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SOFT WHEAT PRODUCTS AND PROCESSES

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UNIT I: CLASSIFICATION AND PROCESSING TECHNOLOGY OF BISCUITS

STRUCTURE

1.0 OBJECTIVES

Thorough study of this unit will enable the reader to understand:

- Types of biscuits
- Quality aspects of biscuits
- Processing methods of biscuits

1.1 INTRODUCTION

The word biscuit drives from *Danis biscoctus* which is Latin for twice cooked bread and refers to bread rusks that were made for mariners (ships biscuits) from as long as the Middle Ages. The dough pieces were baked and then dried out in another cooler oven. They were very unattractive being made from more or less flour and water.

What are biscuits? They can be staple foods, snacks, luxury gifts, dietary products, infant foods, pet foods, and with addition of chocolates and creams, etc. They are all made with flour (usually wheat flour) and all have low moisture content and thereby have long shelf life if protected from moisture and oxygen. The word biscuit is all embracing in Britain and several other countries. It includes items also known as crackers (that make a noise of cracking when broken). Hard sweet and semi -sweet biscuits, cookies (which is the name that originated from Dutch word *koekje* meaning a small cake) and wafers, which are baked between hot plates from a fluid batter. The name cookie was adopted in North America where the term 'biscuit' can be confused with small soda raised breads or muffms. In other countries the term cookie is used primarily for wire cut products of rather rough shape, which often contain large pieces of various ingredients such as nuts, etc.

The term 'biscuit' is used in Britain to describe a flat, crisp, baked; the term cookie is reserved for something softer and thicker. Cookies are made from soft wheat flour and are characterized by formula high in sugar and shortening and relatively low in water. Similar product is known as biscuit in our country. In USA the term 'cookie' covers any flat, crisp, baked good. Cracker is a term reserved for biscuit of low sugar and fat content, frequent bland or savoury. Crackers are usually made from developed dough whereas cookies are made from weaker flour. These foods have in common their ability to stay palatable for a long period of time. Their ease of transportation and their ready consumption without any further preparation make them high on the list of staple snacks

1.2 INGREDIENTS

Flour constitutes the primary raw material to which all soft wheat product formulations are related. It provides a matrix around which other ingredients in varying proportions are mixed to form better or dough systems. Most biscuits can be prepared from flour, which has low quantity of protein and has a gluten content that is weak and extensible. Thus flour with protein level of less than 9%is best and levels of more than 9.5% often create processing problems. The exceptions are fermented cracker doughs and puffs doughs where a medium strength of flour is needed, with protein value of 10.5%or more. Different types of flours are used ranging from soft to strong sponge flour (Table 1). Cookie, cracker flours normally receive no special treatment or additives i.e. they are not normally chlorinated or chemically matured and have no chemical leavening additives or self-raising ingredients. High protein in the flour leads to hardness of texture and coarseness of internal grain and surface appearance. Flour should be sifted to aerate it for easy mixing operation.

Table 1 Typical specification of flour used for chemically aerated biscuits.

Wheat types	A maximum content of soft wheat varieties
Moisture content	14%
Smell	Free from mustiness (mould), no taints from paints, Detergents, etc.
Protein (Nx5.7), %	9.0%$\underline{+}$ 0.5
Colour grade figure (Kent -Jones)	3.5 $\underline{+}$ 1.0
Ash content	0.46 - 0.55%
Particle size range	
Particles greater than 250 ppm	< 1.1 %
Particles greater than 50 ppm	< 40%

Sweetener

It imparts sweet taste, improves texture, crust colour and extends shelf-life. Selection of the proper sweetener mostly is determined by the desired functions the sweetener is to provide. The principal sweetener used is sucrose (granulated sugar). Corn syrup, high fructose com syrup, invert sugar, honey, glucose syrups and molasses are used to a lesser extent except in soft cookies. Granulation of sugar is very important. Coarse grain of sugar will cause more spread of cookie affecting its texture, eating quality etc. Very fine granulation will not incorporate enough aeration resulting in dense texture, toughness and poor eating quality. Coarsely powdered or a fine granulated sugar should be used. Some cookies are moist in eating in which case part of sugar is replaced with fl liquid in which case part of sugar is replaced with liquid sugar such as invert sugar, b honey or com syrup. Dextrose sugar will have reduced sweetness and will impart darker colour to the cookie.

Fat/shortening

Fat lubricates the structure of a baked product. It has tenderizing effect on flour proteins and makes the product tender. Fat improves the eating quality for prolonged period. If the fat level is high the lubricating function in the dough is so pronounced that de little or no water is required to achieve a desired consistency, little gluten is formed and of starch swelling and gelatinization is also reduced giving a very soft texture. The dough and breaks easily when pulled, it is short. This is the origin *of* the term 'shortening' for a dough fat. Generally smooth, plastic hydrogenated shortenings are used for cookie making.

Granular shortenings are unsuitable as they do not aerate sufficiently and distribution *of* fat in the cookie remains uneven. The fat used for cookie making should be able to cream and incorporate aeration and should not melt at baking temperature. Fats used as surface coatings applied as a spray *of* warm oil, for savory crackers are best if they have limited absorption into the cookie and remain as a glossy film. Addition *of* part butter improves the taste and flavor of the cookie and also does not affect the creaming quality Butter should be softened before blending with hydrogenated fat otherwise it will break into lumps which will be difficult to homogenize.

Eggs

Eggs affect the texture in several ways. They perform emulsifying, tenderizing and binding functions. Eggs also contribute colour, nutritional value, and desirable flavor. They are essential for obtaining characteristic organoleptic qualities *of* products. Eggs whites are a toughener and structure builder and the high fat contents *of* yolk function as a tenderizer. Eggs must be fresh. Stale eggs may give bad odour and spoil the overall flavour *of* cookie. Whole eggs are best used at room temperature while egg white whip better when it is cooled. Egg yolk alone or in combination with whole egg produces a cookie with excellent eating quality with a bit inferior grain or internal structure compared to that from whole egg.

Milk

Milk is generally used in the form *of* dry milk non-fat. It imparts good colour, flavor and a very creamy eating quality. One or two percent of milk solids achieve very desirable results. Dry milk is best used after dissolving in water if, water is an ingredient *of* the formula. Milk powder should be mixed with equal quantity *of* sugar in dry state and then small quantity *of* water should be added to make lump free slurry. It can also be sifted along with other dry ingredients

Flavours

Choice of flavours in cookies is very limited. Generally use of butter and milk as the ingredients of the formula perform the function of flavoring agents, which is further fortified with vanilla, which is used within limits of 0.5 to 1 percent based on flour. Some spices like cinnamon, nutmeg, ginger, zeera are also used as flavours. Flavours should be used with utmost care as even slightly enhanced quantity may impart very I strong and unacceptable flavor to the product. The introduction of aromatic ingredients as a contribution to flavor can be made to biscuits and other cooked products in three principal ways:

1. By including the flavor in the dough or batter before baking
2. By dusting or spraying the flavor after baking
3. By flavoring a non -baked portion, such as cream filling, icing, jam or mallow, which is applied later?

Other ingredients

Ingredients that play a texture-modifying role include raising agents and emulsifiers. Raising agents lighten the structure of a baked product during, baking by releasing tiny bubbles of gas in the dough or batter, which expand as the temperature rises, opening up the products structure and thereby lightening the texture. Baking powder, bicarbonates of soda and ammonia are commonly used raising agents.

Baking powder

Baking powder is combination of sodium bicarbonate and an acid salt (phosphates, tartrates, sulphates) when moistured and heating will evolve gas, which leaven the product giving it volume and making light and easy to digest. Baking powder must yield not less than 12% available carbon dioxide. The reactivity of baking powder is determined by their neutralization value (NY), which is defined as the numbers of grams of soda that 100 g of acidic salt will neutralize.

Baking powders are classified as 'fast acting' 'slow acting' and 'double acting'. Fast acting powders release most of their gas at room temperature. Slow acting powders release a portion of the available carbon dioxide during mixing but generate most of it by reactions occurring at elevated temperatures. Double acting powders are version of the slow acting type that has somewhat more gas producing potential during mixing. This type of baking powder is most widely used by bakers. (Table 2)

Baking soda

It is chemically known as sodium bicarbonate. It will liberate CO2 gas, a leavening gas, when heated. It also liberates the same gas when mixed with an acid, either hot or cold. The popularity of sodium bicarbonate as a gas source is based on its low cost, lack of toxicity, ease of handling very small contribution to the taste of the end product.

Ammonium bicarbonate

When ammonium carbonate or bicarbonate is heated CO2 and NIl3 is produced. No solid is left behind in this reaction. However, the ammonia imparts a detectable odour unless it is completely removed. It is used in biscuits and crackers as they have large surface to mass ratio and ammonia escapes when baked at high temperature. It can be used in products that are to be baked at low moisture.

Table 2- Types of Baking Powder

Type	Ingredient	(%)
Fast action		
Formula No.1		
	Tartaric acid	5.97
	Cream of tartar	44.90
	Sodium bicarbonate	26.73
	Starch	22.40
Formula No.2		
	Monocalcium phosphate	33.43
	Sodium bicarbonate	26.73
	Starch	39.84
Slow action:		
	Sodium acid pyrophosphate	40.38
	Sodium bicarbonate	30.59
	Starch	29.03
Double action:		
Formula No.1		
	Monocalcium phosphate	13.28
	Sodium aluminium sulphate	19.92
	Sodium bicarbonate	26.73
	Starch	40.07

1.3 CLASSIFICATION OF BISCUITS

Biscuits may be classified in various ways.

1. Based on the texture and hardness.
2. Based on the method of forming dough and dough pieces e.g. fermented, develop laminated, cut, moulded extruded, deposited, wire cut, co extruded etc
3. The enrichment of recipe based on fat and sugar.

In this paper biscuits have been classified based on the dough consistency such hard dough biscuits and soft dough biscuits.

1.3.1 HARD DOUGH BISCUITS

In hard doughs the gluten is partially developed and to some extent extensible depending on the percentage of sugar and fat in the composition. In this category the biscuits that can be included are:

Water biscuits

Sweet gluco biscuits

Semi sweet Marie type or cabin biscuits and

Some of the specialty biscuits having slightly higher percentage of shortening

Water biscuits

Receipe

Flour	100
Fat	6.5
Salt	1.0
Water	29

Water biscuits have a simple recipe mostly of flour, fat, salt and water in the ratio of 100:6.5:1:29. The dough is under developed and crumbly or in balls after mixing.

They may be then given the conditioning period before sheeting when some form of proteolytic activity mallows the gluten to make it more extensible. A dough sheet is formed which after laminating is cut and baked in a very hot oven Water biscuits are usually round and may be as large 3:S 70 mm in diameter. As longitude shrinkage occurs in the oven, the cutter must be oval and the shape is controlled by the relaxation of the dough before cutter. Mostly Jewish community prepares water biscuits. No flavor is added in biscuits.

Gluco biscuits

In India gluco biscuits are manufactured in the largest quantities and because of lower cost it is most popular among children. A typical recipe of these biscuits is given below.

Receipe

Wheat flour	100 parts
Sugar	33 kg
Salt	1.1kg
SMS	4.2g
SMP	l.5kg
Shortening	24kg
Invert syrup	15 kg
Ammonium	0.6
Water	10 liter
Flavour	Vanilla

Preparation

1. Wheat flour is passed through a sifter removes all the dirt, stones etc.
2. Sugar is ground and fat is incorporated in molten form
3. Mixing: Ammonium bicarbonate, sugar syrup and water are mixed thoroughly in a high-speed mixer for a couple of minutes. Shortening and flavour are creamed for a few minutes. In dry mixing, maida, salt, sugar, SMS paste, SMP and vitamins premix are mixed. The mixing time is about 3-5 minutes
4. Shaping and conveying to oven. The Rotary molder is used for shaping operation. This operation involved feed roll rubber roll and die roll and extraction belt and panning table belt.
5. Baking: The biscuits baked in an oven that has different temperature zone e.g. 120^0C, 350^0C and 150°C.
6. Cooling: In cooling, two cooling conveyors are used. The cooling time is around 4 minutes.

Packing: The biscuits are packed in BOPP or any other moisture proof packaging materials.

1.3.2 HARD SWEET AND SEMI-SWEET

All these biscuits are characterized by doughs that contain a well-developed gluten network but with increasing amounts of sugar and fat the gluten becomes less elastic and more extensible. The prime requirement is a biscuit with a smooth surface, which has a slight shine or sheen and an open even texture giving a bite that ranges from hard to delicate.

These biscuits are commonly produced in many countries, particularly developing countries where the low cost of the formulation is attractive.

Early hard sweet types were with little or no sugar. The majority of popular types now available, such as Osborne, Marie, Rich Tea and Petit Beurre, all has very similar recipes and differ principally in their shape and thickness. It is difficult to add any flavorful ingredients successfully so most have a basically mild vanilla flavor or a caramel buttery flavor derived either from the use of real butter or synthetic buttery flavours. All have some syrup and or malt extract. Their mild slightly sweet flavor complements warm beverages like tea and coffee. These types known as Rich Tea or Morning Coffee reflect when they are eaten rather than that they taste of either of these beverages. Sometimes these biscuits and chocolate coating and the low sweetness and richness make them very suitable for these purposes. The fruit sandwich of currents (known as Garibaldi) or small sultanas is an interesting and significant variation.

Ingredients and recipes

Cabin biscuits with low sugar and fat levels are popular in African countries where the biscuit industry is developing and low cost and minimum effects of fat deterioration during storage are required.

Most semi-sweet types, despite varying names and shapes, have similar recipes at the upper limits of the fat and sugar level. The dough is mixed to about 40°C so the physical quality of the fat is less critical than for short doughs, there is enough dough water to dissolve the sugar completely so the crystal size is largely unimportant.

Soft flours are used in the production of semi-sweet, hard dough biscuits. Flour from harder wheats with higher protein levels give less extensible gluten and higher dough water requirement. This type of flour results in harder biscuits. Some improvement in the suitability of these flours can achieved by dilution with up to 10% of starch such as arrowroot, com starch or potato flour. The quality of gluten can be tempered by the use of SMS (Sodium Meta bisulphate). This has a mellowing *effect* on the gluten, which is brought about by sulphur dioxide.

Typical general semi-sweet biscuit recipes are given in Table3. Many semi-sweet recipes use baking powder, which is a mixture of sodium bicarbonate and an acidulant like acid calcium phosphate or sodium pyrophosphate. Normally the level of sodium bicarbonate is adjusted to give a baked biscuit with a pH of about 7, but some consumers like higher pH levels.

Table3 Receipes for typical semi-sweet types on the percent flour basis.

	Marie.	**Rich Tea**	**Cabin**
Flour (9% protein)	100	100	100
Sugar	19	25	10
Fat	13	20	5.0
Syrup and! Or malt extract	2.0	4.0	2.0
Skimmed milk Powder	1.7	1.4	Nil
Salt	1.0	1.0	0.80
Sodium bicarbonate	0.40	0.60	0.80
Lecethin	0.26	0.40	0.10
SMS	0.030	0.035	0.030
Ammonium bicarbonate	1.5	0.40	0.80
Water (approx)	2.4	19	20

Dough Mixing

There are four basic requirements for the mixing of these doughs. The ingredients must be blended, the flour has to hydrate, the sugar must dissolve and the hydrated protein must be kneaded to produce the three-dimensional structured material known as gluten. The hydration of the flour and dissolution of the sugar are time dependent, the others are related to the design and speed of mixer. Normally, all the ingredients are placed in the mixer together before mixing begins. In some cases the fat, water and sugar are mixed initially to allow dissolution of the sugar and plasticizing of the fat.

It is usually necessary to mix to higher dough temperatures in large universal mixers than in small ones in order to ensure that sufficient kneading is given to develop the gluten. The mixing to constant final dough temperature is a prime control parameter. It is recommended to aim for a final dough temperature of 4O-42°C where SMS is used and 44-460C in unsulphited doughs. If the mixer does not produce a. extensible dough by the time these temperatures are reached (with not less than 4 min of vigorous mixing action), the starting temperature of the blended should be reduced (usually using cooler water) to allow an extension of the mixing time before the final temperature is used.

The length of mixing time varies with the type and size of mixer and the level of SMS used. Slow-acting vertical spindle type mixers may require as much as 50 min.
speed of around 60 rpm require about 20-25 min. and small mixers with dough capacity of around 160 kg and a beater speed of 90 rpm can mix a satisfactory dough in 4.5 minutes, use of SMS has a dramatic effect on the dough quality. The use of about 0.03 unit of this salt per 1°° of flour allows at least a 10% reduction of dough water and a significant reduction of mixing time compared with doughs using no SMS. The benefit of SMS is that is acts immediately, in fact it can be added towards the end of dough mixing with the satisfactory result that the reaction goes to completion very quickly.
The enzyme proteinase will accelerate gluten softening, resulting in reduced mixing times. The quantity to use will depend upon the type of flour available, on the dough temperature, fat and sugar concentrations and on the activity or strength of the enzyme preparation

Dough piece forming

Dough sheeting is another very critical part of the process. The dough must be supplied in a suitable quality for sheeter to produce a continuous homogeneous sheet with a smooth surface. Thus dough of acceptable consistency and quality as judged at the end of mixing may produce inferior biscuits if the handling of that dough before sheeting is variable or careless

Dough at about 40°C should be protected from cooling used without delay and scrap dough should be immediately mixed with it in the sheeter as metered in some other way. It may be necessary to heat the steelwork of the pre-sheeter, sheeter, guage roller etc., to avoid chilling of the dough and the baker air should not be allowed to chill or skin the dough surface at least prior to sheeting. On standing, a semi-sweet dough tends to lose its extensibility but a small amount of remixing usually revives the dough. The standing time before use of a dough should not be more than about 3- min.

A three-roll sheeter is used to form a continuous sheet of dough. Holes or imperfections in the sheet will be lost as the dough is laminated. Following the sheeter there should be two or three pairs of gauge rolls before a sheet at the correct thickness is formed. Too great a reduction may cause distortion and damage to the dough structure, which will affect the development during baking and also the biscuit shape.

Sometimes the dough will tend to adhere to one or the other of the gauge rolls such that release is difficult and the dough surface is spoilt. This problem can be overcome by some techniques. An air blower to skin the dough before the gauge rolls is frequently sufficient but failing this or light flour dusting may be necessary.

Semi-sweet doughs exhibit a certain amount of elasticity so the correct biscuit shape can be achieved by allowing a relaxation of the dough prior to cutting. This is usually achieved by rippling the dough onto an intermediate web or onto the beginning of a long web prior to cutting. The relaxation results in some thickening of the dough sheet so the setting of the final gauge roller is always less than the thickness of the dough sheet at the cutter.

Semi-sweet biscuits are always cut with a complete surround of 'scrap' dough. This is lifted clear and returned to the sheeter for reincorporation. This dough is denser and often cooler than the fresh or virgin dough. Semi-sweet biscuits are always dockered and usually bear a name and stamped into the surface. With a reciprocating cutter this dockering and printing is made at the same time as the cut of outline. As the cutter rises an ejector plate rests on the dough surface to effect a clean release.

After cutting the scrap is lifted away. Following the cutting operation the dough pieces may be garnished with sugar or other granular material or washed with milk or an egg/milk mixture to enhance the gloss and appearance after baking. Most semi-sweet biscuits are no~ garnished at all but if any sort of surface dressing is applied, care must be taken not to spill the dressing onto the panning web, otherwise either the oven band or the subsequent performance of the panning web will be impaired.

Baking

Lift, or the development of biscuit structure is a result of gas released from the leavening chemicals and the expansion of water vapour as the temperature rises. The biscuit can be up to 4-5 times thicker than the dough piece entering the oven and the moisture content is reduced from about 21 % to less than 1.5%. As moisture removal, to a relatively low level, is necessary to avoid the condition known as checking when the biscuits cools, it is normal to bake semi-sweet biscuits on wire type oven bands. However, Marie biscuits and sometimes-other thin types are traditionally baked on steel bands. A pre-requisite for semi-sweet biscuits is a smooth surface of even, fairly pale colour with a sheen. The smooth surface and even lift is determined by the condition of the dough surface after sheeting and gauging. The sheen can be enhanced by passing steam into front of the oven to increase the humidity of that section so that it exceeds the dew point at the dough surface. This allows a film of moisture to be deposited which becomes sheen when it dries out later in the oven.

At the oven exit checks must be made to determine whether the biscuit size, shape, colour and moisture are within the limits set for quality and packet specifications. Colour measurement (the reflectance value or darkness) of the top surface of biscuits can be made continuously, however colour on both top and bottom surfaces are important and as yet the underside seem to be neglected.

Checking is a potential problem for semi-sweets biscuits. In order to prevent this it is necessary to bake to low overall moisture content or to cool the biscuits carefully.

Flavoring of biscuits

The large amount of moisture that is lost during baking of semi-sweet biscuits and their low final moisture content make it very difficult to flavor these biscuits. Volatile flavoring materials added to mix are driven off in the oven. One technique that may be considered is to oil spray with flavored oil. The biscuits must be hot enough to allow the oil to soak in but not so hot that the flavours in the oil are volatilized.

Cooling and handling of biscuits

Semi-sweet biscuits usually strip easily from the oven band because they are rigid even when hot. It is usual to let the biscuits cool in air before packaging. Cooling conveyors are typically two or three times as long as the oven and normally of the same width as the oven band.

For high capacity plants very close attention is needed to the biscuit handling up to the wrapping machines so that the transfer can be made with minimal human intervention and breakage. A number of plants have forced cooling of biscuits, which have been stacked immediately after stripping from the oven band. This arrangement saves much space. Soft flours are used in the production of semi-sweet hard dough biscuits and frequently the flour is weakened by the addition of corn flour, or potato flour.

1.3.3 CONTINENTAL SEMI-SWEET BISCUITS

Biscuits of this typed are commonly made in France, Germany and Switzerland The recipes are slightly higher in fat level and are mixed by two-stage process similar to short doughs. All ingredients except the flour are firstly mixed up to a homogeneous 'cream'. The dough is then rested for between 30 minutes and 90 minutes to reduce the stickiness, before sheeting and gauging. The formulation sometimes includes proteinase and this requires at least 60 minutes standing time for enzyme to react with the gluten. The dough is not normally laminated.

These doughs tend to be sticky which makes them more difficult to process through gauge rolls and a good smooth surface may be achieved prior to cutting by ensuring that at least the final gauge is very clean and the dough pieces are often brushed with a milk wash to enhance surface appearance after baking. The resultant biscuits are softer and shorter in texture than traditional British semi-sweet types and surface is not as smooth.

1.3.4 SOFT DOUGH BISCUITS

Short doughs, which are soft enough to be just pourable, are called as soft doughs. Pieces are formed by extrusion in a similar way and in the same machine as wire cut and rout biscuits but nozzles rather die holes are used to channel the dough. The dough is pressed out either continuously or intermittently on the oven band that may be raised up and then dropped if discrete deposits are requires. As the band drops, the dough pieces break away from the nozzle. The biscuits produced in this way are usually rich in fat or based on egg whites whipped to a stable form, the dough must be very short to allow it to break away easily as it is pulled away from the nozzle.

The nozzles through which the dough is extruded are usually indented to give a pattern and relief to the deposits. Also by rotating the nozzles, swirls, circles and other attractive shapes can be developed. In the case Spritz biscuits, the nozzles are oscillated from side to side during continuous extrusion. This forms a ribbon of dough. Depositing allows not very fancy shapes to be formed, but also by synchronizing two or more depositors, different colored and flavoured doughs can be combined. Jams and Jelly can be added on the top of dough deposit.

Typical recipes for soft dough biscuits

Deposited biscuits

Ingredients	I (g)	II (g)
Flour	100	100
Butler (salted)	54	70
Fine sugar	35	40
Fresh eggs	1	1
Sodium bicarbonate	0.2	1.0
Biscuits dust	20	
Salt	0.7	0.5
Water	7.5	6.0
Flavors	Yes	no
Invert syrup		1
Sodium pyrophosphate		1

Ingredients

Nearly all these biscuits are luxury types. The production rates are usually low and the ingredients are expensive. Butler is widely used also eggs, grounds almonds, coconut flour and cocoa. But contrast with wire cut types, coarse particle size ingredients are avoided as these block or interfere with the smooth functioning of the depositing nozzles. The consistency of the dough is critical so the temperature of the ingredients is important. A temperature of about 170 c is recommended for butter. The sugar should be fine or very fine as there little water is available to effect solution and fine crystals give a better eating texture in the baked biscuits. Some manufacturers maintain that ground biscuits crumb (from the same type of biscuits) aid the texture and structure. Care should be taken not to include crumbs from over baked product as it will adversely affect the flavor and colour of the baked product.

Dough mixing

As the dough of pourable consistency is required, detachable bowl type mixer is used. The mixing times are quite short and relatively gentle. It is usually best to cream up the butter with sugar, eggs, milk and water and to add the flour later with a minimum mixing to achieve a homogenous mash. Dough temperature is important to maintain consistency and correct fat dispersion. It may be necessary to cool the flour and certainly any water and milk and should be very cold. Dough temperature between *10-150* c should be aimed at.

Dough piece forming

As already stated the dough is pressed out through nozzles on to the oven band which may be raised up and then dropped if discrete deposits. As the band drops pieces break away from the nozzle. The nozzles through which dough is extruded are usually required to give a pattern and relief to the deposits. Thus it may involve more than one type of nozzle on a single depositing machine located one after another or more commonly a series of machines located one after another and with synchronized action.

Baking

It is essential to use a steel band to bake products in this group. All types shows some spread but those rich in sugar spread the most. Fat rich products do not stick to the oven band. Treatment of the band with oil or flour may be necessary. Baking is normally slow at low temperatures. There is little water to remove so the baking process is principally to develop the texture and colour the surface. The letter may be very irregular with fine peaks, which will colour very easily if the oven temperatures are too high. The biscuits have a soft and "'melt in the mouth" type and are very delicate and easily broken.

Biscuit Handling and Packaging

Where the biscuits are thick and irregular shape they do not bend themselves to stacking and mechanical handling into wrapping machine like other biscuits. It is, therefore, usual to transfer the pieces individually in to trays, boxes or tins prior to final packing.

1.3.5 SPONGE BATTER DROPS BISCUITS

Receipe

Ingredients	(g)
Flour	100
Fat	3.2
Fresh eggs	6.5
Fine sugar	80
Sodium bicarbonate	0.14
Sodium phyrophosphate	0.20
Salt	0.80
Glycerine	3.0
Glucose syrup	6.2
Water	10.0

There are variations on the sponge mix recipe but in all cases, the dough is an aerated batter that is pumped to a sponge pipe depositor or in baking trays according to the set routine and at end of each deposit the holes are shut off to prevent drips. It is important that the batter is not too stringy otherwise tails are formed at the end of each drop.

Sponge batter mixing and depositing

It is normal to make the mixture of batter in two distinct places. Firstly, a premix of all the ingredients (eggs. flour. sugar and water) is blended together to form a more or less homogenous slurry. This is then pumped for the aerator and metering pump that supplies the deposit manifold. Air is metered in and the batter is converted into fine foam. During aeration, it is necessary to provide cooling to prevent the overheating of the batter. The density should be about 0.88/C.C. and the temperature 19j:1 0 c. Depositing is with a depositor, that is a sponge pipe that follows the oven band during the depositing stage then moves back while holes in the pipe are closed.

Baking of sponge drops

Baking is usually in a moderately hot steel band oven for about 8 minutes. The fat less batters opt to stick badly to the oven band during baking so it is always necessary to grease the band in someway. Considerable difficult can be encountered in the search for the optimum means of preparing the oven band. There are various techniques but all involve the use of flour in addition to an oily lubricant, spreading the oil and flour evenly and at the desired low levels either together as slurry or separately, is a major engineering challenge. Without the flour the batter may spread to an unacceptable extent prior to setting in the oven, with insufficient oil baked pieces may adhere so firmly to the ban that stripping is virtually impossible

Fermented soft dough biscuits

In India fermented dough biscuits are prepared by fermented slurry and then it is mixed with rest of the batch for dough mixing. Slurry is fermented for 2-3 hrs only. The composition of typical slurry is given below.

Recipe

Wheat flour	90 kg
Sugar	4kg
Yeast	21kg
Mixing time	2-3 minutes
Fermentation time	2 Hrs

Preparation of batch

Wheat flour	160 kg
Sugar	30kg
Scrap	30kg
Invert syrup	9kg
Ammonium bicarbonate	8kg
Salt	3.7 kg

Sodium bicarbonate	1 kg.
Sod.metabisulphite	100 ml
Lactic acid	450 ml
Mixing time	6- 7 minutes

After preparation of the slurry, batch ingredients are added in the slurry and mixed for 6-7 minutes using vertical mixer. The dough is ready for further processing.

Shaping and cutting

A laminating machine helps to make 8-10 layers. This imports good puffing and crispness to the biscuits.

Sheeting

There is a cluttering roll and rubber roll on the lower side for putting up the pressure.

Baking

After cutting the biscuits are baked in an oven. The baking time is around 3-4 minutes.

Oil spray

To improve the shining of the biscuits coconut oil is sprayed on both sides of the biscuits which gives better appearance and eating quality to the biscuits.

Cooling

Cooling conveyors at room temperatures does the cooling of the biscuits. The cooling time is about 3 minutes. At the end of the cooling conveyer which detects metal pieces if contaminated from any part broken part.

Packing

The biscuits are packed in BOPP wrap and then sealed.

1.4 SPREAD OF THE BISCUITS

Spread of the finished biscuits is the most important character, which should be carefully controlled as its excessive variation may create serious problems in the product line.

Factors allowing greater spread	**Factors which reduce spread**
Factors related to flour in the formulation	
Coarse flour particles	Higher flour water absorption value, including heat treated and chlorinated flours
Minimum mixing after flour addition	Over mixing of dough
Factors related to sugar in the formulation	
Sugar with low means aperture	Sugar with high mean aperture size
Increased quantities of crystalline	Lower level of sugar
Factors related to fat in the formulation	
Soft doughs due to higher temperature	Cold doughs
More fat	less fat
Factor related to aeration in the formulation	High dough pH (more Ammonium or sodium bicarbonate)
Factors related to dough age and dough piece weight	
High dough piece weight	Old dough
Factors related to oven conditions	
Greasy oven band	Flouring of oven band
Low temperatures in front of oven	Higher bake temperatures, faster bake

1.5 SUMMARY

The term 'biscuit' is used in Britain to describe a flat, crisp, baked; the term cookie is reserved for something softer and thicker. Cookies are made from soft wheat flour and are characterized by formula high in sugar and shortening and relatively low in water. Similar product is known as biscuit in our country. In USA the term 'cookie' covers any flat, crisp, baked good. Cracker is a term reserved for biscuit of low sugar and fat content. Crackers are usually made from developed dough whereas cookies are made from weaker flour. These foods have in common their ability to stay palatable for a long period of time. Biscuits are classified into hard and soft dough biscuits. In hard doughs the gluten is partially developed and to some extent extensible depending on the percentage of sugar and fat in the composition. Soft doughs, which are soft enough to be just pourable, are called as soft doughs. Pieces are formed by extrusion in a similar way and in the same machine as wire cut and rout biscuits but nozzles rather die holes are used to channel the dough. The dough is pressed out either continuously or intermittently on the oven band that may be raised up and then dropped if discrete deposits are requires. As the band drops, the dough pieces break away from the nozzle. The biscuits produced in this way are usually rich in fat or based on egg whites whipped to a stable form, the dough must be very short to allow it to break away easily as it is pulled away from the nozzle.

1.6 KEY WORDS

Biscuit: A flat, crisp and baked product with low moisture content.

Cookies: A baked product similar to biscuit but it has uniform cracks on the top surface of the product. Cookies are also rich in fat and sugar contents.

Crackers: Cracker is a term reserved for biscuit of low sugar and fat content. Crackers are usually made from developed dough whereas cookies are made from weaker flour.

Hard dough biscuit: In hard dough biscuit the gluten is partially developed and to some extent extensible depending on the percentage of sugar and fat in the composition.

Soft dough biscuit: The dough is mixed with excess of water and it remains just pourable dough i.e. very loose dough from which the biscuits are baked.

Shortening: It refers to the fat used in bakery application. The fat is called shortening because of its action on gluten. It does not allow the gluten to develop fully and the term shortening is given to bakery fat.

1.7 SELF ASSESSMENT QUESTIONS

1. How biscuits differ from crackers and cookies?
2. Classify biscuits and give a brief account of hard dough biscuits
3. Describe manufacturing process of sweet and semi sweet biscuits
4. Discuss unit operations used in the preparation of soft dough biscuits.
5. Discuss the importance of biscuit spread and also explain the factors affecting the spread of biscuits.

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PGDBST- 06 **B.S.Khatkar**

UNIT II: CLASSIFICATION AND PROCESSING TECHNOLOGY OF COOKIES

STRUCTURE

2.0 OBJECTIVES

This unit is designed to explain the following concepts of cookie making:

- Definition and types of cookies
- Processing technology of cookies
- Role of major ingredients in cookie making

2.1 INTRODUCTION

Wheat is considered unique as the basic raw material for the production of bakery products such as breads, biscuits and cookies because of its special gluten development properties as compared to those of other cereal grains. The wheat flour has added advantages of being relatively cheap, low moisture content, nutritious and its dough has very good machinability due to its elasticity as well as extensibility and hence suited to continuous commercial production.

After green revolution due to introduction of high yielding Mexican dwarf wheats in the late sixties, it has been observed that there is a galloping increase in the production of wheat in India as shown in Table 2.1. Because of the surplus and the availability of wheat ideally suited for the production of baked products, the bakery industry in India has made a significant progress during the last decade. Today, bakery industry has come to occupy an important place on the industrial map of the country. It has already recognized as the largest of the processed foods industries in the country; touching a level of annual consumer outlay of about Rs. 10000 crores.

As compared to biscuits and crackers the cookies, in India, resemble home made baked products and commercial production of cookies in India is quite low. In recent years, however, an increased interest has been noted in the production of cookies, because of their attractive features like good catering quality and long shelf life. Good catering quality makes cookies a popular snack and long shelf life allows large scale production and wide distribution.

Table 2.1 Wheat production in India

Year	1965-66	1970-71	1980-81	1996-97	2002-03
Production (Million tones)	10.5	23.8	36.3	69.4	73.5

2.2 CLASSIFICATION OF COOKIES (TYPES OF COOKIES)

Cookies are chemically leavened baked products with top surface broken by fairly wide cracks somewhat evenly spaced to give uniformly sized islands. They have richer crust colour and a moisture content ranging from 1 to 4 percent. Cookies differ from biscuits in respect to their crispness, bite, taste, texture and level of ingredients used. Cookies are generally crisper and contain larger amount of sugars and shortenings than biscuits.

Cookies can be classified into four major groups depending upon the kind of equipment used to form the individual places.

A. Deposit Cookies

B. Rotary-moulded cookies

C. Wire-cut cookies and

D. Cutting machine cookies

2.2.1 DEPOSIT COOKIES

This category of cookies is made form very soft dough deposited directly onto the oven band by a forming machine. Deposit cookies contain about 35 to 45 percent sugar, 60 to 70 percent shortening and unbleached soft wheat flour with 8 to 8.5 percent proteins and 0.35 to 0.40 percent ash. The flour must be able to carry the sugar and shortening without too much spread, so that the top design is preserved through baking. At the same time, the flour and other ingredients must contribute enough adhesive properties to the dough so that it will adhere to the band and pull away form the main tube dough in the deposit stage.

2.2.2 ROTARY-MOULDED COOKIES

Rotary-moulded cookies are made from crumbly dough pressed into a form on a rotation cylinder, later removed and deposited onto the oven belt. Rotary moulded doughs are often high in sugar and fat but low in water content. Most manufacturers use flour of about 8.1 to 8.2 percent protein for rotary moulded cookies, although a range of 7.1 to 9.2 percent has been reported. Ash should be about 0.415 per cent, with a known range of 0.33 to 0.47 per cent being used satisfactorily. The dough is crumbly, lumpy and stiff with virtually no elasticity. Cohesiveness of dough is due to fat used. For rotary moulded cookies, the dough consistency must be such that it will feed uniformly and readily fill all of the crevices of the die cavity under the pressures existing in the feeding hopper. During baking, dough spread is minimum. Lecithin at about 0.4 per cent level is added to improve machinability.

2.2.3 WIRE-CUT COOKIES

Wire-cut cookies are extruded products of slightly stiff dough extruded through a die and cut by an oscillating wire. It is necessary to have the wire cut dough sufficiently cohesive to hold together as it is extruded through an orifice, and yet it must be relatively non-sticky and short enough, so that it separates cleanly as it is cut by the wire. Formulae may contain up to 100 per cent sugar and 100 per cent shortening based on the flour weight. Advantages of the Wire-cut cookies over rotary moulded cookies are more open grain and softer texture, and, as compared to deposit cookies, a more uniformly shaped cookie. Disadvantages over the rotary moulded piece are the lack of potential for making a surface design and somewhat less uniformity of size and shape.

2.2.4 CUTTING MACHINECOOKIES

Cutting cookies are those cut into appropriate shapes from a sheeted cookie-dough. For cutting cookies, the dough must be properly developed to provide tensile strength and extensibility for sheeting. A dough with slightly less fat and sugar but more water is used than rotary moulded dough. Typical formulas for the production of various types of cookies are given in Table 2.2.

Table 2.2. Ingredients of cookie formulations

Ingredients	Type of cookies			
	Deposit	Rotary moulded	Wire-cut	Cutting
Flour	100	100	100	100
Sugar	45	45	50	30
Shortening	45	63	50	15
Water	17	12	13	12
High-Fructose Corn syrup	-	-	3.5	8
Non-fat Dry Mild	2	2.8	1	1
Egg Albumin	-	1.12	-	3
Sodium Chloride	1.0	0.6	1.5	-
Sodium Bicarbonate	0.2	-	0.2	0.5
Calcium Phosphate	-	-	0.7	-
Ammonium Bicarbonate	-	-	0.7	-
Lecithin	-	-	0.4	-

2.3 PROCESS FOR COOKIE MAKING

Typical cookie making process can be described as follows.

A. Preparation of Ingredients

B. Mixing of Dough

C. Cutting and shaping the Dough

D. Baking

E. Cooling

F. Packaging

2.3.1 PREPARATION OF INGREDIENTS

Soft wheat flour with particles less than 38μ gives the most desirable cookies. Therefore, flour fraction with 38μ particle size should be used. All the ingredients should be weighed separately according to the recipe. Water requirement depends upon the recipe and it is never constant. It also depends on the flour quality as water retention capacity of flours varies due to varying degree of starch damage.

2.3.2 MIXING OF DOUGH

The mixing requirements vary for different products and also depend upon the raw material. Cookie doughs are usually mixed in upright horizontal mixers, low speed and short time cycles are used for mixing cookie doughs, because gluten strength is neither necessary nor desirable for sweet doughs.

Generally, two methods are followed for mixing of cookie dough.

1. Creaming method and

2. All-in-one method.

1. Creaming method

In this method first the sugar and shortenings are creamed and then syrups, eggs, mild and salt are added, water with leaving agents is added next, and, finally the flour is added and mixed to the proper stage. The mixing is carried out at slow or medium speed of about 25 to 35 rpm. The excessive speed of mixing raises the temperature of dough and the fat melts, which caused the stickiness of dough and cause problem in machinability. Therefore, mixing speed and time are important for good dough development.

The beneficial effects of creaming, as opposed to other mixing method, lie in the fat-coating effect which delays the hydration of flour proteins and starch, and the incorporation of small air bubbles, which assists in leavening and establishing the structure of the finished product.

2. “All in one” method

It involves the mixing of all the ingredients in a single step. This method is simple and easy in operation. All in one mixing facilitates better dissolution of sugars in the dough.

2.3.3 CUTTING AND SHAPING THE DOUGH

There are three general methods of forming of shaping cookie dough.

1. Pressing the dough into a die cavity and extracting it onto a moving belt. The dough to be formed into die cavity should form a solid lump when pressed together, but should possess little or no elasticity and have the general appearance and texture of crumbly lumps of shortening and sugar. Furthermore, they must possess sufficient cohesiveness so that the individual cookies do not tear apart at transfer points.

2. Extruding the dough or batter, which may be formed in fancy shapes by moving the orifice, and which may either be cut off by an oscillating wire or deposited on the moving oven belt without cutting.

3. Cutting shapes from sheets of dough, either with or without docking or embossing a design on the surface.

If the dough is to be formed into a sheet to maintain its continuity and uniform thickness so that it does not tear. It must have a certain amount of elasticity and adequate tensile strength to bear its own weight. Such dough is, as a rule, not suitable for forming into die cavities since they do not usually fill the die completely, they may not cut off cleanly, and they tend to shrink, distorting the design. Conversely, the rather soft dough suitable for extrusion cannot be extracted from the dies properly.

2.3.4 BAKING

Cookies are generally baked in traveling belt oven. The dough pieces are continuously fed on oven band, the speed of the bank can be adjusted to suit the baking time for different types of cookies. The ovens are generally, divided into three zones. The recommended temperature pattern for most cookies is a fairly low temperature (150-165°C) in the first zone, where the fat melts and undissolved sugars and chemicals pass into solution, and the whole of the cookie piece becomes soft and spreading of cookie dough takes place. The chemicals used produce gas, and the heat causes it and the air already present, to expand, resulting in the cookie increasing in volume. A considerable high temperature (200-205°C) in the intermediate zone is provided where setting and baking of cookie takes place due to coagulation of proteins and gelatinization of starch. In final zone slightly lower temperature is recommended to give desired colour and flavour to the cookies.

The baking time of cookies is recommended between 10 to 15 minutes. Because after 15 minutes of baking the cookie diameter become constant and, the loss of volatile matters increases as shown in Table 2.3.

Table 2.3 Effect of baking time on cookie diameter and loss of volatile matter

Baking time (Min)	Cookie diameter (Cm)	Loss of Volatile matter (%)
0	7.0	0
4	8.5	6
8	9.5	12
12	11.5	26
15	12.5	40
18	12.5	70
20	12.5	85

2.3.5 COOLING

Hot cookies must be cooled uniformly before they are packed or sent for any secondary treatment. Non uniform cooling may lead to varying stresses at different points of the product, which will result in cracking and hence undesirable. The cooling is achieved by transferring the cookies in a single layer to a canvas conveyor and allowing them to travel on the belt for double the baking time.

2.3.6 PACKAGING

The cookies have the following quality characteristics those affect the packaging and shelf life of the product.

1. Low moisture content and hence the product has to be protected from moisture pickup during storage.

2. The product has crispness and therefore, it is brittle and hence should be protected from breakage during handling and transport.

3. The product is rich in fat and thus it should be protected from air to prevent development of fat rancidity and off flavour.

Keeping in view the above properties, packaging of cookies is done in unit packs consisting of paper, aluminum foil and polyethylene. Corrugated fiberboard boxes are used for bulk handling. These boxes are used to contain the small packs.

2.4 ROLE OF MAJOR INGREDIENTS

2.4.1 WHEAT FLOUR

Flour constitutes the primary raw material to which all cookies formulations are related. It provides a matrix around which other toughening or tenderizing ingredients in varying proportions are mixed to form dough or batter systems. A distinguishing characteristic of cookie flour is that, it is relatively coarse as compared to cake flour; however, it is finer in granulation than hard wheat fours, which are used for the preparation of bread.

1. Wheat flour

The raw material of foremost importance in cookie making is the wheat flour. The flour obtained by milling in roller flourmill with 70-72 percent extraction is preferred.

(a) Flour quality: Pratt defined flour quality as "the ability of the flour to produce an attractive and product at competitive cost, under conditions imposed by the end product manufacturing unit". The tests most commonly used to characterize cookie flours and described as follows.

(i) Protein content and flour strength: the quantity and quality of protein present in flour is considered important in dough making. Cookies require a softer type of flour, which provides for structure building and leavening. The quantity and quality of gluten in flour influence the flour strength. It is observed that the stronger flour yields harder cookies with lesser spread and more puffing in the centre. Standard cookies flour is generally soft flour having protein content between 7.0 to 8.0 per cent.

(ii) Viscosity: The protein strength is often measured by the viscosity method, in which the flour viscosity is noted in dilute acid solution. In a dilute lactic acid solution, flour gluten swells considerably and starch to a limited extent, this increases the viscosity of flour-water suspension. The increase has indirect relation to the swelling properties and quantity of gluten present in the total flour.

(iii) Ash content: Ash colour is closely related to the colour-influencing components such as bran of flour. The bran, outer covering and aleurone layer have higher ash content than endosperm in wheat.

(iv) Particle size: Flour granulation is of utmost importance in cookie baking. Different fractions of air-classified flour have different baking properties. Finer fractions of flour have low protein content and give greater cookie spread, than the coarse fractions. It has been observed that soft wheat flour fraction containing particle size smaller than 38 microns gives the most desirable coolies in relation to parent flour. Large particle size fractions give poorer cookies.

(v) Colour of flour: The flours best suited for cookie purpose will have a slightly yellowish tine due to the presence of natural pigments in the endosperm. The colour of the flour decreases with the storage due to oxidation reactions. Cookie flours are not improved by oxidizing treatment and this processing step is generally avoided in making the cookies. Increasing the intensity of chlorine treatment of soft wheat flour reduces the diameter and increases the thickness of test bake.

(vi) Alkaline water retention capacity (HWRC): The results of alkaline water retention capacity directly correlate with cookie diameter, since the test is done at pH 8.0 to 8.1, the conditions that actually exist in cookie doughs. It is much more informative, when combined with baking.

(vii) Damaged starch, Diastatic activity and Maltose value: Damaged starch is one, which has been physically damaged during the milling process. Mechanical injury to the starch makes it more susceptible to enzyme action, which results of differences in intensity of grinding during production of flour. Granulation and its relationship to starch damage both must be considered to properly assess the effects of granulation in cookie spread. Both factors are dependent on grinding practices, severity of grinding and type of wheat relative hardness being milled. The diastatic activity is the capacity of the flour to produce sugars i.e., its amylolytic activity. For cookie making, high diastatic activity is not desirable and the flour unfit for bread-making purposes due to low diastatic activity can be easily used for cookie making.

Maltose value of 2.0 (200 mg of maltose per 10 g flour) is considered as maximum for the production of cookies.

The diastatic activity is the test, which reveals the extent to which the diastatic enzymes alpha-and beta-amylases produce sugars while acting on starch present in the flour. Normally, wheats have sufficient beta-amylase activity but lack in alpha-amylase activity. However, amylase activity increased thousand folds during wet harvest or germination. The diastatic activity is expressed as mg maltose produced/10 g of flour.

(viii) Banking test-spread ratio of cookies: No single test can be of much use unless the actual product is made and hence the cookie-spread factor of flour is of great importance. The control of cookie spread is one of the most serious problems faced by production supervisors. Minor variations in appearance, flavour and texture are usually accepted with little complaint, but a cookie which spreads so much that it cannot be filled in the package, or one that spreads too little, causing slack fill or excess height for the package, can create have on the packaging line and generate large amounts of scrap. The width (W) and thickness (T) of the cookies are measured and spread ratio (W/T) is calculated after baking. High (>9.0) W/T ratios are desirable characteristics of the flours for preparing cookies.

(b) Specifications for cookie flour: Soft wheat flour is particularly good for making cookies. Generally, soft wheat flour has relatively lower protein content, more mellowed gluten quality, lower absorption capacity, less starch damage, more spread and relatively short mixing tolerance properties as compared to hard wheat flour.

Soft wheat flour, as illustrated by the farinograms, develops and breakdown faster than hard wheat flours. Soft wheat flours absorption is lower than HRW flours (Hard red winter wheat flours). The weak dough and low absorption of soft red winter wheat flour (SWR) most likely reflects the differences in gluten quality and quantity between hard and soft wheat flours. Because of these differences, together with the others as mentioned before, soft wheat flour is superior to hard wheat for making sugar cookies by the better spread ratio and top grain with soft wheat than with hard wheat flours.

2.4.2 WATER

Water is an essential ingredient in cookie dough which when added to wheat flour helps in the formation of gluten by hydrating the gluten proteins when dough is subjected to mechanical mixing. The gluten provides to the dough its characteristic rheological properties like desired strength, extensibility, gas retention power and elasticity.

The water has additional functions as follows:

1. It helps in maintenance of a particular temperature of dough during mixing.
2. Amount of water determines the consistency of dough.
3. It helps in the distribution of dissolved salt and sugar uniformly throughout the dough.
4. It facilitates the activities of enzymes in dough.
5. Water helps in the gelatinisation of starch during baking.

It is the quality of water which is important in cookie making. Microbiologically water used for doughs should be as free from microorganisms as is necessary for drinking water. Infected water may have a deleterious effect on human health even when the microorganisms are destroyed during baking.

Hardness of water also affects the dough characteristics. Soft and hard water are the terms linked with the amount of soap needed to produce a lasting lather and this is particularly due to the levels of calcium and magnesium. Normally water with medium hardness (50-1000 ppm) with neutral pH is preferred for cookie making. Water that is too soft can result in sticky dough because of the absence of gluten tightening minerals. On the other hand water that is too hard results in very tough dough which prevents the spreading of cookies during baking.

Certain metals, particularly copper and iron, have marked catalytic effects on the development of rancidity in facts and oils. Drinking water standards demand low concentrations of copper and other metals associated with the development of fat rancidity, so this problem is likely to be under control if only drinking water is used in dough. If, however, it is suspected that metal ions are the cause of difficulties in dough quality, it is possible to reduce their effects with chelating agents like EDTA. In conclusion it is felt to be wise and good practice to select water for cookie making that is of constant quality and which confirms to the international standard for drinking water.

2.4.3 **SWEETENING AGENTS**

Sweeteners are regarded as the most important class of ingredients in cookies. Some unusual varieties can be prepared without flour, a few without water (as such), and number without added leaveners, but no cookie formula is possible without some form of sweeteners.

The primary purpose of sweetening agent is to make product sweet. The quantity of sweetening agent added is usually such that it has significant effect on the texture and appearance of the product as well as on favor. Machining properties closely related to the dough piece to oven conditions are also closely related to the type and quantity of sweetening agent employed.

The sweetening agents used in cookie making have varied functions and may be divided into three categories: 1. Sucrose and invert sugar; 2. Derivatives of cornstarch and 3. Other sweeteners.

2.4.4 SHORTENING AGENTS

Any edible fat used in bakery products is known as shortening. Shortening is essential components of most cookies. The amount of shortening in the formula influences both the machining response of the dough and the quality of the finished products. The saturated fatty acids are more important than unsaturated fatty acids as shortening in cookie making because the saturated fatty acids are chemically complete and stable and therefore, do not undergo much bio-chemical when stored.

1. Properties of shortenings

Shortenings should have a plastic nature over a wide range of temperature. Temperature plays an important role in the distribution of fat. If the temperature rise is higher than the maximum of the shortenings plastic range, then liquid oil will result, causing an oily dough while low temperatures tend to cause hardening of the shortening, causing uneven distribution in dough.

The plasticity of shortening while mixing dough encourages the entrapment and retention of considerable quantities of air and thus contributes to the texture of the baked products. Further, the smaller the crystal sizes of the glycerides in a well plasticized fat the required plastic range, the greater the value in cookie making. Shortening, super cooled badly, having a large crystal structure gives dough with poor moulding potential and variable cookie weights and dimensions. Hydrogenated oils with their mono-diglyceride fractions encourage not only emulsification but also the homogeneous distribution of the fat soluble and emulsified ingredients throughout the dough and hence contribute to tenderness in cookies.

During hydrogenation process, hydrogen is added directly to the points of unsaturation in the fatty acids to convert the oils into solid fats, by which the stability of fat is increased to oxidative rancidity.

The “off flavour” developed in cookie during an extended shelf life is due to rancidity developed in the shortenings. These are mainly due to:

(a). Breakdown of fatty acid chains by oxidation,

(b). Spoilage by micro-organisms,

(c). Fat splitting by enzymes, particularly lipase and

(d). Absorption of foreign odours.

2. Functions of shortenings in cookie Dough

(a) Shortening reduces the toughness of dough.

As gluten does not form until the flour is in contact with water and mixing action, the inclusion of fat tends to insulate and the gluten forming proteins from the water and consequently, a less tough dough results which is rather more extensible and ideally suited for cookie making. The greater the amount of fat, the greater will be the insulating effect. Excessive mixing will breakdown the insulation and a tough dough will result again.

(b). It improves dough for machining and sheeting by lubricating the gluten.

(c). Controls the flow of cookies.

(d). Gives shorter bite to the goods

(e). Enhances the cookie flavours

2.4.5 ANTIOXIDANTS

High level of fats may cause rancidity problem in cookies because of their long storage period. Therefore, use of antioxidants is very important in cookies to prolong their shelf life. Antioxidants are those compounds, which function by inhibiting the free redical mechanism of glyceride auto-oxidation and thereby retard the development of off flavour in products. At present time, only four chemical compounds are commercially important as antioxidants for foods. They are butylated hydroxy anisole (BHA), butylated hydroxytoluene (BHT), tertiary butyl hydroquinone (TBHQ) and propyl qallate. Synergists like citric acid or phosphoric acid may be added to improve the effectiveness of the antioxidants but they do not themselves function directly to prevent fat oxidation.

BHA is considered as the best synthetic antioxidant, because it has got very good carry-through properties and therefore, not destroyed during baking process, and hence extends the storage life of cookies and other baked products up to 3 to 4 times.

2.4.6 LEAVENING AGENTS

Leavening agents aerates a mixture and thereby lightens it. They also improve the texture and appearance of baked products. Leavening action may be produced by mechanical, chemical and biological means. In cookies leavening action is generally achieved by chemical and mechanical means. In cookies biological method of leavening is not practiced because the higher amount of sugars and shortening do not permit the efficient growth of yeast.

1. **Ammonium Bicarbonate:** Ammonium bicarbonate, often use in cookies, decomposes at high temperature into ammonia, carbon dioxide, and stem. Its usage increases spread and gives a large, more desirable "crack" in sugar cookies. But, it cannot be employed in moist, large volume bakery products as ammonia retention producers an objectionable strong pungent flavour and odour.

2. **Sodium Bicarbonate:** Sodium bicarbonates generate carbon dioxide and water in the oven by reaction with acids in the flour, leaving the sodium carbonate as the residual salt. Sodium carbonate has an unpleasant flavour and can react with fats to cause soapy tastes. Sodium carbonate has marked softening action on gluten causing spread and also darkening the product.

3. **Baking powder:** This leavening agent is produced by mixing an edible grade acid and sodium bicarbonates with or without starch or flour as filler. Banking powder are classified as slow acting and fast acting. The fast-acting powders give off most of their gas volume during the first few minutes of contact with product. On the other hand, the slow-acting powders give up very little of their gas volume at low temperatures-they require the heat of the oven to react completely. Since banking time of cookie is short, therefore, it requires fast-acting powder for better results. On the other hand cake where baking time is more requires slow-acting banking powder. Level of banking soda recommended for cookies is 0.4% on flour weight basis.

2.5 SUMMARY

In recent years an increased interest has been noted in the production of cookies, because of their attractive features like good catering quality and long shelf life. Good catering quality makes cookies a popular snack and long shelf life allows large scale production and wide distribution. Cookies are chemically leavened baked products with top surface broken by fairly wide cracks somewhat evenly spaced to give uniformly sized islands. They have richer crust colour and a moisture content ranging from 1 to 4 percent. Cookies differ from biscuits in respect to their crispness, bite, taste, texture and level of ingredients used. Cookies are generally crisper and contain larger amount of sugars and shortenings than biscuits. Cookies can be classified into four major groups i.e. deposit, rotary-moulded, wire-cut and cutting machine cookies depending upon the kind of equipment used to form the individual places. The major operations required manufacturing cookies are mixing, cutting and shaping the dough, baking and packaging.

2.6 KEY WORDS

Cookies: They are chemically leavened baked products with top surface broken by fairly wide cracks somewhat evenly spaced to give uniformly sized islands. They have richer crust colour and a moisture content ranging from 1 to 4 percent.

Deposit cookies: This category of cookie is made form very soft dough deposited directly onto the oven band by a forming machine.

Rotary-moulded cookies: This category of cookies is made from crumbly dough pressed into a form on a rotation cylinder, later removed and deposited onto the oven belt.

Wire-cut cookies: These cookies are extruded products of slightly stiff dough extruded through a die and cut by an oscillating wire.

Cutting cookies: These cookies are cut into appropriate shapes from a sheeted cookie-dough.

Creaming method of mixing: In this method first the sugar and shortenings are creamed and then syrups, eggs, mild and salt are added, water with leaving agents is added next, and, finally the flour is added and mixed to the proper stage.

Leavening agents: These are chemicals that aerate a mixture and thereby lighten it.

2.7 SELF ASSESSMENT QUESTIONS

1. Give a brief account of the attractive features of cookies.

2. Classify cookies and discuss various types of cookies.

3. Discuss general process of cookie production.

4. Discuss importance of mixing unit operation in cookie production.

5. Why cookies are baked in different zones maintaining different temperature profiles?

6. Discuss the importance of each temperature zone of baking in cookie production.

7. Discuss the role of major ingredients in cookie making.

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POST GRADUATE DIPLOMA
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PGDBST – 06

SOFT WHEA PRODUCTS AND PROCESSES

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UNIT III: CLASSIFICATION AND PROCESSING TECHNOLOGY OF CAKES

STRUCTURE

3.0 OBJECTIVES

Thorough study of this unit will enable the reader to understand:

- Formula balance & types of cakes
- Production of cakes and pastry
- Cake faults and remedies

3.1 FORMULA BALANCE & TYPES OF CAKES

Quality of cake depends on three factors

(i) Quality and type of ingredients

(ii) Formula balance in which the ingredients are combined and

(iii) The conditions of mixing and baking.

Formula balance depends on the type of cake manufactured. Each ingredients used in different types of cake contributes on the quality. Any basic change in one of the ingredients requires a counter balancing adjustment in the other ingredient. The ingredients can be classified as follows:

(i) Structure building material: flour, egg and mild powder.

(ii) Softener/ Tenderizer: Sugar, fat and baking powder.

(iii) Moistener: Milk, water and egg.

The cake formulation should have a right balance of the above ingredients. If cake contains too much tenderizer such as fat, sugar, etc. The structure is weakened to that extent that it collapses. Too much baking powder also results in collapse of cake in the center. Excess liquid in the cake causes toughness of the structure.

Cakes are classified mainly in three categories:

i) Batter type

ii) Foam type

iii) Pound cake

3.1.1 BATTER TYPE

Batter type cakes can be divided into high ratio cake and low ratio cake. High ratio cake contains more sugar than flour while low ratio cake contains less sugar than flour. A basic difference between them is the stiffness or fluidity of the batter. High ratio cake requires more water to dissolve the sugar. Introduction of emulsified shortening enables to use high amount of water. Because of liquid nature of batter, the capacity to retain gas is very low. Hence, introduction of chlorinated flour enabled to retain gas due to faster "set" of cake in the oven.

Formula for batter type cakes is as follows:

	High ratio	Low ratio
Flour	100	100
Sugar	100-180	80-98
Shortening	54	50
Egg	60	55
Salt	2-4	1-2
Baking powder	3-4	1-2
Milk	100	60

3.1.2 FOAM TYPE CAKES

These cakes are leavened by air whipped into egg portion. These are of two type i.e. angel and sponge cake. Angel cake makes use of egg white to entrap air, whereas sponge cake uses mixture of whole egg and egg yolk.

The formula for Angel cake is presented below

Flour	-	100
Sugar	-	260-300
Egg White	-	260-300
Acid salt	-	4 to 4.5
Salt	-	4 to 4.5
Flavour	-	as desired

Acid salt is used to neutralize the alkalinity of egg white and also to strengthen the egg. If fruit juices are used, acid salt can be reduced. 60-70% of sugar could be used in the first stage of mixing. Remaining sugar when added with flour enables distribution of flour more evenly.

In these types of cakes sugar is added in equal proportion to egg white. Fruits and nuts could be added equal to weight of flour. Lemon rind, oranges if used moisture content and acidity should be checked.

Sponge cake: Sponge cakes are of two types - one is a basic sponge which contains flour, egg mixture, sugar and salt. Short sponge in addition to the above ingredients, contains additional sugar, water, milk solids, and baking powder.

Formula for basic sponge cake is as follows:

Flour	-	100
Sugar	-	166%
Egg mixture	-	166%
Salt	-	3.0%

In short sponge, for each addition of 1% flour, the following ingredients are used.

0.75 to 1%	-	Sugar
0.75 to 1%	-	Liquid milk
0.015 to 0.030%	-	Baking powder
0.03%	-	Salt

In hot method of mixing, and equal part of sugar and egg are taken and whipped. If sugar and milk are to be used, dissolve the additional sugar in the milk and add alternatively with flour. If fat is used, the mix should contain higher egg. In cold method, either creaming or one stage mixing method could be used. The amount of baking powder must be doubled and water has to be increased slightly. Dextrose or corn syrup could replace sugar up to 20-25% in jellyroll. Corn syrup will make the rolling easier. Since the cake is high sugar product it should contain more lecithin. Thus, egg yolk ranging from 25-50% of the egg product is added. Salt up to 3% is also added.

Important considerations in the preparation of sponge cakes are:

1. Use quality ingredients.

2. The temperature at which egg is whipped with sugar should be 90-110°F.

3. Equal parts of egg and sugar give the best results.

4. The ratio of moisture to sugar is very important from the stand point view of keeping quality and edibility. Moisture should be 25 to 30% more than the sugar based on flour.

5. The pH of cake should be 7.0.

6. The addition of 10 to 25% egg yolks based on the whole egg content improves color, texture and volume.

7. Addition of more fat reduces the volume of cake.

3.1.3 POUND CAKES

Pound cake represents oldest examples of aerated fat in cake.

Flour	-	1 lb
Butter	-	1 lb
Egg	-	1 lb
Sugar	-	1 lb
Lemon Extract	-	to taste

The ratio of egg to fat becomes 1 to 0.8 because of 20% moisture present in butter. This ratio holds good for any fat. The ratio of equal parts of flour to a sugar is also found quite satisfactory. However, the formulation is quite costly. The pound cake formula can be changed to any level by following the formula balance given below.

i) The total weight of egg should be equal or greater than fat.

ii) The weight of sugar should be equal or slightly more than weight of flour.

iii) The combined weight of liquid ingredients (milk plus egg) should be equal to the weight of the flour or sugar which ever is higher.

Formula ingredients of pound cake:

Flour	-	100%
Sugar	-	75 to 125%
Fat	-	40 to 100%
Whole egg	-	40 to 110%
Salt	-	2 to 3.0%
Liquid milk	-	0 to 60% (varies)
Baking powder	-	0.2%

The precautions recommended include:

1. Batter temperature	-	68-78°F
2. Batter	-	plastic consistency
3. Specific gravity	-	0.183
4. Baking temperature	-	350-360°F.

3.1.4 FRUIT CAKE

For each 100g of flour, 300 to 700 g of fruits and nuts are used for fruit cake. The consistency of the batter should be stiff to prevent sinking of fruits. The flour used should be strong to enable carry fruits and sugar. Blend of soft and strong flour is normally used.

Cake structure will be stronger when less sugar is used. Normally 60 to 100% sugar based on flour is used. When shortening more than 60% is used, no baking powder is needed. 25-50% shortening needs ½ to ¼% of baking powder. Good fruitcake usually contains 60-90% shortening. The egg content should be 5 to 10% more than shortening.

3.2 PRODUCTION OF CAKES AND PASTRY

Cakes are essentially produced by leavening agents and by air incorporation. A high fat and low water content characterize pastry. The major operations required to manufacture cakes and pastry are described below.

3.2.1 MIXING

The mixing of cake formula ingredients is carried out stage by stage process. The objective during mixing remains to avoid gluten development. Thus, fat and sugar are blended first to a light, aerated cream and then egg is added in the second stage. The addition of egg is critical. It should be done carefully otherwise dense, low volume cake is baked. Finally flour is added along with baking powder and any fruits. The aim of mixing is to achieve homogeneity of all the ingredients. During mixing aeration and creation of fine air bubbles is important to give good volume and textural property to the cake.

3.2.2 BAKING

Cake batter should be baked at right temperature for even colour of the crust without making the crust thick. The temperature conditions in the oven should be controlled to avoid burning of crust of the cake. As the cake batter is heated in the oven its viscosity increases. The leavening gases also expand. This provides foam structure to the batter. As the temperature of the system increases further the starch gelatinizes and the free water become bound. All these reactions are responsible for setting of the cake texture.

3.2.3 PACKAGING OF CAKES AND PASTRIES

Most cakes will have high equilibrium relative humidity and consequently tend to dry out fairly rapidly under normal conditions of storage. The staling of cakes is attributed to two factors. Firstly, due to the movement of moisture through the cake, the dry cake crust attracts moisture and the moisture content decreased from 28% to 20%. The second factor is a staling process similar that of bread that is due to changes in amylopectin fraction of the starch. The maximum staling of cake occurs between 20° C and 25° C. Hence, the packaging requirements of cake and pastry are:

1. Prevention of excessive drying out. This is limited by the need to prevent the microorganism growth such as moulds and yeast.

2. Retention of aroma of product.

3. Cakes and pastry are more susceptible to crushing than bread and as a result they require packages which would provide greater physical protection.

4. They also require packaging materials having grease resistance and aroma barrier properties

Conventional packages:

Grease proof and glassine papers, one-side coated die cut paperboard sheet are commonly used for ordinary cakes. Cup cakes are placed in paperboard and over wrapped with MST cellophane in a die-fold configuration that permits the heat sealing of the film at the bottom. The board being larger than the dimension of the cup cake allows for stretching of the cellophane over the top edge of the icing and thus minimizes the side-to-side crushing of the product. The film is transparent to allow product visibility, moisture proof to minimize moisture loss.

3.3 CAKE FAULTS AND REMEDIES

The faults in cake are due to imbalance in the formulation, use of poor quality raw materials and faulty processing conditions. Cake faults and their possible remedial measures are discussed next.

Cake faults are divided into six categories.

1. Shape faults
2. Structural faults
3. Texture faults
4. Crust faults
5. Colour faults
6. Miscellaneous faults

3.3.1 SHAPE FAULTS

A. Collapsed cake with white surface spots:

Possible cause	*Effects and Remedies*
Too much sugar	Too much sugar in the formula causes the cake to collapse and white spots on the top surface of the cake appear. When too much sugar is used, the cake expands beyond the structural limit of flour and eggs and collapse occurs towards the end of the baking period. To avoid this, the formula must be correctly balanced and the sugar correctly weighed.
B. Cake with flat top	Sugar and leavening agents are the ingredients, which tend to open the texture of the cake. Use of excessive grain openers reduces the crumb strength and hence flat top.
i) Excess of grain opening ingredients	Too much of baking powder or sugar will cause the cake to expand beyond the holding powers of the structural ingredients, flour and egg. This will result in a slight collapse giving a flat-topped cake with an open texture. Correct formula balance and careful weighing of the ingredients will avoid the fault.
ii) Too little liquid in the batter	This will create an imbalance between the liquid and sugar and baking powder. Too little liquid in the batter will close the texture of the cake and hence flat top.
iii) Oven too cool	This gives a slower and more even expansion in the oven yielding a flat topped cake. A slightly cooler oven can be used when the layers of cake are to be sandwiched

together.

iv) Incorrect balance between fat and egg — If the fat content is greater than the egg content, the latter will be unable to support the higher fat level and the cake will have a flat top. This fault can be removed by observing the basic rule of formula balance. The egg content must be equal to or slightly greater than the fat content.

C. Cake with baked top:

i. Flour too strong: Soft flour is used for general cake making. When strong flour is used for cakes, the cake batter develops.

ii. Insufficient aeration: incorrect mixing either over or under mixing can cause this. Over mixing tend to drive out the air beaten into the batter. This loss of air prevents the cake from expanding evenly and properly which causes cake with low shoulder and a peak in the center. While the under mixed cake batter will not have enough air to expand properly.

Correct mixing time and batter consistency should be observed.

iii) Too much top heat: Too much top heat in the oven will pull the cake up in the center and set it early. The crust will then burst as cakes expand during baking. This fault can be corrected by either reducing the top heat or baking under covers.

D. Cakes sinking during baking

i. Using too much baking powder: During baking the volume expands beyond the structural limits of flour and egg and hence collapses in the oven. Reduce the amount of baking chemicals.

ii. Using too soft flour: Soft flour cannot carry more fat and sugar due to poor gluten strength. Hence, use strong flour or reduce fat and sugar in the formula.

iii. Using too much milk: If batter is too soft, then reduce quantity of milk.

iii. Using too much of fat or sugar: Makes the batter too soft and the expanding grain cells break through and hence collapse. Balance the recipe and use correct quantity of fat and sugar.

iv. Lower baking temperature: When cake is baked at lower temperature aeration starts without the structure formation. When the aeration stops, the unset structure collapses. Use correct baking temperature and time.

vi. Knocking or disturbing the cake in the oven before it is set

Avoid disturbing the cake in the oven before structure sets in.

E. Poor volume

i. Insufficient aeration: Use sufficient baking powder

iii. Insufficient creaming: Cream fat and sugar properly. Beat egg nicely and cream the beaten egg into the above cream properly, so that sufficient aeration takes place.

iii. Using too much flour or too strong flour: Strong flour toughens the batter and will not rise during baking.

Use right type of flour or reduce the strength by adding a proportion of weak flour.

iv. Baking in too hot oven: Hard crust forms before the cake fully expanded.

Bake at correct temperature and have some moisture in the oven to prevent a hard crust forming.

v. Baking in too cool oven: Cakes do not rise to their fullest extent and will take longer time to bake and so give eating. Hence low volume bake the goods as quickly as possible at the correct temperature.

vi. Not using sufficient moisture: Too thick batter and hence insufficient rise and low volume.

Use correct amount of water.

F. Shrinkage in cup cakes

i. Too little baking powder: When insufficient baking powder is used cakes shrink on cooling and pull away from the sides of the paper cases.

ii. Too little sugar: Again shrinkage occurs on cooling. A properly balanced formula and care in ingredient weighing will eliminate this.

iii. Too much mixing: Excess aeration produced by too much mixing will increase the tendency for small cup cakes to shrink on cooling a cup cake batter should have less mixing.

iv. Toughening of the batter: If the batter is over mixed after the flour is added it may be toughened and shrinkage will then occur during baking.

v. Too much bottom heat: This causes the batter to pull away from the bottom of the paper case. Bottom protection in the form of paper layers or cardboard will allow the cakes to fill the cases without shrinkage from the bottom.

3.3.2 STRUCTURAL FAULTS

A. Under baked area close to top crust

i. Under baking: The last part of the cake to set during baking is the part just under the center of the top crust. Under baking result in a higher moisture concentration which produces a damp or apparently unbaked area. If this occurs and the top crust is highly coloured, baking temperature should be reduced by 10°F and the baking time may be increased. If the unbaked area is accompanies by discoloration of the lower part of the crumb, the baking temperature should be increased.

ii. Bumping the cake during baking: If the cake is bumped in the oven before the structure is completely set, some of the cells in the middle portion collapse, resulting in a damp or apparently unbaked area.

Cake should never be disturbed until the structure is set.

iii. Faulty testing: To test whether a cake is baked or not. The top of it is slightly touched with the fingers. If too much pressure is exerted this will cause the cake to dip in the center and have a damp area below the top crust. If the fingers are drawn gently across the cake surface, minimum pressure will be applied. By above mentioned technique, the cakes can be assessed for bake without unnecessary damage.

B. Tunnel-like holes in the cake

i. Toughening the batter: This result from over mixing in the final stage. The flour should be carefully cleared until it is evenly distributed through out the mix after which the mixing should be stopped.

ii. Lumps of unmixed fat in the batter: This is due to under mixing or bad scraping down of the bowl and beater when the mixing is done with machine.

Care should be taken to follow the correct-mixing procedures and to scrape down efficiently.

iii. Packets of air entrapped during sealing: This occurs when batter is sealed-in portion by portion. It is better to scale-in one large portion of batter and then removes the surplus to arrive at the correct weight.

C. Fruits fall to the base of the cake

i. Thin batter: When the batter is too thin it will not hold fruits. If this fault occurs, check should be made with regards to liquid content and reduce the liquid content. Under weighing of flour will also give rise to similar results.

ii. Lack of structure: If the protein content of flour of egg is low, or the quality of protein in flour is poor, then the cake will not have sufficient structural strength to hold the fruits. This can be overcome by ensuring that correct type of flour is used. i.e. medium strong flour for cakes.

The adverse effect of egg can often be corrected by increasing the amount of flour at the rate of 225 g for every 2.25 kg. When only slight fruit movement occurs, this can be overcome by extra mixing of the batter after the flour is added and before the fruit is mixed through.

iii. Too much sugar: Sugar delays the setting of the cake structure. If excess sugar is included, the batter will not hold the fruits in position during the last part of the baking period. The fruit will sink. So, careful adjustment in the level of sugar is necessary to correct this fault.

iv. Too much baking powder: Too much baking powder weakens the cake structure by its effect on the protein and also creates larger cells, which are weak and will not hold fruits. Correct the level of baking chemicals.

v. Incorrect baking temperature: If the fruit cakes are baked at too low a temperature, the time required for the cake to set needs to be increased. The risk of fruit movement is, therefore, greater. Hence, the baking temperature should be checked before and during baking to ensure that it is correct at the outset and does not fall during baking.

D. Fruit cake crumbles when cut

i. Weak or wrong type of flour: If the flour is weak, the cake will lack structure and the texture will be weak and fruits will be pulled out of the crumb as the knife passed through. Special cake flour should not be used for fruitcakes. High protein special cake flour must be used when high ratio fruit and cherry cakes are being made.

ii. Unbalanced formula: Too little egg in relation to the fat will give a weak texture. Too much sugar will cause the cake to be tender. A dry cake is usually made from a formula that does not contain sufficient liquid. Hence, the cake becomes crumbly.

iii. Use of dry fruits: If the dry fruits are not washed and cleaned, it will draw moisture from the cake crumb, leaving it drier and more crumbly. Careful preparation and conditioning of fruit ensures that fruit cakes mature well and improve with age when they are to be stored. Lightly fruited cakes will be less moist in eating and will not dry out quickly.

iv. Incorrect baking: If cakes are over baked or baked too slowly, dry cake results. Careful baking is essential to the production of cakes that will cut and eat well.

3.3.3 TEXTURE FAULTS

A. Texture too close

i. Insufficient baking powder: Increase the baking chemicals.

ii. Too much liquid: This will close the cake texture.

iii. Too little sugar: Low sugar content allows the cake to set too early in the bake and give less time for it to expand.

iv. Hot batters: If the ingredient temperatures are high and batters hot, they will not allow sufficient air incorporation during creaming. This results in poor volume and close structure. The best creaming temperature is 65-75°F. Careful control of the temperature of ingredients is essential.

B. Coarse texture:

i. Too much baking powder: Too much baking powder gives rise to over aeration and open texture and also acid taste. Careful observation of the cake formula will prevent over weighing of the baking powder.

ii. Insufficient liquid: This has much the same effects as too much baking powder. Liquid closes the cake texture and balances the opening effect of mechanical and chemical aeration. If too little liquid is used the cake will open up and have a coarse texture.

iii. Too much sugar: Sugar opens the texture of the cake and if used in excess will delay the setting of the cake so that the final volume will increase together, with the cell size.

iv. Too little mixing: When ingredients are mixed, an emulsion is formed and longer mixing time gives an even dispersion of ingredients and a better emulsion. If the mixing time is too short, it results in poorer distribution and emulsion formation that yields a more open and uneven texture in the baked cake.

v. Over too cool: As a hot oven will restrict the expansion of the cake during baking so a cool oven will allow too much expansion and open up the cake texture. Careful baking, at the correct oven temperature will prevent this problem.

3.3.4 CRUST FAULTS

A. Thick crust on cake:

i. Too much sugar: More sugar in the cake batter will increase the density of sugar/water solution. During baking it produces thicker crust on the cake. More sugar also causes dark crust colour and brown colour on the lower half of the crumb due to sugar caramelisation.

ii. Too little milk on other liquid: Too little milk or liquid increases the density of sugar solution and hence thick and dark crust.

iii. Baking fault: If the oven as a whole is too hot a heavy crust will be produced around the cake. When only the top heat is excessive the top crust will be thicker. When cakes are baked in a cool oven the crust is formed over a longer period of baking and will be thicker.

Over baking will also give heavy crusting. Careful baking at correct temperatures will overcome problems of this type.

iv. Cakes standing too long before baking: If the sealed batter is allowed to stand too long before baking, moisture will evaporate from the top surface and this will result in increased caramelisation.

B. Cracks on the surface of cake

i. Too hot a bake: This is the common cause of surface cracks, sealing the top surface of the cake before the cake has completely expanded. The set crust eventually bursts under the pressure of gases formed during the baking processes. This can be avoided by lowering the baking temperature. 360°F is a good general guide for slab cake baking, but this will need to be modified according to the size and type of cake being baked.

ii. Dry oven atmosphere: This causes the crust to set early and the slab to crack in much the same way as too hots a bake. Too much injected steam will also cause surface cracks.

iii. Too little sugar: Too little sugar will allow the top surface to set before the center of the cake. Continued expansion of the center portion may burst the crust.

iv. Toughened batter: If the batter is toughened by over mixing after the flour has been added, the flour protein will be developed to the point where it results expansion and causes the surface to burst during baking.

v. Too much batter in the tin: In this case, the batter reaches the top of the tin too quickly and the crust will form before expansion is complete.

vi. Insufficient air in the batter: If the batters are too cold or too hot it will not retain sufficient air to start the expansion of the cake. Cakes from under aerated batters tend to crack during baking. Care should be taken to incorporate correct amount of air during mixing by creaming for the recommended period at the right temperature. Traditional batters should have a temperature of 70-75°F and high ratio batters 65-70°F.

C. Ring round a layer cake

i. Over-greasing the tin: heavy greasing of the tin causes this fault. The batter moves inwards during baking and carries surplus greasing materials with it, causing the ring.

This problem can be avoided by giving only a light coat of greasing material to inside surfaces of the tin.

The recommended greasing material for tins is a blend of 1 kg shortening and ½ kg of flour that has been creamed well until light.

If greasing materials are carefully used the fault will not occur.

D. Top crust peels and flakes off:

i. Over mixing: If too much air is incorporated during mixing, the cake will tend to shrink on cooling. The body of the cake will leave the top crust, which will then peels off during handling.

ii. Over too cool: A slow bake will give a dry top crust that will break away from the cake on cooling. Layer cakes need to be baked at about 400°F for the best results.

iii. Insufficient steam during baking: Normally the steam given off by the layers is sufficient to give a slightly moist atmosphere that will result in a good bake. If, however, this small amount of moisture leaves the baking chamber by an open damper or a door which is not steam-tight, the top crust will dry out with the same result as in the paragraph above.

iv. Cooling in dry conditions: This will cause moisture from the crust to be taken up by the surrounding air, given a dry flaky crust. Cakes should not be cooled in a draught of air. As soon as they are cooled to 70-75°F, they should be placed under cover to prevent further moisture loss.

iv. Handling cakes before they are cooled: Over-handling of hot cakes is to be avoided because this practice will crack the crust and cause it to peel off.

3.3.5 COLOUR FAULTS

A. Discolored crumb in fruit cake

Discoloration is usually caused by caramelizaton of sugar. When sugar is subjected to heat, it will decompose eventually, turning into carbon. This colour change is gradual from white through various shades of brown to black and can be caused in a variety of ways.

i. Slow baking: A slow bake allows a longer time in which sugar will caramelize and cause shading from the base of the cake. This can be avoided by reducing baking time and increasing oven temperature.

ii. Too much bottom heat: Over baking the base of the cake and consequent discoloration can be prevented by adjusting the bottom heat in the oven or protecting the base of the cake.

iii. Type of sweetening agent: Moist sugars and other materials such as golden syrup and honey will caramelize more readily than granulated sugars and the baking temperature should be reduced by 10-15°F when they are used.

Up to 10% of the total sugars can be replaced by moist sugar, syrup or honey without much risk of discoloration.

iv. High sugar content in fruit: If the sugars content of the fruit is unusually high, discolouration will occur in the crumb surrounding each piece of fruit.

v. Too much bicarbonate of soda: Too much bicarbonate of soda will cause the crumb to darken by partial dehydration of sugar, and increase the rate at which the sugar caramerized.

B. Very pale crust color:

i. Too little sugar: The partial caramelization of the sugar during baking gives good crust colour. If too little sugar is used the crust will be pale.

ii. Lack of milk: Omitting milk powder or using water instead of milk affects crust colour as the milk sugar also caramelizes during baking. It is bad practice to use water alone because the appearance and flavour of the cake suffers.

iii. A very slow bake: This can give a poor colour and spoil an otherwise acceptance cake. Correct baking avoids this fault.

iv. A wet oven atmosphere: Excessive steam in the oven should be avoided because this acts as an insulator, inhibiting the baking of the crust.

C. White spots on the cake surface

i. Batter standing too long before baking: This allows moisture to evaporate from the surface; sugar crystals are held in the slightly dehydrated surface and remain there to give white sports on the baked cake.

Batters should be taken directly from scaling to the oven, if possible. If they have to stand they should be covered to prevent the surface of the batter from drying.

ii. The use of very coarse sugar: If sugar crystals are too large they dissolve slowly. White spots appear on the surface of the baked cake when large crystals do not dissolve and are held in the top surface during baking. Granulated sugar is usually too coarse for cake making. If granulated or coarser sugar is used the problem will not normally occur.

iii. Too little liquid: Insufficient liquid in the formula will cause undissolved sugar to remain in the batter which will bake out as white sports in the top crust.

iv. Slow baking: This slows the top surface to dry out slowly in the oven and will give a similar effect.

D. Crumb discolouration in white cake

i. Insufficient free acid in the formula: Discolourisation is often caused by the alkalinity of egg white. The effect may be offset by the incorporation of free acid in the form of 30g cream of tartar for each 2.25 kg of flour mix.

ii. Use of invert sugar: This should be restricted 10% of the total sugar content.

iii. Egg white standing in metal bowls: This will darken and discolour the baked cake crumb.

iv. Baking conditions: The cake crumb will discolour when cakes are baked with too much bottom heat or when cakes are over-baked.

In the former case discolouration will be accompanied by a thick bottom, crust, in the latter by a thick crust around.

3.3.6 MISCELLANEOUS FAULTS

Mould growth in cakes:

i. Excessive moisture: Mould requires moist conditions to grow. Any circumstance, which allows cut surface or outer crusts of cake to become very moist, will increase the risk of mould development.

a) Wrapping cakes while they are still warm. Cake temperature should be reduced to about 75°F before wrapping.

b) Storage in a warm, moist place. Baked foods should always be stored in cool dry conditions.

ii. Contamination: Care should always be taken to avoid contamination. The contamination may occur due to following:

a) Storage of cakes in contact with moldy cakes, or in trays previously used for moldy cakes.

b) Packing contaminated wrappers: All wrapping materials should be covered during storage.

c) Use of dirty utensils, such as knives.

d) Handling with unwashed hands: All cup-boards, racks, trays and utensils which have been in contact with moldy cakes should be thoroughly washed in a weak solution of acetic acid (glacial) and water.

3.4 SUMMARY

Cakes are classified mainly in three categories namely batter type, foam type and pound cake. Batter type cakes can be divided into high ratio cake and low ratio cake. High ratio cake contains more sugar than flour while low ratio cake contains less sugar than flour. Foam type cakes are leavened by air whipped into egg portion. These are of two type i.e. angel and sponge cake. Angel cake makes use of egg white to entrap air, whereas sponge cake uses mixture of whole egg and egg yolk. Pound cake represents oldest examples of aerated fat in cake. Cakes are essentially produced by leavening agents and by air incorporation. A high fat and low water content characterize pastry. The major operations required manufacturing cakes and pastry are mixing, baking and packaging. The faults in cake are due to imbalance in the formulation, use of poor quality raw materials and faulty processing conditions. Cake faults are divided into six categories

i). Shape faults

ii). Structural faults

iii). Texture faults

iv) Crust faults

v). Colour faults

3.5 KEY WORDS

Batter type cakes: Cakes which are made from liquid types of batter (loose dough). These cakes can be divided into high ratio cake and low ratio cake.

High and low ratio cakes: These are batter types of cakes. High ratio cake contains more sugar than flour while low ratio cake contains less sugar than flour.

Foam type cakes: These cakes are leavened by air whipped into egg portion. These are of two type i.e. angel and sponge cakes.

Angel and sponge cake: These are classified as foam types of cakes. Angel cake makes use of egg white to entrap air, whereas sponge cake uses mixture of whole egg and egg yolk.

Formula balance in cakes: It depends on the type of cake manufactured. Each ingredients used in different types of cake contributes on the quality. Any basic change in one of the ingredients requires a counter balancing adjustment in the other ingredient to maintain cake quality.

3.6 SELF ASSESSMENT QUESTIONS

1. How formula balance is important in the quality of cakes?

2. Classify cakes, given their formulations and explain each category in brief.

3. How faults develop in the cakes?

4. Discuss ways to eliminate cake faults.

5. Give a brief account of unit operations used in the processing of cakes.

6. What are the packaging requirements of cakes?

3.7 SUGGESTED READINGS

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PGDBST-06 **Dr. Alka Sharma**

UNIT-4 CRACKERS AND MISCELLANEOUS BISCUIT LIKE PRODUCTS

STRUCTURE

4.0. OBJECTIVES

After studying this unit you should be able to:

- Classify soft wheat products and differentiate them.
- Understand the importance of various technological steps involved in their manufacture.
- Know the process of baking.
- Know the ingredients used in their making.

4.1. INTRODUCTION

Biscuits and biscuit like products have been consumed by humans for hundreds, perhaps thousands, of years. Although in existence for a very long time, the difference, the difference between a biscuit, cookie and a cracker is still often less than clear. This is due to a recognized overlap between the boundaries used to define each of the categories. The intent of this summary is to present a definition of the terminology, enumerate the types of product in each category, and describe the features common to the various products.

The term ‘biscuit’ is derived form the Latin ‘*bis coctus’* or the Old French ‘*bescoit*’, meaning twice cooked. This refers to the practice, generally abandoned in the 18^{th} century, of first baking the product in a hot oven and then transferring to a cooler oven to complete the drying process. The word cookie is derived from the Dutch ‘*koekje*’, meaning little cake. Crackers likely derived their name from the sound made while being eaten.

The name ‘biscuit’ is regarded differently based upon geographic location. In the USA the term ‘biscuit’ describes a chemically leavened product which has no true parallel elsewhere but bears some similarity to what in the UK is a scone. In contrast, those products recognized in the UK as ‘biscuit’ would be termed ‘cookies’ or ‘crackers’ in the USA. The products described in this work will be those recognized as biscuits in th UK and cookies and crackers in the USA.

The characteristic that all biscuits have in common is their general composition. All are based on cereals, the most common cereal being soft wheat flour. However, these products differ form other cereal based products (breadstuffs) in that they are baked to a moisture content of less than 5%. The low moisture content serves two purposes. It ensures that the products have a relatively longer shelf life without risk of microbiological spoilage. Further, it confers a crisp texture deemed to be desirable in most biscuits and crackers.

In addition to flour, the two principal ingredients that all biscuits have in common are shortening and sugar. While water is common to all formulae, it is not considered a principal ingredient because it is utilized to modify the raw product's rheology during processing and is then driven off during baking.

4.2. CLASSIFICATION

Biscuits can be classified based upon their formulation, their method of manufacture, their dough rheology and/ or finished product texture or their name. In the UK, biscuit dough is characterized as either 'hard dough' or 'short dough'. Hard dough is that possessing a continuous, three-dimensional gluten network formed during mixing and processing. Such dough is usually elastic with some degree of extensibility. The dough are sheeted and then cut to form the desired product shape. In the USA these dough are usually referred to as 'cutting machine dough', a name which reflects the equipment utilized in processing. Regardless of the name given to the dough, finished products in this group are referred to as crackers and semisweet biscuits.

All cookies are classified as 'short dough'. Short dough is distinct from hard dough in that the former are neither elastic nor extensible. Wheat flour along with shortening, sugar and a relatively low level of water create plastic, cohesive dough with minimal gluten network formation when subjected to limited mixing. Short dough is formed into finished biscuits in a number of ways: rotary molding, wire cutting, extrusion and sheeting/ cutting. Cookies formed by the extrusion method are sometimes called soft dough or deposited biscuits. In the UK these products may be referred to as sweet biscuits. The internal structure of the baked cookie is a mixture of a discontinuous protein phase, starch and the sugar in glass form. The fat is present in large globules or as interconnecting massed between the starch and protein.

4.2.1. SODA CRACKERS

The term ‘soda’ or ‘saltine’ describes a very particular type of cracker. The soda cracker is an unsweetened, long fermented and laminated dough product. A typical soda cracker is a square biscuit approximately 50X50 mm with a thickness of 4mm. Individual saltines are not formed and baked. Instead, wide dough sheets are perforated by scrap less cutters prior to baking. After baking, these perforations form lines of weakness which enable the sheet to be broken into individual units. An additional feature of the product is the nine docker holes arranged in three rows of three which serve to tie the layers of dough together at those points. During baking, a good quality soda cracker puffs (springs) uniformly at every space between the docker holes as well as at the edge of the cracker. The top’s blisters are uniformly brown while the bottom surface is nearly flat with many small blisters. The internal structure of the product consists of a series of layers between each docking hole generated by lamination during the manufacturing process. The cracker usually weighs 3-3.5 g and has a moisture content of 2.5%. The cracker is usually bland in flavour but with a unique crisp texture. The texture is the result of the laminar structure and low moisture content.

Soda crackers are made from dough that is lean relative to the other products of this category. A typical formulation has 8-10% shortening in the dough, up to 0-5% yeast, plus salt, and optionally, malt or malt syrup. The crackers are produced in a sponge and dough process with a lengthy sponge fermentation followed by neutralization with soda before sponge mixing and fermentation. The pH of the product does not drop appreciably during the dough fermentation, resulting in a slightly alkaline product; hence, the name ‘soda’ cracker.

4.2.2. CREAM CRACKERS

Cream crackers originated in the 1880s from an Irish firm named Jacobs. Although the product name implies that there is cream in the product, there is none. It seems that the name is traditional with no reference to the ingredients utilized to make the product. The cracker is similar to a soda cracker in that it is created from an unsweetened but long fermented, laminated dough. However, there are a significant number of differences between the two products. The cream cracker is usually relatively large (65X75 mm) and rectangular in shape. Its surface is pale with lightly browned blisters on both the top and bottom surfaces. The puffing and blistering give the product its uneven surfaces and a flaky layered structure that should be even throughout the interior. The finished moisture content is approximately 3-4%, slightly higher than for saltines.

All cream crackers have a simple formula containing flour, shortening (12-18%), salt (0.9-1.5%), water and yeast (1.0-2.4%). The dough is mixed in a single stage and fermented for a length of time defined by the manufacturer, which ranges from 4 to 16 h. As with saltine the product is laminated, but in this case a fine cracker dust is added between layers prior to cutting and baking. The cracker dust filling, which consists only of flour, shortening and salt, is thought to facilitate separation between the layers of rather wet dough (approximately 26% moisture) during the processing. During baking, the laminations lift apart, form the irregular layers and give rise to the characteristic blisters and flaky structure. As is true for the production of saltines, a very hot oven is preferred to provide rapid expansion from steam and to dry the product.

The texture of a cream cracker should be soft so that it melts in the mouth and does not shatter. The texture is a result of both the fat content and the degree of separation of the layers. Because there is no chemical leavening, the product's flavour is bland and slightly nutty.

4.2.3. SNACK CRACKERS

This group of biscuits may also be termed savoury or fat sprayed crackers. They are made in a wide variety of sizes and shapes, but the essential feature that defines the group is that they are oil sprayed while still hot from the baking process. The products may also be salted or dusted with a flavoured powder after the oil spraying. The flavourings may range from herb or savoury to cheese powders.

The products in this group may be generated by a range of manufacturing methods. As a rule, the dough is usually not fermented although exceptions exist which employ a one or even two stage fermentation. Generally, those products that have been fermented are also laminated; products generated without fermentation may be laminated or simply sheeted and cut.

Depending on the process utilized to create the dough, the products are either yeast or chemically leavened with most being chemically leavened. The texture of the products in this group depends on the manufacturing process utilized and differs from that of either saltines or cream crackers. In general, they have a more dense structure than that of either saltines or cream crackers and a relatively soft bite. Snack crackers have a finished moisture content that should not exceed 2%. The flavor of the product comes primarily from the fat spray and the topping applied. Surface oil sprays improve the mouth feel and enhance the appearance. It is common for a small amount of sugar or syrup to be included in the formulation. The sweetener acts to reduce the dry mouth feel and also as a flavor enhancer.

4.2.4. HARD SWEET AND SEMISWEET BISCUITS

The biscuits comprising this group are colloquially called 'hard dough' biscuits. They originate from the UK. All doughs of these products are characterized by a well developed gluten network which is the result of a relatively high water content, relatively low amount of fat and sugar, and vigorous mixing. The usual formula is quite simple, containing only flour, sugar, shortening, molasses or corn syrup, chemical leavening and water. The sugar content is usually 18-20% of the flour weight for the semisweet biscuits. In hard or semi hard biscuits the shortening is present in about the same proportion as the sugar. Corn syrup or molasses is present at 8-9% while water varies at up to 20% of the flour weight.

These biscuits receive a very short rest period once out of the mixer, and may or may not be laminated. Following the cutting operation, the dough may be washed with milk or an egg/milk mixture to enhance the glossy appearance obtained during baking. The biscuits may also be garnished with sugar or other granular material.

The visual characteristics of this product are a smooth surface with a slight sheen and a pale colour. The products are always docked and usually include a product name and identifying pattern stamped into the top surface of the biscuit. The texture of the products is highly dependent on their formulation, ranging from a hard to a delicate bite. However, all products have an open texture. The higher the flour protein content and the lower the formula sugar level, the harder the resulting texture of the biscuit. As the sugar level increases, the texture becomes more delicate and the flavour is modified.

Most products have a mild vanilla or butter flavour that is derived from the ingredients, not developed by baking. This is particularly evident when butter is used in the formula. Artificial flavours are rarely added to the product.

4.3. MANUFACTURING TECHNOLOGY

The manufacturing process used to produce all biscuits, coolies, and crackers consists of a mixing step, a shaping or forming step and a baking step. The mixing and baking steps are common to the manufacture of all types of these products. What is distinct for the products are the shaping or forming steps. The processing steps used to produce these products are as follows:

4.3.1. MIXING

Mixing is commonly defined as a process designed to blend separate materials into a uniform, homogeneous mixture. In the context of cookie and cracker dough the term takes on a broader meaning in that it also applies to the development of gluten from hydrated flour proteins, the aeration of a mass to give a lower density, and the dispersion of solids in liquids. One or more of the functions is required for the formation of cookie and cracker dough. These processes are accomplished with three principal types of mixers: vertical spindle mixers, horizontal drum mixers, and continuous mixers.

4.3.2. THE FORMING PROCESS

While the same mixing and baking process may be used for many types of cookies and crackers, the forming step is specific to each product type. There are following three steps processes used to form cookie and cracker dough:

(1) Sheeting & Cutting

(2) Rotary moulding

(3) Extrusion

For each of these methods the rheology of the dough is different, and designed to be compatible with the process. In general, dough that are to be sheeted possess a significant gluten network as a result of mixing, and are both elastic and extensible. Those destined for rotary moulding lack gluten development and are best described as cohesive. Dough intended for extrusion are soft, frequently high in shortening, and spread while baking.

4.3.2.1. SHEETING AND CUTTING

The most common and versatile method to form cookie and cracker dough is by sheeting and cutting. This method consists of the production of a thick sheet of dough, evenly reducing the thickness of the sheet, cutting out the desired shapes, and returning the scrap dough to be reincorporated either in the mixer or early in the sheeting process. This method is used for the production of cracker, semisweet biscuit, and selected soft dough.

After mixing, the dough is fed into a hopper, below which lie the sheeting rollers. There typically are three rollers below the hopper arranged in a triangular fashion. At least one of the top two rollers known as forcing rollers, is grooved so that a positive feed is provided to the gauge or gauging roller. The gauging roller, which is always smooth, serves to deliver the dough to the conveyor belt. The purpose of the sheeting unit is to compact the mass from dough hopper uniformly and provide a sheet of even thickness having the width of the processing line.

The relatively thick dough slab form the sheeter then passes through a series of reduction or gauge rollers. These are smooth steel rollers used to reduce the dough sheet to the thickness which is desired before cutting of the finished dough piece. The gauge rollers occur in pairs mounted vertically. For products having sticky or adherent dough it may be necessary to mount a scraper blade against one or both of the rollers to release the sheet of dough. On most process lines there are two to three pairs of rollers. This ensures that the thickness is reduced no more than 50% at any one rolling operation.

Some dough, such as those of saltines and cream crackers, are laminated before cutting. The lamination occurs by lapping the dough back upon itself in the process direction. At the lapper, the take away conveyor lies at a 90^0 angle relative to the line delivering the dough. The number of layers is controlled by the relative rate of the lapper and takes away conveyor. The lapped dough then passes through several more sets of gauging rollers to bring the dough sheet to the desired thickness prior to cutting.

The repeated working of the dough in one direction results in an accumulation of stress. If the dough was cut at this point the resulting pieces would shrink to relieve the stress and misshapen or distorted products would result. Therefore, it is normal to relax the dough after reduction and before cutting. The relaxation is accomplished by transferring the dough to a conveyor, still moving in the same direction, but at a slower speed.

Once the dough has been relaxed it passes onto the cutting operation. Two different types of cutting methods exist: reciprocating cutters and rotary cutters. The reciprocating cutters are heavy block cutters that stamp out one or more pieces at a time. The cutter head may have a dual action whereby the cutter drops first, followed by a docking head or an embossing plate. The equipment operates via a swinging mechanism so that the dough sheet moves at a constant speed, the cutter drops and moves with the dough, then it rises and swings back to the original position. The second type of cutter, the rotary cutter, consists of a rotating metal cylinder. On the face of the roll are formed the desired shapes with a sharp metal edge. As the cutter rotates with the dough conveyor, the metal edges cut into the dough sheet to form the product. The product pieces are then conveyed into the oven.

As a result of either cutting process, from 20 to 60% of the dough sheet remains as scrap. The scrap dough is lifted way from the cut dough pieces and returned either to the mixer or to the sheeter. Return to the mixer permits uniform incorporation of the scrap into the dough mass. However, most systems route the scrap back into the sheeter either along the full length of the hopper or at the backside of the hopper. If dough is incorporated behind the new dough, imperfections will be on the bottom side of the dough sheet and will not be visible on the finished product.

4.3.2.2. ROTARY MOULDING

Three rollers are placed in a triangular arrangement below a dough hopper. A roller called the forcing or feed roller has deep grooves designed to pull dough down from the hopper. The dough is forced into the cavities of the engraved roller by the forcing roller. A scraper blade is mounted against the engraved roller to remove any excess dough and return it to the hopper via the forcing roller. Beneath the engraved roller is a rubber covered extraction roller that serves to drive the take away belt. The extraction roller applies pressure to the engraved roller via the belt, causing the dough to adhere preferentially to the conveyor belt. Dough pieces are dropped from the take away belt into pans or directly onto the baking belt.

The rotary moulding process is suitable only for dry, crumbly dough. This process offers advantages over sheeting and cutting in that there is no scrap to recycle, and there are very low labour requirements to run the process.

4.3.2.3. EXTRUSION

There are two types of devices used in the production of extruded cookies: wire cut machines and bar/rout press. Both systems are very similar in design. A hopper is placed over a system of two or three rollers that force dough into a pressure chamber. The rollers may run continuously or intermittently to force dough out of the pressure chamber at the die. For wire cut cookies, the dough is extruded through a row of dies and a wire or blade mounted on a frame moves through the dough just below the die nozzle outlet. The cut dough pieces then drop into a conveyor band for transport to the oven. The wire usually moves only in one direction through the dough, opposite that of the conveyor. The wire cut machines operate at rates of up to 100 strokes per minute. Difficulties encountered with this type of production are distortion of the extruded dough piece during cutting, and inconsistent placement or drop of the cut piece onto the conveyor.

The design of the bar or rout press is very similar to the wire cut machine. The hopper rollers and pressure chamber are essentially identical to their wire cut counterparts. Unlike the wire cut machine, the base of the pressure chamber has a die plate that is inclined in the direction of the extrusion. A continuous ribbon of dough is extruded from a nozzle which is shaped to impart the desired finished product design. The dough ribbon can be cut into individual pieces by a vertically operating guillotine before the oven or after baking. If the product can be baked as a continuous ribbon the dough is extruded directly onto the oven band, otherwise it is extruded and cut onto a conveyor belt.

4.3.3. BAKING

The cookie and cracker industry relies almost exclusively on band or traveling ovens to bake its products. The band oven is essentially an insulated, heated tunnel equipped with a continuous conveyor. The ovens vary both in length (from 30 to 150m) and in band width (from 1.0 to 1.5 m). More modern ovens frequently consist of a series of modular units or zones. Each of the zones is equipped with its own set of controls so that the temperature and air flow may be controlled within that zone. The oven band is typically continuous, passing onto a drive drum at the end of the oven and returning underneath the baking chamber to a tension drum at the feed or input end of the oven. The chamber through which the oven belt returns may or may not be enclosed. Frequently, the oven band serves as the baking surface for the product. Depending on the product type the oven band may be solid or any of a variety of open wire mesh types. Choice of mesh is a critical factor in the process as it affects the heat transfer at the bottom of the product. This, in turn, can have a marked effect on quality of the finished product.

There are three basic typed of ovens: direct fired, indirect fired and fully indirect fired. Ovens are usually heated by the combustion of gas, although there are a few manufacturers who use oil or electricity for economic reasons. The most common type is the direct-fired oven in which gas is burned inside the baking chamber itself. In these ovens, the burners are placed across the width of the oven at regular intervals, both above and below the oven band. In other oven types, termed ‘indirect ovens’, the gas or oil is burned outside the baking chamber and the heated combustion gases are circulated into and throughout the baking chamber. Indirect fired ovens typically have al single burner for each section. The hot gases from the burner pass along pipes parallel to the length of the oven, both above and below the oven band. The products of combustion are circulated throughout the baking chamber by large fans. Fully indirect ovens are those in which the heat source is independent from the baking chamber and heat transfer occurs via a heat exchanger. None of the products of combustion circulate inside the baking chamber. This type of oven is not common except when oil is used as a combustible material. If circulated, the products of this type combustion would impart an unacceptable flavour to the products.

4.3.4. COOLING

Products hot from the oven must be cooled prior to packaging for several reasons: the products may not be firm enough to withstand the packaging process while warm, the packaging material may shrink around a warm product, or the quality of the products would deteriorate if palletized while warm because the cooling rate across the pallet would be quite slow.

The normal method of cooling products is to place them on an open conveyor and transfer them a distance 1.5-2 times the length of the oven. The products cool naturally in the ambient factory atmosphere. In a few cases, it is necessary to provide forced air to aid the cooling process.

4.4. WAFERS

Wafers are baked as sheets, cones and sticks or with different fancy shapes.

Characteristic features in respect to other bakery products are as follows:

1. They are very thin biscuits: the overall thickness is usually between < 1 and 4 mm. They often carry the typical 'wafer pattern' on one surface or on both.
2. The texture is delicate and crisp. The product density is approximately 0.25 g $cm^{-3.}$ In cross section the matrix is highly aerated and primarily of gelatinized starch.
3. The surfaces are smooth and precisely formed, with the dimensions and all the details- engravings, logos, etc. of the baking moulds.

4.4.1. CLASSIFICATION

There are two basic types:

1. No or low sugar wafers. The finished biscuits contain from zero to a low percentage of sucrose or other sugars. Typical products are flat and hollow wafer sheets, moulded cones, and fancy shapes.
2. High sugar wafers. More than 10% of sucrose or other sugars are responsible for the plasticity of the freshly baked sheets. They can be formed into different shaped before sugar recrystallization occurs. Typical products are moulded and rolled sugar cones. Rolled wafer sticks, and deep-formed fancy shapes.

In both wafer types, the main ingredient is usually wheat flour. Wafers fit very well into current dietary recommendations to consume more cereals, as they are high carbohydrate, low fat products.

Modern wafers are low fat cereal products, very similar to the altar breads for Christian churches, and are basically made out of flour and water.

4.4.2. MANUFACTURING TECHNOLOGY OF WAFER BISCUITS

Wafer are often part of different products in the market, both with savoury or, mostly, with sweet tastes

The following table lists the common ingredients for both types of wafer.

Wafer batter ingredient ranges (Weight parts, flour=100)

	No/ low –sugar	High-sugar
Wheat flour	100	100
Water	130-160	100-140
Sucrose	0-4	25-70
Milk powder	0-2	0-2
Oil and fat	0.5-2	2-6
Soya Lecithin	0.2-1	0.2-1.5
Sodium bicarbonate	0.1-05	0-0.3
Salt	0-0.6	0-0.6

Some minor ingredients like other cereal flour, soya flour, starches, other sugars, eggs, ammonium bicarbonate, yeast, caramel, cocoa powder, spices, flavours, colours may be added optionally.

Typical productions schemes for two most important types of wafers are shown in the following table.

Scheme of wafer production lines

Step	No-sugar wafer (e.g. sandwiched wafe biscuits)	High-sugar wafer (e.g. rolled suga cone)
1.	Ingredient mixing	Ingredient mixing
2.	Batter transport and depositing	Batter transport and depositing
3.	Oven baking of a sheet	Oven baking of a sheet
4.	Release and cooling	Release and forming
5.	Conditioning	Cooling
6.	Creaming and book building	Stacking
7.	Cooling and cutting	Packaging
8.	Enrobing or moulding	
9	Cooling and Packaging	

4.4.2.1. INGREDIENT MIXING

After mixing for a few minutes, the water-soluble components are dissolve and the farinaceous ingredients made up into a homogeneous suspension

4.4.2.2. BATTER TRANSPORT AND DEPOSITING

From a storage tank, the batter is pumped to a depositor head and spread onto the baking mould.

4.4.2.3. OVEN BAKING

The baking of wafer sheets is performed in ‘tongs’, i.e. pairs of cast iron metal plates with a hinge and latch on opposite (shorter) sides. The precisely machined baking plates carry readings or other engravings (‘flat’ wafer sheets). The plates can also carry special figures (nuts, sticks, hemispheres, fancy shapes) up to a depth of approximately 20 mm. This kind of sheets are called ‘hollow wafers’. The plates can be surface plated, e.g. with chromium. The plates are edged with metal strips to give a closed baking mould, except for small venting channels for steam release. Baking plate sizes up to 350X700 mm are available. Wafer baking ovens have 32 to 120 of these pairs of plates, continuously circulating on a chain. They can be gas or electrically heated and operate at temperatures between 160^0 C and 180^0C.

The Baking Process

A few seconds after deposition of the batter, the baking moulds close and are locked. At first, the batter is distributed mechanically, but then it is spread completely by the steam which evolves. Small ‘bobbles’ of batter are extruded through the venting strips as the pressure rises. Aeration of the batter and gelatinization of starch start immediately.

When most of the water has been driven off by evaporation through the venting holes, the glass temperature of the wafer matrix rises and the stable structure is formed. The temperature of the wafer is coming up to $160\text{-}180^0$C, which is the temperature of the baking mould. Now, by Maillard reactions, the typical colour and flavour are developed.

Overall baking times vary from 1.25 to 2.5 min, depending on wafer thickness and baking temperature.

During the manufacturing process, there is no substantial degradation of starch molecules compared to other bakery products such as extruded cereals. Therefore wafers have two unique textural properties:

1. Extreme crispness on biting and initial chewing.
2. Good mouth-feel during prolonged chewing and swallowing, owing to the absence of sticky, glutinous stimuli.

4.4.2.4. RELEASE AND COOLING

At one end of the oven, the plates open to release the baked sheets and spread fresh batter, and then reclose very quickly. The sheets are cooled to room temperature while passing through an arch-type sheet cooler.

4.4.2.5. CONDITIONING

After baking, the water content is below 1% for this reason wafers absorb humidity very easily. Parallel to water uptake, the dimensions of the sheet increase by approximately 0.2% for every 1% of additional water. To compensate for the low water activity, humidity conditioning up to 3% or 4% water content is possible. It is recommended, especially if enrobed or chocolate moulded wafer products are made, that this first dimension increase is anticipated, so that cracking of the coating during shelf life can be avoided.

Up to a water content of 5-6%, wafer sheets have the typical crisp texture, but higher water levels result in an inadequate, tough, or even soft and soggy texture.

4.4.2.6. CREAMING AND BOOK BUILDING

The sheets then pass the creaming station, where a cream layer is applied to one side. Sugar and fat creams with different flavours (hazelnut, chocolate, caramel, milk, fruit) at temperatures of 30-40^{0}C are used. Several creamed sheets, together with a non-creamed top sheet, form a so-called ‘wafer book’.

4.4.2.7. COOLING AND CUTTING

The cooled wafer books are wire-or saw-cut into small biscuits.

4.4.2.8. ENROBING OR MOULDING, AND COOLING

The cut biscuits may be enrobed with chocolate, sometimes after the application of chopped nuts or crispies to the top wafer. Moulding in chocolate is another possibility. After a final cooling step, the biscuits are ready for packaging.

4.4.2.9. PACKAGING

The biscuits have to be packed tightly to protect against humidity, and also against oxygen and light, to ensure a shelf life of 6-9 months.

4.5. PRETZEL

The pretzel is one of the world's oldest snack foods. The word pretzel stems from the Latin, *pretiola*, or little reward. According to popular legend, it was invented by a monk in the twelfth century to be given to children as a reward to those who said their prayers correctly. Legend also has it that the crossed center of the pretzel form represents the crossed arms of prayer, the early Christian sign of the cross, which predated the folded hands we are familiar with today.

The pretzel appears on the coat of arms of the bakers of Vienna, first awarded in 1529. Pretzel bakers, up early to bake their wares for the day, heard the Turks tunneling under the city walls and gave the alarm that saved the city. A grateful prince awarded a coat of arms to the bakers, thus establishing the pretzel as the symbol of bakers throughout Europe. Today, all over Europe, but especially in Germany, Switzerland, and Austria, the sign of the pretzel signifies a bakery-which may or may not make the pretzels displayed on its sign. The pretzel has taken many forms during its 800 years of evolution and is manufactured and sold in six of the world's seven continents. It is the third largest selling salty snack in the United States, with sales totaling $ 1.3 billion in 1998.

4.5.1. CLASSIFICATION

Pretzels are divided into two broad categories: soft and hard. Soft pretzels, the largest of all pretzel types, are traditionally shaped and consumed as fresh bread like snacks. They are often baked at the point of sale, served fresh, and have a shelf life measured in hours. Hard pretzels are smaller, crispy and consumed like breadstick snacks. Hard pretzels have a shelf life of six months in good packaging. Some of the important characteristics of pretzel types are listed in Table 1

The size and shape of a pretzel are significant and are at the core of why certain shapes are valued by individual consumers. Unlike other snack foods, the pretzel has the combination of alkaline exterior and acidic interior. The two radically different pH levels give pretzels their unique and characteristic flavour. It is the unique combination of shape and composite pH that attracts pretzel eaters.

Table 1. Characteristics of Selected Pretzel Types

Item	Size	Unit weight	Count per Pound	Moisture (%)
Standard soft	4”X 5”	3 oz	5.3	18-23
Stadium soft	8” X 8”	6 oz	2.7	18-23
Regular twist	3” X 3” X3.75”	2.5 g	120	2.5
Mini	1.5” X1.5” X .187	1.5 g	303	2.5
Bavarian	3” X 3” X .5”	15 g	30	2.7
Hanover hard	3” X 3” X .6”	16 g	26	2.7
Sticks	3” X 4”	1.0 g	454	2.0
Nuggets	1” X 1.5”	2.8 g	162	2.5
Logs	2.75”	2.6 g	162	2.5
Rods	7”	14 g	32	2.5
Specially shapes	-	-	200-300	2.5

4.5.2. MANUFACTURING TECHNOLOGY

The pretzel is a simple and basic food. The most basic formula consists of only flour, yeast, salt and water. Malt is often added for both color and sweetness. Hydrogenated soybean oil is commonly added as a fat to soften the texture.

4.5.2.1. FORMULATION

Soft pretzels are similar to fresh bread, and bread flour is the most common flour used in their manufacture. Like bread, soft pretzels require a gluten structure to capture the carbon dioxide form yeast fermentation and sufficient protein to resist staling. Hard spring wheat flour, with a protein content of 11-14.5%, commonly makes up 100% of the flour component of soft pretzel formulas. Some manufacturers, in pursuit of lowering total manufacturing cost, blend in lower-priced, lower-protein winter wheat flour (protein content 8.5-9.5%) and may further add soft winter wheat flour with protein as low as 7.5% to the mix.

Table 2. A Typical Soft Pretzel Formula

Ingredients	Quantity (lb)	Baker's Percent
Flour (14-14.5% protein)	200	100
Non diastatic malt	4.0	2
Compressed yeast	3.0	1.5
Water	90	45

Low-protein components reduce shear in the make up equipment and make the dough more extrudable, but shorten the shelf life of the baked product because higher ratios of water to gluten tend to stale more quickly. Some soft pretzels are manufactured in a central location, par-baked and frozen, and finish-baked at the point of sale and served to the consumer right from the oven. In this case, the use of a portion of lower-protein flour reduces cost to the manufacturer but does not create a perceptible difference to the consumer. Where shelf life is more critical, bakers obtain better results with formulas that use a single, high-protein type of flour. A typical soft pretzel formula is shown in Table 2.

Soft red winter wheat with low protein content is the best flour for hard pretzels because most are extruded through dies to create their unique shapes, and consumers want crispy textures. The use of flour with stronger protein, while adding strength to the finished piece, also creates more shear in the extrusion equipment, which may damage the extrudate, create unsightly marks in the finished product and also slow production. Nondiastatic malt is a traditional choice of pretzel bakers for adding flavor and color to the dough. It is a humectant and extends the shelf life of the finished product. When active yeast is used as a leavening agent, diastatic malt is often selected for its enzyme diastase, which promotes yeast activity by modifying the starch in the flour.

Corn syrup is almost colorless when added to the dough and is useful in markets where brown-colored baked products are perceived as burned. Corn syrup is less expensive than malt, is sweeter and also acts as a humectant. Adding malt to the formula darkens both the interior and the exterior of the pretzel. Corn syrup is not as effective in bringing out flavors in baking as malt, but is widely accepted in bakeries because it is easy to handle.

As in all baked goods, fats have an enormous influence in pretzels. Added to the dough, fats impart tenderness, moisten mouth feel, improve structure and strength, provide lubricity, and incorporate air and aid in the transfer of heat. Generally, it is not necessary to add more than several percent fat to substantially change the product. Pretzels are one of the few snack foods that can be made without the addition of any fat and have among the lowest fat contents among snack foods.

Table 3. A Typical Hard Pretzel Formula

Ingredient	Quantity (lb)	Baker's Percent
Flour (soft winter wheat protein 7-9%)	200	10
Hydrogenated soybean oil	8	2
Diastatic malt	4	2
Active dry yeast	2	1
Baking soda	0.125	0.0625
Water	54	37

Active yeast is the most commonly used leavening agent in pretzels. Instant active dry yeast is most popular in batch mixing processes, often added directly to flour before hydration. In modern continuous mixing applications, yeast slurries are created by mixing either active dry yeast or compressed (crumbled form) yeast with water, which is then metered into the continuous mixer in correct proportion with other ingredients.

Chemical leavening systems can also be used in pretzels although they do not create the glycerol, organic acids, aldehydes, fusel oil or alcohol flavor precursors associated with yeast activity. Ammonium bicarbonate is used by some bakers. Decomposition at room temperature is insignificant, but above 140^0F (60^0 C) it decomposes into ammonia, carbon dioxide and water. When ammonium bicarbonate is used to leaven cookies and crackers, the cell structure porosity of these products allows full escape of the ammonia during baking. In pretzels, however, bathing the pretzels in a mild solution of sodium hydroxide and water prior to baking creates a shell that can trap some of the ammonia.

The trapped gas can create blister, which later dry and break, resulting in an unsightly product. If the shell fails to break, the trapped ammonia also creates an off-flavor. In general, the use of ammonium bicarbonate is not recommended in pretzel manufacture. A typical hard pretzel formula is shown in Table 3.

4.5.2.2. MIXING

Integrated machinery is available for fully automated production that produces consistent pretzels. Pretzels dough is low absorption dough (35 to 45%) and is very stiff, requiring a great deal of energy to mix. Batch mixers have been designed specifically to handle pretzel dough. Processors typically increase the horsepower of their mixers when specifying pretzel-mixing service. Batch mixers have the advantage of being very flexible and able to handle a wide array of formulations and products. However, they have the disadvantage of producing batches that must be mated to what is otherwise continuous production. One of the chief problems with batch mixing in pretzel manufacture is the change in dough viscosity that occurs during the time interval between batches. The change creates variations in the extruded weight of the product. As a result, underweight product may burn in the oven while overweight product will be under baked, resulting in higher moisture content.

In addition to batch mixers, continuous mix systems are available and very efficient when long runs of one type of pretzel product are made. A typical continuous mix system consists of a gravimetric dry ingredient feeder of the flour and mass flow liquid metering for the water, fat, sugar and yeast slurry. Continuous mixers consist of a single shaft with a multiplicity of impellers and mixing blades mounted to achieve the desired actions of shear, stretching and pressure. At the completion of the mixing cycle, the dough emerges from the discharge orifice, is cut to predetermined chunks and is ready for transfer to the extruder.

4.5.2.3. DOUGH-HANDLING SYSTEMS

Fully automated dough-handling systems are capable of depositing dough into hoppers of many extruders without under filling or overfilling. This greatly improves scaling weights and helps ensure accurate, continuous production. When integrated with batch mixers, the dough-handling system includes a loaf-making machine that receives the entire batch of dough and gently guides it by two slow-turning feed rolls through an orifice, cutting the dough into the predetermined loaves ready for transfer to the extruder. From this point on, transfer of the dough is similar for batch or continuous mixing systems. The dough is deposited on a lift conveyor that consists of three belts. Two of which operate vertically, trapping the loaves between them and delivering them to the shuttle. Because the loaves always are uniform in size, the lift conveyor is extremely reliable in lifting the dough piece to the shuttle. The shuttle is a self-contained transporter built on a frame that moves rapidly on rails over the hoppers of the dough-forming machinery, normally extruders.

After receiving the dough, the shuttle moves away from its home station and carries the loaf to the specific hopper compartment or zone requiring dough, where it is discharged by a pneumatically operated clam-shell door, similar to the bomb bay doors found on military aircraft. The required dough level is determined by level control switches mounted in the shuttle support frame. An onboard programmable logic computer keeps track of requests for dough and sends the shuttle to the various hoppers on first-call, first-served basis to each extruder hopper.

4.5.2.4. EXTRUSION

The development of extruders for forming pretzels marked a major breakthrough in high-volume production. The function of the extruder is to force the dough through an array of dies to produce rows of pretzels simultaneously. A nearly limitless array of die patterns is easily interchangeable on a extruder, giving it flexibility to make all pretzel shapes with a single machine. Pairs of screws are driven through heavy-duty gearboxes by variable-speed motors. There may be as many as six pairs of screws per extruder, each pair fed by its own dough hopper. The screws transport the dough to be extruded into a primary compression barrel, then into a pressure equalization chamber and finally into the die that shapes the pretzel cutting it with a high-speed cutter band stretched across the face of the entire pretzel dies. The reciprocating knife is capable of making from 20 to 265 cuts per minute, where shapes are small; it is sometimes possible to arrange the dies so that a single knife stroke cuts two pretzels at a time, thus doubling the output of the machine. A guillotine cutter is used to cut nuggets, sticks and rods.

As with the dough-conveying system, the extruder is designed to transport and form the extruded dough without changing the properties of the dough. The short-barrel, low-pressure design reduces friction and thereby reduces stress on the dough. Augers are machined from a high-density, food-grade plastic for non-stick performance and minimum friction, and are lightweight, readily removed and easily cleaned. Production rates can range from 200to 2,000 lb (90to 900 kg) per hour, depending on the dough and the size of the pretzel being extruded.

4.5.2.5. PROOFING

From the extruder, the cut pretzel drops onto a proofing conveyor, which is designed to provide a holding period between the extruder and cooking- the next automatic process. The length of proofing time of pretzel products depends on dough formulation. Traditional hard, thin, pretzels require approximately 5 minutes on the proofing conveyor, while thick, Bavarian pretzels often require up to 20 minutes to properly proof. When higher levels of yeast are used for production of soft pretzels, proofing times may be as long as 25 minutes. Because the proofing conveyor is fixed in length, the design is almost always a compromise. When a wide variety of pretzel products is to be produced on the same line, the proofing conveyor must be long enough to handle the product requiring the longest proof.

Proofing conveyors are often operated under ambient conditions in the oven room, meaning there is no cover over the conveyor, Products requiring proofing temperatures in the 100^0F (38^0C) range usually need an enclosed proofing conveyor configured with controlled heat and moisture. On the proofer, the extruded dough piece develops an outer sealing skin that later becomes important in creating the rich, lustrous appearance of the finished product. The rest period also allows time for the yeast action to round out the cut piece and increase its volume before entering the caustic cooker.

4.5.2.6. COOKING

Of all the operations in the production of pretzels, cooking is the most important and, in some ways, the most interesting. Proper application of cooking solutions to raw pretzels is the most taste-critical step in their processing. Time, temperature and alkalinity (pH) are the key factors in developing the taste in pretzels.

In the cooker, the formed pretzels remain in their production rows and are transferred through an automatically fed pool solution of hot water and sodium hydroxide. Here, the surface pH of the dough becomes alkaline. The contrast of the alkalinity of the surface and the acidity in the interior makes the taste of pretzels unique. During the 10 to 15 seconds that the product is exposed to the 200^0F (93^0C), 1.0-1.5% sodium hydroxide solution:

1. Surface alkalinity is changed.
2. The surface starches are gelatinized.
3. Sugars in the surface are caramelized, creating the basis for the characteristic lustrous brown appearance of the product when later exposed to oven heat during the baking cycle.

Automatic cookers, with adjustable level controls that allow the immersion pool to be lengthened or shortened by the operator, are available. Although adjustable while in operation, the system maintains a liquid level within a tolerance of 0.01 in. (0.254 mm). Also, the concentration of sodium hydroxide solution does not vary more than plus or minus1%, and immersion time does not vary more than plus or minus 10%. In many cookers, a hydrometer is used to control the concentration of sodium hydroxide. Each time the water control system calls for more solution, the flow of water through a venturi draws a metered amount of 50% alkali solution and combines it with the entering water stream. Different concentrations of sodium hydroxide can be obtained by changing the size of the orifice in the venturi tube.

Cooker heat is provided by firing gas through a totally enclosed immersion tube designed to transfer the maximum BTUs directly into the surrounding solution. The belt and rack system can be raised out of the tank of the automatic cooker at the touch of a control button. In the lifted position, operators have clear and virtually instant access to the immersion tube and the sloped tank bottom.

The cooker has a fully enclosed design that keeps steam vapor and dust out of critical components as a sanitation feature. The full hood may be raised or lowered automatically. Soft pretzel products with higher yeast content tend to float in the alkaline solution of the cooker. In those cases, the formed pretzels are conveyed either beneath a waterfall-type curtain of sodium hydroxide solution, or through the tank under a hold down top belt.

4.5.2.7. SURFACE SALTING

After cooking, the wet, steamy pretzels are conveyed under a steady curtain of salt delivered by a specially designed roll. Excess salt falling through the wire-mesh conveyor belt is automatically cleaned of large particles and dust and recirculated to the dispensing device. The salting process is by passed in making salt-free products. Typically, large pretzels are salted with large grains of salt and smaller pretzels with a smaller size.

4.5.2.8. BAKING

After the very short salting process, the product proceeds to the baking chamber. The pretzel oven operates at maximum efficiency by close integration. The efficiency arises from the configuration of two separate chambers, one above the other-the oven above the dry kiln-each equipped with a traveling wire-mesh belt and each operating independently in the opposing direction.

The oven/drying kiln is constructed in modular sections coupled together to achieve specific length requirements. Oven bands are available from 39 in. (1 m) to 80 in. (2 m) wide. A wide variety of bake times and temperatures are used in pretzel baking like for regular thins a temperature of 288/260/260^{0}C for 2.8 min. is used and for soft a temperature of 315/302/260^{0}C is used for 4-5 min. while using a 3-zone oven.

Temperature control is essential. For example, if the dough temperature increases too rapidly, the surface of the product will dry before the internal moisture is driven off, resulting in formation of blisters on the surface. Each pretzel product has a heat process profile peculiar to its particular shape and/or formula. For optimal results, the oven must have the capability of matching its heat profile with the requirements of the respective pretzel type. In the past, many bakers used direct-fired ribbon burners installed above and below the oven band. Although generally inefficient, well designed, direct gas-fired (DGF) ovens have broad capabilities for matching product profiles because of the multiplicity of burners and ability to operate each one at a different setting. However, DGF ovens are difficult to adjust from product to product and have the further downside of variability in zone temperature. Today, the most popular ovens used in making pretzels are hybrid designs that combine radiant and convective energy control in the first zone and forced convection in succeeding zones and in the dry kiln. The ability to change the proportion of radiation and convection in the first zone enables pretzel bakers to easily adjust their oven profile to the requirements of almost any product. Since the heat input to these ovens is computer controlled, there is little problem with repetition of setup as the baker moves from one product to another.

4.5.2.9. DRYING

After the pretzel emerges from the oven, it is lustrous brown in color. However, the moisture content has been reduced to only 8 to 10%, and further drying, not baking, is required. The pretzels are allowed to follow the band over the main drive pulley where a knife frees them from the band, after which they gently cascade down onto the dry kiln wire-mesh band below. The kiln band travels in a direction opposite to that of the baking band where it enters the completely separate thermal structure of the drying kiln. At this point the product no longer remains in rows, but is allowed to form a bed on the dryer band. Drying time varies between 6 to 45 minutes, at temperatures between 240-270^{0}F (115-132^{0}C).

4.5.2.10. FINISHED PRODUCT CONVEYING

As the product finally emerges, it is discharged to the side of the oven/dry kiln onto finished product conveyors leading to packaging machines. The moisture content at this point is 2-4%. Finished product moisture is critical. Pretzels too low in moisture tend to break easily during packaging and transport, while pretzels too high in moisture content easily become stale resulting in reduced shelf life.

Color monitoring and computer control of the complete process from mixing through packaging is the latest addition to full automation. After the operator selects the products to be made, the system automatically sets temperatures, speeds, levels and pressures accordingly, and the computer monitors and regulates all process variables. The software can be modified to allow the operator to change all or some process set points and can also be designed to limit the range of the change allowed. Essentially, this means the oven can be controlled manually or automatically,

Automation, safety, operation control and variety of products made are integrated requirements in the production system affecting the pretzel's fragility and unique flavor characteristics. All transfer points must be gentle and smooth; products must be kept at uniform shape and weight and proceed in even production rows to expose each piece to the same proofing, alkali bath, cooking, salting and drying to achieve the same lustrous browning.

4.5.2.11. PACKAGING/COOLING

Pretzels exiting the dry kiln process are quickly cooled to less than 200^0F (93^0C) by natural convection currents. Pretzels are resilient to breakage while two to three times (^{0}F) warmer than room temperature. Breakage at the end of the kiln typically is less than ½ of 1% of total output. As the pretzel cools to room temperature, it becomes more fragile and must be handled with greater care. Finished pretzels are normally handled by an inclined belt conveyor from the dryer exit to a point overhead where they are gently transferred to an oscillation-motion conveying system. These conveying systems consist of vibratory pan conveyors (long, sturdy sheet-metal trays that are lifted and thrust in a specific reciprocal pattern, which causes material in the tray to gently move forward). They have the advantages of being easy to clean and convey large quantities of product with virtually no physical damage. In the case of pretzels, too much agitation in the conveying system is certain to cause salt loss.

On reaching the packaging area, the majority of pretzels move through multiple-head scales, which capture a tiny portion of the desired total package weight in a circular arrangement of weighing bins. A computer weighs each bin and rapidly calculates the combination of bins to be dumped that best equals the desired net weight of product.

Scales of this type are very accurate, producing errors no greater than1-2 grams at speeds of up to 150 bags per minute. Typically, a form, fill and seal bag maker receives the output of the scales. The bag maker makes packages from roll stock consisting of several laminations of co extruded preprinted material that is automatically fed into the machine. The finished product is placed into cartons either by hand or by machine.

4.5.3. PROBLEMS IN PRETZEL MANUFACTURE

The problems encountered in the manufacture of pretzels are very similar to those associated with the production of bread; out of many the following are most important:

1. Crystallization
2. Cooking Problem

Crystallization occurs as a direct result of extrusion. Dough exiting the extruder has visibly changed color, taking on a slightly grayish cast. The dough forms into and extruded pretzel, but when picked up by hand, it exhibits complete lack of elasticity and cohesiveness, often simply falling apart. The product does not rise in the oven and develops a dense, glassy texture. When cooled, the pretzel is extremely brittle, often breaking into tiny pieces when placed under the slightest stress. Product breakage rates after packaging can easily exceed 50%.

At this writing, no proven scientific explanation of crystallization in pretzels exists. It has been suggested that when put under sufficient pressure, or when damage or weakening of the amylopectin chains exists, the starch chains fracture and lose their normal ability to swell up in water and create the starch paste resulting in lack of product rise and lack of cohesiveness of the extrudate.

One or more of the following strategies have been designed to reduce pressure or reduce enzymatic damage to the dough:

1. Increase the proportion of water in the mix
2. Slightly increase final dough temperature
3. Reduce the amount of yeast in the mix
4. Reduce floor time or hold time of the dough
5. Check to ensure that the dough is mixed to the peak of gluten development
6. Using a flour after ensuring that it is not sprout damaged

The use of sodium hydroxide (NaOH) as a processing aid is unique to pretzels when viewed in the context of all baked goods. Indeed, the characteristic flavor that makes a pretzel a pretzel instead of a cracker or breadstick is derived from the application of a mild solution of hot water and sodium hydroxide, which changes the surface pH of the acidic dough piece to alkaline and prepares the pretzel for the browning reaction in the oven. The effect of bathing the pretzel in an alkaline solution is not unlike brushing a loaf of bread with an alkali such as egg white to create a deep, brown crust. But, unlike the bread process, the cooker bath is heated to temperature of 190-205^{0}F (88-96^{0}C), which creates both thermal and chemical gelatinization of the surfaces starches in the pretzel. In addition, the heated solution caramelizes surface sugars that participate during gelatinization to create the unique glossy surface characteristic of pretzels. The rapid increase in dough temperature causes a concomitant increase in enzymatic activity as well as initial swelling of the starch granules in the dough.

Because so much happens in the pretzel cooker, a lot can go wrong as well. Failure to maintain a constant proportion of NaOH to water alters the ratio of surface alkalinity to interior acidity and dramatically affects the taste of the final product. Typical ranges for cooker solution concentrations are 0.5-2.5% NaOH, with a tolerance of plus or minus 0.1%. Immersion time, though less critical than alkali concentration, affects gelatinization and caramelization, and affects temperature rise in the pretzel during its trip through the bath. Changes in internal temperature of the pretzel change enzymatic activity and the extent of initial starch swelling of the product. During the cooking process, dextrins are stripped from starch and dissolved in the hot water solution. Other ingredients meet a similar fate, combining to form an ever-increasing concentration of unwanted compounds. These contaminants cloud the otherwise clear cooker solution and cause the finished product to lose its characteristic shine. Modern cookers employ pumps and filters to remove contaminants and extend the life of the solution.

4.6. SUMMARY

Crackers can be classed into unsweetened soda cracker, cream crackers, snack crackers, hard sweet biscuits and semisweet biscuits. Cream crackers are alike soda cracker but are

of relatively large size and rectangular in shape. Snack crackers are oil sprayed while still hot. Hard sweet and semisweet biscuits are made by dough with fully developed gluten.
Manufacturing process used for making crackers is same as that for biscuits except shaping or forming step. Three main steps are involved in forming i.e. sheeting and cutting, rotary moulding and extrusion. After baking the product needs to be cooled before packaging. Wafers are very thin biscuits that are manufactured in fancy shapes like sheets, cones and sticks. They are delicate and crisp. Wafers are mainly of two types i.e. no or low sugar wafers and high sugar wafers. As the water content is less than 1%, they are susceptible to moisture gain. They need to be packed tightly to protect against humidity and to enhance shelf life. Pretzel is one of the oldest kinds of snack food and can be divided into two broad categories i.e. hard and soft. Hard pretzels are small and have shelf life of six months as compared to few hours shelf life of soft pretzel. During cooking, proper application of cooking solution to raw pretzels is the most taste critical step, although time, temperature and alkalinity are also important factors. Main problems encountered in pretzel manufacture are crystallization and cooking problems.

4.7. KEY WORDS

- Proofing: a step prior to baking wherein the dough is rested at a specified condition of temperature and relative humidity.
- Gelatinization: swelling of starch granules and loss of some starch ,when starch is heated with water to thicken the food products.
- Caramelization: fragmentation of sugars into organic acids, aldehydes and ketones due to intense heat.
- Dough: flour, kneaded generally with water to yield a thick mass i.e. capable of being moulded.
- Moulding: giving shape to the product.
- Batter: a beaten mixture of flour and water i.e. capable of being dropped or poured.
- Rheology: study of stress-strain relationship of materials.
- Dextrins: partially hydrolysed starch fractions.
- Humectants: Moisture retaining agents.

- Malt: a substance made by sprouting (generally barley) followed by drying and grinding. Malting enzyme esp. diastase converts starch to sugars.
- Sodium-bi-carbonate: a chemical leavening agent used for volume increase in baked products.
- Lecithin: a phospholipid, a very strong emulsifying agent.

4.8. SELF ASSESSMENT QUESTIONS

4.8.1. How can you classify crackers?

4.8.2. Discuss various methods of forming crackers?

4.8.3. What is the importance of "mixing" and "proofing" in baking?

4.8.4. Differentiate between biscuits, cookies, crackers, wafers and pretzels?

4.8.5. What are pretzels? What are the technological steps involved in their manufacture?

4.9. SUGGESTED READING

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