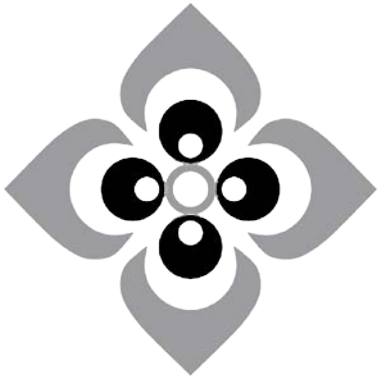

Consortium for Educational Communication

Module
on
Technology Of Biscuits

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TEXT

Introduction

The word biscuit is derived from the Latin "*bis coctus*" meaning twice cooked. Biscuits are flat, crisp, baked good and one of the best-known quick snack products. Biscuit is a low moisture bakery product (1-5 %) thereby has long shelf life if protected from moisture and oxygen. Biscuit dough is usually made from soft wheat flour with a high amount of sugar (25-55%) and shortening (20-60%). Biscuits can be grouped in many ways based on their texture and hardness, their change in outline during shaping and baking, the extensibility or other characteristics of the dough, or the ways that the doughs are handled prior to biscuit formation. 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. In contrast, those products recognized in the UK as biscuits would be termed cookies or crackers in the USA.

Raw material in biscuit manufacture

1. Flour

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 dough systems. Wheat flour when mixed with water, its protein components forms an elastic network capable of holding gas and developing a firm spongy structure during baking. The protein substances contributing these properties (glaidin and glutenin) when combined with water and mixed are known collectively as gluten. The suitability of flour for biscuit making is generally determined by its gluten. Most biscuits can be prepared from flour, which has low quantity of protein and has a gluten content that is weak and extensible. The softer wheat possess a less compact starch/protein complex that allows less starch damage and lower water absorption. The protein levels of soft wheat are usually lower, producing a less resistant, more

extensible dough. These weaker flours are traditionally deemed more suitable for biscuit making than harder flours used for breads. Thus flour with protein level of less than 9% is best and levels of more than 9.5% often create processing problems. Also, flour should not contain more than 14% moisture.

2. Sweetener

All biscuit formulae contain sweeteners, which constitute the bulk of dissolved materials in most doughs. Sugar imparts sweet taste, acts as a vehicle for other flavours, improves texture, crust colour and extends shelf life. 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. Sweeteners tenderize the finished product by interfering with gluten hydration and starch gelatinization.

3. Shortenings and emulsifiers

Fats are the third major component used in biscuit making. In doughs, they tenderize (impart shortness to) the crumb by being dispersed in films and globules during mixing, which interferes with gluten development. Fat acts as a barrier and prevents water from reaching the protein and as a result gluten does not form and the ingredients are not strongly bound together, giving the short, crumbly texture required. Shortening also aids dough aeration. The overall effect improves palatability, extends shelf life, improves flavor, and adds energy. If the fat level is high the lubricating function in the dough is so pronounced that a little or no water is required to achieve a desired consistency, little gluten is formed with reduced starch swelling and gelatinization giving a very soft texture. As a result dough breaks easily when pulled. The fat used for biscuit making should be able to cream and incorporate aeration and should not melt at baking temperature. Animal fats, primarily lard are used by bakers. Soya bean,

cotton seed, palm, coconut and peanut oils are the primary vegetables sources used in shortening production.

Surfactants like lecithin, mono- and diglycerides, polysorbate 60, and sodium stearoyl 2-lactylate modifies the surface behavior of liquids. They form complex with the protein-starch structure, thereby strengthening the film, and delay dough setting during baking. The behavior of surfactants is due to their amphoteric (possessing both hydrophilic and hydrophobic molecular region) properties. Their behavior varies according to the charges on the molecules, their solubility, the hydrophilic-lipophillc balance, and the type of functional groups involved. Surfactants modify dough consistency and reduce stickiness. They appear to react with gluten and increase its gas-retaining properties. Crumb softners also complex with the starch molecules to delay retrogradation and texture staling. The grain pattern and volume of the finished products are often improved.

4. 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. Egg whites are 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 biscuits. Whole eggs are best used at room temperature while egg white whip better when it is cooled. There is also the leavening effect, where eggs help to retain air that is beaten into batter during mixing. During baking this air will expand and being held in a fine network of egg protein (albumin) and flour protein that cannot escape and so remains to increase the volume of the final product.

5. Baking powder

Baking powder is combination of sodium bicarbonate and an acid salt like monocalcium phosphate, sodium acid pyrophosphate, and potassium acid tartarate. When these

agents combine with water, they react to form controlled amounts of carbon dioxide, which leavens 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.

6. Other ingredients

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.

Salt performs two principal functions in biscuit doughs. The first is flavor. It accelerates the flavor of other ingredients e.g, the sweetness of sugar is emphasized. Salt has a slight effect on the consistency of hard doughs, because it has strengthening effect on gluten. Salt also controls fermentation and aids in suppressing undesirable texture.

Other minor ingredients include malt, proteases, mould inhibitor, spices and flavourings. Though used in relatively small amounts, these ingredients have quite important effects on the sensory and physical qualities of biscuit. Biscuits may be flavoured in one or more of three ways: adding the flavouring to the dough before baking, dusting or spraying the flavor on after baking, or by flavouring a nonbaked portion such as cream filling, icing or jam that is applied after baking. Flavourings are

alcohol extract from fruits or beans. Vanilla is the most common because it blends with other flavours and is used within limits of 0.5 to 1 percent based on flour. Because flavourings are volatile much of them may be lost during baking.

Biscuit making processes

The manufacturing process used to produce biscuits consists of a mixing step, a shaping or forming step, a baking step, then cooling and packaging.

1. Mixing

Mixing is commonly defined as a process designed to blend separate materials into a uniform, homogenous mixture. Mixing achieves certain chemical and physical changes in the ingredients that are essential to the manufacturing process. These processes are accomplished with three principal types of mixers: vertical spindle mixers, horizontal drum mixers , and continuous mixers. The length of mixing time varies with the type and size of mixer. Slow-acting vertical spindle type mixers may require as much as 50 min whereas high speed mixers require about 20-25 min.

a. Vertical spindle mixers

Vertical mixers were used extensively before the development of the high-speed mixer. Most mixers of this type are equipped with two or three spindles. The spindles are lowered into the dough and move in either a planetary or a stationary, circular motion when activated. The mixer blades are designed to provide a cutting action rather than kneading or stretching the dough. The advantage of vertical spindle mixers is that they can be used for almost any product. The primary disadvantage of vertical mixers is their slow operating speed. Other disadvantages include lack of uniformity of the mix, and labour-intensive nature of the system's design.

b. Horizontal mixers

The blades of horizontal mixers are mounted on a horizontal shaft and may have any of several different shapes depending on whether a cutting, scraping or kneading

action is needed. The advantages of horizontal mixers are their high speed, ability to supply dough to a processing line continuously, uniformity of the mixes they produce, and their potential for complete automation. Horizontal mixers may be operated at speeds of 15-80 rpm.

C. Continuous mixers

Continuous mixers are the best described as rotor or screw operating within a barrel jacketed for temperature control. The ingredients are fed continuously, either from one end of the barrel or in successive ports at intervals along its length. The mixing action may be altered from gentle blending and dispersing to vigorous or high-intensity kneading by varying the arrangement of different mixing arms along the length of the barrel. The primary disadvantage of this mixer type is its high cost and the additional cost of the associated automated, continuous ingredient feeding systems.

2. The Forming process

The forming stage is very important because it is the first step in the whole process that affects the products appearance. Sheeting and cutting in biscuit processing is the most popular way of forming pieces of dough. 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 incorporated either in the mixer or early in the sheeting process. Dough at about 40°C should be used and protected from cooling. 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. A three-roll sheeter is used to form a continuous sheet of dough. The new dough sheet will then pass into one or more sets of gauge roll pairs, which are designed to reduce the thickness that is required for the dough cutting. The dough is typically carried on conveyors between the sheeter and each of the gauge rolls. In certain instances, when the thickness of the dough has been reduced, the sheet is then folded to form many laminations before it is further gauged into the final thickness that is desired. During this process, certain

stresses also built up in the gluten structure. If the dough is cut at this put the resulting pieces would shrink to relieve the stress and misshapen or distorted products would result. Therefore it is necessary to relax the dough after reduction and before cutting. The relaxation is accomplished by transferring the dough to a conveyer, still moving in the same direction, but at a slower speed.

Once the dough has been relaxed it passes onto the cutting operation. The cutting phase is designed to produce the outline of the desired size and shape. 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 conveyer, 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 away from the cut dough pieces and returned either to the mixer or to the sheeter. 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.

3. Baking

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 made 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%. Biscuits are usually baked in tunnel oven, which consists 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 length of an oven varies from about 30 to 150 m and the conveyer width from 0.8 to 1.2 m. Biscuits are placed either on a flexible metal or wire mesh band that travels continuously through the ovens length. Heat energy is generated by burning oil or more usually gas in the oven or by electric elements. Some ovens are built to transfer heat to the product by radiation from the burners and from the hot internal surface of the wall and roof of the oven. Other types of oven rely on directed currents of heated air to transfer heat to the product by convection.

Dough undergoes several changes during baking. Changes in dimensions and texture, loss of moisture, and color and flavour development are the most important. In the first stage, biscuit structure is developed. The dough piece enters the hot oven and heats up to about 40^{o}C before much change takes place. At this temperature, the fat it contains will melt. Heating continues, and at around 60^{o}C, the raising agents start to give off the gas they contain. Soon after this, between 80^{o}C and 100^{o}C, starch in the flour gelatinizes, and protein denatures, transforming the dough piece into more rigid structure, which has more or less shape and size of the final biscuit.

The next two stages, drying and coloring, actually overlap. Above 100^{o}C, oven heat drives off the moisture, and color starts to form as the product dries out. The finished biscuit will always have a darker color compared with its inner crumb color, because it is the outer areas that dry out first.

A typical baking time and temperature profiles are given below:

Baking Time	Zone I	Zone II	Zone III	Zone IV
3.0 min	310^{o}C	290^{o}C	270^{o}C	250^{o}C
5.5 min	250^{o}C	250^{o}C	240^{o}C	210^{o}C

4. Cooling

Products hot from the oven must be cooled prior to packaging for several reasons: the product 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 conveyer for a period of 1.5- 2 times longer than the baking period.

5. Packaging

The most commonly used material for biscuit packaging is orientated polypropylene (OPP), either as plain or pearlized OPP film, co-extruded OPP or acrylic-coated on both sides. If a superior oxygen barrier is required, acrylic-coated OPP is used, and sometimes one side is coated with polyvinyl chloride/polyvinylidene chloride copolymer rather than acrylic. These films also provide superior flavour and aroma barrier as compared to uncoated OPP.

Different types of biscuits

Biscuits have been classified based on the dough consistency into following types.

1. Hard dough biscuits: In hard dough's 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.

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. The majority

of popular types available include Osborne, marie, and rich tea, 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.

3. Continental semi-sweet biscuits

Biscuits of this type are commonly made in France, Germany and Switzerland. The recipes are slightly higher in fat level and are mixed by two-stage process. All ingredients except the flour are firstly mixed up to a homogeneous ‘cream’. The dough is then rested for 30 to 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 resultant biscuits are softer and shorter in texture than traditional british semi-sweet types and surface is not as smooth.

4. Soft dough biscuits

Short dough’s which are soft enough to be just pourable, are called as soft doughs. Dough pieces are formed by extrusion and pressed out either continuously or intermittently on the oven band that may be raised up. The biscuits produced in this way are usually rich in fat or based on egg whites whipped to a stable form.