated with fat. These prevent the chocolate flowing properly when the fat is in a liquid state. Because of this the chocolate cannot yet be used to make sweets, and does not have the normal chocolate texture in the mouth. The conching process, therefore, coats these new surfaces with fat and develops the flow properties as well as the flavour. This is normally carried out by agitating the chocolate over an extended period in a large tank. Some manufacturers prefer to limit the conching time by restricting the conching process to primarily one of liquefying the chocolate. This is made possible by treating the cocoa mass at an earlier stage in order to remove some of the less desirable volatile chemicals.

Sugar-free Confectionery

Laxative Effects

One problem with all of the polyols except erythritol, and to a lesser extent with polydextrose, is that they can have a laxative effect. This effect is osmotic in origin where the unabsorbed material upsets the osmotic balance within the gut; the necessary correction can have unpleasant consequences. Although values for acceptable consumption are published, the response of individuals varies considerably; a few individuals are hypersensitive to this effect, whereas some other people are largely insensitive to it. Warnings to this effect are required in the UK, and the laxative threshold has to be the most effective limit to consumption yet devised. Erythritol avoids the laxative effect because it is excreted via the kidneys.

Making Sugar-Free Products

In general, sugar-free confectionery is made to imitate sugar-containing confectionery. The argument in favour of this is that the consumer already knows the product and if an acceptable sugar-free analogue is made then the consumer is likely to be satisfied. The problem with this approach is that none of the sugar substitutes is an exact substitute for sucrose, so making an exact match of the sugar and glucose product will probably not be possible. Indeed, this has been found in practice: sugar confectionery products have developed around the properties of sucrose and glucose syrup, and making imitations of these products but using other ingredients is inherently difficult. There is the possibility of making products that are based around the inherent properties of the sugar-free ingredients, which indeed could not be made with sucrose. There is, however, little evidence of this happening.

Reducing the Energy Content

A popular claim, particularly in the English speaking countries is the term ‘low calorie'. Calorie reduction in most products is made by one of a number of ways: replacing ingredients with water; lowering the fat content; reducing the density; or making the portion smaller. In sugar confectionery, replacing ingredients with water is not really possible without making the product unstable. Some sugar confectionery products do not have any fat in them anyway, whereas in others, because fat is more expensive than sugar, the fat content is already near the technically necessary minimum. The density of the product can be reduced by aerating it.

The Problems of Making Sugar-free High Boilings from Isomalt

The inherent technical problems of making high boilings from isomalt are considerable but they have been solved. Isomalt has only 45-60% of the sweetness of sugar, and therefore the reduced sweetness is normally made up by adding an intense sweetener. Also, the solubility of isomalt at 20°C is only 24.5 g per 100g water; thus at low temperatures isomalt and water are handled as a slurry. In the temperature range between 90 and 180°C isomalt masses are less viscous than a sugar and glucose syrup mass and this lower viscosity tends to cause problems in plants designed to process sucrose and glucose syrup high boilings. A further related problem is the need for more cooling, needed because the mass could be hotter and because the heat capacity is approximately 17% higher than for a sucrose and glucose syrup high boiling. The low viscosity of the mass can cause problems with the discharge system from the vacuum chamber of some plants.

Quality Control and Chemical Analysis

Introduction

The better the quality, the greater the cost'. For years, this supposition was thought to be valid, and indeed, where the quality control emphasis is on finished product inspection, then it will apply. Under this policy, insufficient attention is paid to the earlier parts of the process - out -of-specification materials are used, correct operating procedures are not followed, production operators are unaware of the standards they should be working to and therefor unaware of the process running ‘out of control'; at the end of the manufacturing line reject product is sorted from that which, by chance, complies with the quality standards, and significant quantities of scrap are produced at appreciable cost of the company.

Under these conditions, when manufacturing management is under pressure to meet volume targets, a common remedial action is to increase the speed of the production line. Unfortunately, this generally results in the line becoming further out of control and generating even greater volumes of scrap.

The answer to the problem is to adopt the correct approach to quality control, that of prevention rather than cure, of controlling the whole manufacturing operation from raw materials through to despatch of finished product, the policy of getting it ‘right first time'.

Designer quality

The basic principles of quality control apply to all manufacturers, regardless of the end product. However, each company is unique in its operation, and the parameters critical to the quality of its products

will differ from those of other companies, even within the same industry, depending on the products manufactured, the processes employed and the market sector within which the company operates.

Quality control procedures therefore need to be tailored to fit the requirements of each individual company, and indeed each manufacturing operation within the company. Hence the concept of ‘designer quality'.

Quality must be ‘designed' into a product as part of the development process; this starts with a product brief from marketing, which includes a definition of the quality standards. These are, therefore set by marketing, but not in isolation from other functions. It is absolutely crucial that all relevant managers are involved in this process, to ensure that they are not only aware of the standards required, but are also in agreement that the standards are achievable in practice.

Having defined the standards, it is the responsibility of each department to fulfil its role in ensuring that they are adhered to, from the procurement of materials by purchasing to the correct specification through to distribution, ensuring that products are stored and despatched to customers under the correct conditions. The role of the quality control department is to monitor all the activities involved, report variances from standard and then work in conjunction with the relevant departments to identify the causes of such variances, correct them and implement procedures to prevent recurrences.

Control of Raw Materials and packaging

‘Know your supplier' is a very important maxim in ensuring the consistent quality of materials supplied. A good working relationship needs to be built up with suppliers; visits should be made to suppliers' premises to gain knowledge of their process capabilities and assurance that they will be able to supply to the required specification. Equally, suppliers should be invited to customers' premises, to become aware of the products and processes in which their materials are used and the difficulties caused by supplying material outside specification. Such reciprocal visits, and regular dialogue between technical staff, achieve a greater understanding between customer and supplier, the benefits of which are invaluable.

Process control

In a batch process, all parameters can be controlled for each batch, which in theory, should make all batches identical. However, in practice minor variations occur between batches and a continuous process will therefore lead to a more consistent product, as long as it is adequately controlled. Wherever possible, on-line checks should be automatic, e.g. temperature read-outs, although these need routine manual validation. On a continuous line, regular checks should be made on the levels of addition of ingredients which are pumped in, such as acid solutions, flavours and colours.

Finished packs

Important attributes are general appearance, closures, correct data or batch coding and pack weights; inefficiency in this last-mentioned area can be extremely costly to a company. When packing to a set weight with an indeterminate number of pieces per pack, adjustments can, of course, be made during packing. This does not, however, detract from the importance of controlling individual piece weights during manufacture, since this has a bearing on the achievable pack weight. With a pack containing a fixed number of units, e.g. a presentation pack of pectin jellies, then weight control during manufacture becomes crucial.

Sensory evaluation is very subjective, but becomes less so with correct training of the panel, a carefully considered questionnaire and the proper use of statistics. The technique of sensory profiling, developed in the UK by the Campden Food and Drink Research Association, is a useful step forward in this area and, as well as being a quality control tool, has a particular application in product development. Here, the desired attributes are initially defined, a theoretical profile is then built up, and the product is developed to match that profile.

Medicated confectionery and chewing gum

High boiled sugar medicated confectionery

The manufacturing methods employed are similar to regular boiling techniques - continuous or batch - utilizing plastic or depositing methods for forming and, for some products, centre filling. Both sugar and sugarless technologies are available. The regular ‘plastic forming manufacturing uses a cooked sugars base in which sugar and glucose syrup (normally 42 DE, 43 Be) are blended proportionately in ratios varying from 60 to 50 parts sugar and 40 to 50 parts glucose syrup (as received). The ratio is variable for different types of equipment to prevent sugar graining. The glucose syrup content can be varied with a sugar/glucose ratio of 100:60 using some fully continuous process.

Chewy medicated confections

Other types of product containing active ingredients can be found in chewy or frappe format and contain adsorbates of, for example, dextromethorphan or diphenhydramine, psuedoephedrine or other components. These manufacturing methods are normally patented. The products provide pleasant-tasting cough suppressants which chew out smoothy and dissolve away in the mouth. Similar products also contain antacids, calcium supplements or antibacterial preparations and provide a novel, soft-chew dosage form in an almost soft nougat consistency. Antacids without chalkiness and with pleasing peppermint flavours are already marketed using this technology. The manufacturing methodologies feature equipment and methods common to both chewy candy and chewing gum production, with individual pieces being formed on equipment, which is specifically modified.

Packaging

Alternatively, twist-wrapped or pillow-packed products can be packed in flexible film bags in various materials and laminations, where the product quantity has been accurately preweighed by computer-controlled weighing systems such as those by Ishida Weighpack. Many well-know form-fill machines are available to produce the bags, and another format is blister packing. Weight control to ensure the requisite number of doses if products are sold by weight is essential to meet regulatory requirements.

General technical aspects of industrial sugar confectionery manufacture

Compositional effects

The composition of recipes for the manufacture of sugar confections is based on the use of carbohydrates (sugars), fats, thickeners and stabilisers, and proteins.

1. Sugars

The three basic carbohydrate sources are sucrose (cane or beet sugar), glucose and other speciality syrups produced by the selective hydrolysis of starch, and invert sugar prepared from the breakdown of sucrose. Together these three groups of sugars provide the bulk sweetening material for the different confectionery product.

1.1.*Sucrose.* The major component used in manufacture is cane or beet sugar, and this ingredient is very nearly pure sucrose. Most cane or beet sugar contains traces of mineral salts found when ashing the product. Sucrose, a disaccharide, can be split to form two simpler monosaccharides, usually known as dextrose (-D-glucose) and laevulose (--D-fructose). These sugars are also known under the alternative names of glucose and fructose, and all four names tend to be used interchangeably within the sweet industry.

The minor traces of salts present in commercial sugars provide an inhibiting effect on the breakdown of sucrose to the simpler sugars present in invert sugar. This type of hydrolysis is desirable for certain types of confectionery products such as cream centres, and is induced by the delibrate addition of fruit acids or more preferentially by enzymes.

Vink reported that traces of dextran were found in sugar extracted from cane but not from beet. This trace impurity was considered to give rise to viscosity effects during the manufacture of confectionery products, influencing both plasticity and elasticity. The presence of dextran in cane sugar is considered by

Vink to explain the distortion effects sometimes encountered during the manufacture of count lines.

Change of state

1. Crystallisation

The main effect which involves a change of state during the production of sugar confectionery is the move from ingredients held in a highly saturated syrup to their presence in the confection in crystalline form. Pure sucrose crystals are members of the monoclinic system of **crystal classification** and are probably present in sphenoidal symmetry. The type of sucrose crystal present in a confection is not in the pure shape of a spherulitic crystal but in slightly malformed. This is because other ingredients present, such as other sugars and gelling agents, cause distortion in the crystalline form of sucrose.

2. Polymorphism

Water in the syrup will evaporate as the external temperature conditions change and the syrup crystallises. The crystal grain which occurs induces a layer-by-layer change of state in the main body of the confection moving from the stable amorphous state to the crystalline state. A method for calculating the conversion of amorphous sucrose into crystalline sucrose has been suggested by researchers Makower & Dye Keeney & De Bruin found that sugar nucleation in caramels developed at the fat globule sugar syrup interface.

Caramel Toffee and fudge

Originally toffees did not contain milk and were high-boiled products containing brown sugar, glucose syrup or invert sugar and fats, usually butter. This type of product was in many ways similar to butterscotch, although not usually boiled to such a low moisture content. It is still used on toffee apples, but in many cases this coating is merely a coloured boiled sugar. These products all have moisture levels below 5%.

The introduction of milk into toffees led to the production of higher moisture products with up to 8 or 9% water content, and for some of these products the name caramel was used. Although various authorities have attempted to differentiate in composition between toffees and caramels, there are many exceptions and the two names can be regarded as synonymous.

Unfortunately the name caramel is also used for the products made by the breakdown of carbohydrate by heat or heat and alkali treatment. These are predominantly used as colouring materials and are not relevant in the present context.

Formulation

Formulation depends to a very large extent on the requirements of the toffee, which may be for wrapping as a sweet, for depositing into chocolate shells, or for layering onto another confectionery product or biscuits. Because the requirements of toffee processing are so diverse, specific recipes would be of little value here, but in general a balanced recipe contains 3 parts of sugar, 5 parts of glucose syrup, 3 parts of sweetened condensed milk and 1.5 parts of fat.

Processing

The reason for this is twofold. The first requirement for good toffee is very efficient emulsification, and since this was originally carried out in the boiling pan a good mixing action was essential. In addition, toffee masses do not conduct heat very well and the toffee would burn on the pan. The scrapers prevent this and the efficient mixing distributes the heat uniformly through the bulk. In spite of this it is probably true to say that no two-toffee pans give identical results in terms of finished toffee. The toffee pans are usually fitted with three speed gear boxes, and the main drive shaft and stirrer assembly can be raised by a worm screw at the end of the cook, to allow the pan to tilt to discharge the toffee.

Fudge

The name fudge covers a wide range of products which are basically toffee formulations but in which sugar crystal has been developed during processing. Normally a fudge will contain more sugar and milk than a toffee, but composition can vary between very wide limits and it is much more important to

understand the basic principles involved, since the texture of the finished products is far more dependent on processing than it is on formulation.

The requirements of fudge are that it must be microbiologically stable, it must be firm and it must have a uniform texture. These three requirements virtually define a fudge once the moisture content has been decided. The effect of glucose syrup or invert sugar solids on sugar solubility makes it essential that the concentration of these reducing sugars must be at least 1.5 times, and for safety should be nearer 2.5 times, the moisture content. This will ensure a dissolved solids level of between 75% and 79%.

Frequently fudge has additional ingredients such as fruit, glace cherries, nuts and chocolate. For chocolate fudge cocoa mass is often used, and the addition can be made either before or after cooking. Glace cherries may contain significant quantities of syrup, which must be thoroughly drained before addition to fudge batches, and it is not unusual for cherries to be lightly dusted with icing sugar and stoved before use. Addition of cherries should be left as late as possible, as excessive mixing leads to breakdown of the cherry and colour leaching into the fudge. Nuts do not present problems, but walnuts particularly should be thoroughly checked as they can introduce the risk of infestation.

Toffees and Caramels

All toffees contain skim milk solids and usually some fat. A toffee can be made using full cream milk and butter or with skim milk and vegetable fat - some toffees lie somewhere in between the two extremes. A few toffees are extremely hard: they are in the glassy state. They are a sugar glass with some fat dispersed in it although these toffees, e.g. bonfire toffee, are little made nowadays. Another variation is cinder toffee which is made by heating sugar and glucose to a high temperature in the presence of bicarbonate of soda. The heat decomposes the bicarbonate of soda to give carbon dioxide; this forms a foam in the sugar glass which sets as it cools.

Most toffees are chewable rather than glassy. They are made with sugar, glucose syrup and some form of milk. The preferred form of milk for making toffees is sweetened condensed milk, either full cream or skimmed.

As toffees normally have dispersed fat in them, they are emulsions. Toffees are nearest the oil-in-water category of emulsions since water itself is only a minor constituents of a finished toffee; the continuous phase of a toffee is a sugar and glucose syrup mix.

A TYPICAL TOFFEE

A typical commercially made toffee contains the following ingredients:

Sugar

Sugar normally makes up a high proportion of the finished product: some is contained in sweetened condensed milk, and the rest goes into the recipe as crystalline sugar which is similar to the domestic granulated type. The sugar must be dissolved during processing. It would be possible to add the sugar to the mix as a 66% sugar syrup but this material is not microbiologically stable and would have to be freshly made.

Optional Ingredients

Milk Powder

If sweetened condensed milk is not used then milk powder is the most likely alternative. In some cases, milk powder is added to sugar and water to produce a reconstituted condensed milk. One simple reason for doing this is that the plant could have been constructed to use condensed milk.

THE PROCESS

Toffees can be made using equipment ranging from an ordinary saucepan to a large continuous plant. The processes carried out are fundamentally similar.

TOFFEE AS AN INGREDIENT OF OTHER PRODUCTS

Toffee or caramel is often used as an ingredient of other confectionery products. Examples are chocolate-

covered countlines or chocolate assortments.

Tablets, lozenges and Sugar Panning

Introduction

Tablets and lozenges are frequently confused. They are, however, manufactured by totally different processes. Lozenges are cut from a sheet of firm dough and dried to give a hard sweet with a rough surface. Tablets are made by compressing powder or granules in a confined space until the particles bond together. A tablet has a very smooth surface and is generally rather brittle. This chapter outlines the two processes.

Tableting

Tablets are formed by compressing powder in a die. The particles bond together under pressure and the compacted tablet is ejected from the die. Figure 1 shows the operation of a simple tablet press.

The die is filled volumetrically, excess material removed and the powder compressed between two punches. The lower punch ejects the tablet.

Hard panning

1. Pretreatment of centres

Suitable centres for hard panning include nuts, liquorice, chewing gum, tableted sweets and chocolate lentils. The centres must be sufficiently firm to be able to withstand their own weight when loaded into a pan and must not break up whilst tumbling.

Nuts should be sieved and then sealed to prevent oil from the nut migrating through the sugar coating and causing mottling on the surface. The nuts are dried overnight at 30 -36°C. They are allowed to tumble in a dragee pan and a solution of 40 - 50% gum arabic is applied. Sufficient gum is added to form an even coating over the nuts. Once the gum starts drying and sticking slightly, a small quantity of wheat flour is added to dry the surface of the nuts and prevent them from sticking together. A second coat is usually applied. Once dry, the nuts are transferred from the pan into trays and allowed to dry overnight at about 38°C. The gum layer must be completely dry, otherwise moisture will migrate through the sugar coating.

It is sometimes useful to precoat other centres to improve adhesion of the sugar coating. This is of benefit when panning chewing gum, since the gum is water-repellent and it is often difficult to apply the first layers of sugar.

2. Engrossing

Engrossing is the process of building up the sugar layers. For hard panning, the engrossing syrup is made from sucrose alone. The more concentrated the sugar syrup, the faster the drying time will be. There are, however, factors which limit the strength of syrup which may be used. Sugar syrup concentrations may be quoted in degrees Brix or degrees Baume. Table 3 provides a conversion. Generally, in hard panning, the concentration of the syrup will vary between 65 and 85° Brix (35 and 45° Baume).

It must be remembered that syrups containing high percentages of sugar are prone to crystallisation. Such syrups should be prepared carefully, to ensure that no sugar crystals remain in the syrup when it is made and that it is kept covered during use, to prevent dust from seeding the surface. This is especially true of syrups used to coat chocolate centres, as the syrup is used cold and is more likely to crystallise. Syrups should be subjected to minimal agitation.

If there are any signs of crystallisation in the syrup, it must be discarded and fresh syrup prepared. It is also important that syrups are not held at high temperatures for long periods of time, as inversion of the sucrose will slow down drying and soften the casing.

Suitable centres are loaded into a dragee pan. Generally, a large pan is used for hard panning, as this increases tumbling action, but in the case of delicate centres a small pan would be used. The weight of centres will depend upon their texture; the harder the centre, the larger the load that can be panned. The larger the load, the greater the frictional forces developed, resulting in a better quantity product. In most

cases, the pan, its contents and the drying air which is applied are all heated to approximately 40°C. The syrup is also applied hot to improve dispersion and speed up drying. Higher temperatures will reduce panning times, but the resultant coating will be rough. In the case of chocolate centres, the pan and its contents must not be heated. This also applies to chewing gum, which will soften.

The centres are allowed to tumble, and a small quantity of syrup is added to the pan. The wetting must be just sufficient to coat all of the pieces evenly. It is important that the syrup addition is correct, as too much will cause the centres to stick together and an uneven surface coating will result; too little syrup, however, will not coat the pieces and will again produce an uneven surface.

The coating is allowed to dry until the first signs of dust formation become apparent. The second wetting is immediately applied and allowed to dry. (If the sweets are not sufficiently dried, the moisture will ‘sweat back' later, however too much drying produces dust, which then sticks to the surface of the sweets). This process continues until the desired thickness of coating is obtained. The last few applications of syrup should be diluted slightly to create a smooth surface, ready for polishing.

Sugar Confectionery, Chocolate, Jams and Jellies

AGAR-AGAR

Agar-agar is a gelatinous extract from certain seaweeds, largely used in the manufacture of crystallised fruits, piping jelly, etc. Its manufacture was almost entirely confined to Japan and Japanese colonies, although other countries, notably the United States, New Zealand, Australia, and South Africa, have made successful attempts to enter this trade.

CACAO MOTH

Of the three stages in the life-cycle of the cacao moth, the ova or egg is the most difficult to destroy. It was found, however, that anything which destroyed the ova would also destroy both larva (maggot) and moth.

CONCHES

The longitudinal conche consists essentially of two pairs of pots in each of which are one or two steel or granite rolls made to travel to and fro by a plunger arm - the four "arms" being mounted on one main central driving wheel. In the Rowntree-Baker type there is a rake fitted at each end of the roll mechanism, and shaped to the curved ends of the pots; so as to move the whole of the chocolate at each stroke and eliminate any possibility of "blind" spots where chocolate is liable to lodge. In the larger machines of 3 tons capacity, an independent drive from a variable speed motor is desirable. Small conches of 800 lb. capacity can be conveniently driven from a shaft drive. Now-a-days the "bed" of the conche pots (as also the rolls) is of steel, but some prefer granite. The pots are heated by steam or gas, but the latter is preferable in those cases where steam is not available in the factory at all times, such as week-ends and holidays.

FERMENTATION OF CACAO BEANS

Cacao beans fresh from the pod are surrounded with a soft moist pulp. This pulp is of a sugary consistency, and fermentation soon develops and, with the generation of heat, enzyme action takes place.

The first essential in the curing of cacao is to kill the germ and so destroy germination of the seed. This is done by the heat generated by the fermentation of the pulp. The heat of fermentation is very marked, and if not carefully controlled it will rise to a temperature which will not only destroy the germ but the enzymes also.

LIQUID SUGAR/LIQUID GLUCOSE MIXTURES

Very considerable economics are affected by the use of these syrup mixtures since the syrup blend is pumped directly to a bulk storage installation from which it is metered to processing stations in the factory as required. All manual handling is eliminated, and this system cuts down production costs, labour, warehouse space and process losses. It also eliminates material losses, and provides the confectionery manufacturer with the means of streamlining his processing systems.

LIQUORICE

Purchased usually in the form of "block juice," liquorice is used by a large number of food manufacturers and particularly by sugar confectioners. It is extracted from a group of plants, the Glycyrrhizae, cultivated in Anatolia, Caucasia, Syria, Persia, Italy, and Spain. The root is crushed, extracted with boiling water, clarified, concentrated by evaporation, and cast into blocks or sticks as required.

WINNOWER

This machine is designed for the removal and separation of shell from the nib of cacao beans.

It has undergone but few alterations, and, considering the difficulty of the operation which it has to perform, its efficiency is remarkable.

The beans, after roasting, are dry and brittle. Another feature is that the shell is very much lighter and less dense than the nibs, and on these two facts the construction of the winnower is based.

Centers, fondants, marzipan and crystallized confectionery

Fondant is the simplest of crystallized sugar confections, consisting of sugar crystals in a saturated solution of sugar and other carbohydrates. Normally there is approximately 50-60% sugar crystals present in its structure mixed into the 40-50% of syrup. When other things are added to this simple confection, such as egg whip, color and flavor, another type of confection, a crème, is produced. Cremes are used extensively in boxed chocolates, and their manufacture and use are explained later.

A further complication is to add milk solids to the confection. During cooking characteristics flavors are produced by the Maillard reaction, as the sugar and milk protein react together to give carmel flavors. When this material does not crystallize, the resulting confection is called a *caramel* or *toffee*, but when sugar crystals appear in the syrup phase, a fudge is the result.

The chemistry of these confections becomes increasingly complex as more materials are added to the syrup phase. However, the physical properties have several things in common and are dependent on similar parameters such as composition of the syrup phase, its moisture content and the size distribution of the sugar crystals dispersed through the syrup. Each of these will be examined later.

Crystal size of the sugar

The size of the sugar crystals is very important to both the texture and the rheological properties of fondant.

The human palate can detect particles above 12-15 µm in size, and anything below this tastes ‘smooth'. In making fondant, crystal sizes below 15 µm are usually desired to give a smooth texture in the confection. However, often much coarser particle sizes are used to give a rougher ‘sharper' texture which can be appropriate, for instance, in ‘after-dinner' mints to help ‘cleanse' the palate. In coarse fudge, such as tableted fudge, larger sugar crystals can be very desirable and complementary to the extreme sweetness of this high-sugar confection.

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