

– Review –

The Role of Ingredients and Thermal Setting in High-Ratio Layer Cake Systems

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Abstract

High-ratio cakes made from the formulas with more sugar (140% based on flour weight) than flour have come to be preferred recently. To produce good light cake structure, cake batter must retain the many finely divided gas bubbles formed during mixing. Thermal setting of cake structure is mainly caused by starch gelatinization. The formula controls the temperature at which the cake batter changes from a fluid to a solid. Especially, the relatively large amount of sugar used in the formula delays gelatinization, so that air bubbles can be properly expanded by carbon dioxide gas and water vapor before the cake sets. To get a non collapsing high-ratio cake structure after baking, the proper degree of gelatinization of the starch granule, the control of gelatinization temperature, and sufficient gel strength are all important. The role of ingredients (flour, sugar, proteins, chemical leavening agents, water, shortening, and emulsifiers) is reviewed with relation to the formation of satisfactory cake structure.

Key words : high-ratio cake, ingredients, thermal setting, gelatinization

INTRODUCTION

Cake batter is a complex colloidal dispersion, a foamed fat-in-water emulsion containing suspended flour particles, dissolved sugar and proteins in an aqueous phase. The finished baked cake is a heat set foam having a light aerated structure consisting of air cells.

Numerous air bubbles incorporated during mixing provide sites for expansion of carbon dioxide and water vapor produced at baking temperatures. The resulting vapor pressure results in a considerable expansion of the cake volume. In the final stages of baking, the structure of the cake is heat-set as the proteins coagulate, and wheat starch undergoes partial gelatinization^{1,2)}.

Formulas with relatively high concentrations of sugar have come to be preferred. The difference between high-ratio and low-ratio cakes is only in the water/flour or sugar/flour ratios employed, and not in the sugar/water ratio which is the same in both types of cake. The term "high ratio" has been used to describe cakes made from formulas (Table 1) in which the weight of the sugar exceeds that of the flour³⁾, resulting in the dilution of the flour by sucrose

solution. Aside from a sweetener flavor, such cakes are more tender, softer and more attractive than low-ratio types. The high-ratio cakes are often unable to resist the stresses exerted upon it as it cools after being taken from the oven resulting in collapsed cakes. At this point, proper formulation is very important to obtain the desired highly erated cake structure with high volume.

A better understanding of the role of ingredients and thermal setting in the dispersions of high-ratio layer cake system is necessary for a better quality finished product.

Table 1. Typical formulation for high-ratio layer cakes

Ingredients	Percent (flour basis)
Flour	100
Sugar	140
Shortening (emulsified)	55
Egg white (fresh)	76
Milk (fresh)	95
Baking powder	1.3
Salt	0.7
Water	150

FUNCTIONS OF INGREDIENTS IN LAYER CAKE DISPERSION SYSTEM

Generally, the principal raw materials used in making cakes are fat, sugar, eggs, and flour. Howard¹¹ postulated that the essential ingredients in formulation of layer cake structures are proteins (flour, egg, and milk), starch, emulsifiers, chemical leavening agents and water.

Flour

Flour serves as a structure builder in cake making. Generally, a chlorinated soft wheat cake flour (pH 4.7 ~5.1) with low protein (<9%) is used for high-ratio layer cakes⁴. Starch is the major constituent of wheat flour, making up about 80% of the dry weight, and would therefore be expected to play a major role in cake quality. The role of starch in cakes is to act as a water-sink and to set structures in the baking process⁹, whereas gluten can have only a limited water absorption, due to the higher sugar and fat contents. Both the water absorption properties and the degree of gelatinization of the starch during baking are important in cake flour.

During soft wheat milling starch-protein bonds rupture easily, and the kernel crushes with minimal force, releasing a large number of free starch granules. This is one of the reasons why soft wheats are used in cakes⁶.

When batter changes from a fluid, aerated emulsion to a solid, porous structure, the gelatinization properties of the starch become important in the control of the final physical properties of a non-collapsed baked cake. Howard *et al.*⁷ showed that intact starch granules are essential to the thermal setting process of cake baking. Partial starch gelatinization gives a cake structure which still contains intact starch granules, and thus a firm starch gel. Starch granules are building blocks held together by a protein matrix⁸.

The gluten can also partially provide cake structure by cross linking between protein molecules. However, it is generally considered that gluten is not essential to layer cake baking performance. Howard *et al.*⁷ and Cauvain and Gough⁹ employed cake formulation in which starch was substituted entirely for flour.

In a reconstitution study¹⁰ in which starch was substituted for gluten and thus the protein content of the reconstituted flour was reduced to about 15% that of the control cake, gluten had essentially no effect on cake volume. It is expected that the aggregated structure of gluten in water will not exhibit an effect on surface tension.

Recently, a few reports have dealt with the role of flour lipids in cake¹¹⁻¹⁵. Seguchi and Matsuki¹⁴ reported the functional importance of flour lipids, particularly the polar components that can be extracted with water-saturated butanol, to the volume and structure of a basic Japanese pan cake. Other workers^{13,15} also found that hexane-extracted (defatted) flours produced smaller cakes with a poorer texture than did flours with free lipids. Glover *et al.*¹² reported that cakes containing sorghum lipids and those baked from defatted cake flour did not rise as high in the oven as cakes baked from reconstituted flour with wheat lipids, suggesting that the necessary lipid components for cake baking may be glyco- and phospholipid in wheat flour. The study of the effects of various components on batter expansion in white layer cakes showed that free flour lipids are necessary for batter expansion and better cakes, probably contributing to foam stability rather than to batter aeration¹¹. Contradictorily, Howard¹¹ stated that flour lipids are very surface active and can affect the gelatinization properties of granular starch, but are not essential because layer cake structure can be developed without them. Whether the flour lipids exert an improving action by themselves or in combination with other constituents such as starch or protein is still not known.

The use of chlorinated cake flour enables the baking industry to produce cakes containing high levels of sugar and water. The chlorine treatment of wheat flour leads to an increase in cake batter viscosity, improving batter stability. It has been reviewed that the principal action of chlorine on wheat flour will result in the following: increased starch granule swelling (up to 30% larger than untreated), more easily dispersed gluten, and possibly changing the lipid structure on starch granules, resulting in higher water absorption and increased viscosity at the same temperature¹⁶. It

is believed that the most important effect of chlorination is on the starch. Batters made from chlorinated flours are capable of retaining gases to a greater extent and for a longer time than those prepared from unchlorinated flour¹⁷. The improved functionality may result from enhanced foam stability imparted by changes associated with an increase in protein solubility¹⁸ and/or from the improvement in flour lipid emulsification properties¹³.

In spite of the studies on chlorinated flour, the exact mechanism of chlorination improvements remains unclear. Chlorinated flour appears to gain stability at a point which coincides with the attainment of the maximum batter temperature. It was thought that optimum chlorination provided a compromise between expansion and contraction rates of the batter¹⁹. Therefore, by chlorine treating cake flour, rigid cake structure can be formed as a result of greater gel strength and overall cake quality can be improved with higher cake volume, reduced crumb stickiness, a whiter crumb color, and finer grain.

Heat treatment of cake flour has been proposed as an alternative to chlorination by Russo and Doe²⁰. Their results were confirmed by Japanese workers^{14,21,22}. Japanese workers postulated that the hydrophobic character of wheat prime starch granules which resulted from either chlorination or heat treatment, could be attributed to a change in the proteins on the starch granule surface, and may contribute to air bubble stability and thus to final cake structure.

Another important flour parameter that has been investigated by many workers is flour granulation and its effect on cake quality. Generally, the finer the particle size, the better the cake. Within a soft wheat patent cake flour, flour particle size reduction (usually by pin- or turbo-milling) has a beneficial effect on cake volume and overall quality of various types of layer cakes²³.

Sugar

Sugar is the major flavor imparting a desirable sweet taste to the cakes. It further functions as a tenderizer by inhibiting the absorption of water by the flour components reducing gluten hydration and development. The relatively concentrated sugar solution (50

%) delays starch gelatinization and decreases the rate of protein denaturation during baking, so that air bubbles can be properly expanded by carbon dioxide gas and water vapor before the cake sets, resulting in a highly aerated cake structure with higher cake volume²⁴⁻²⁶. Bean and Yamazaki²⁷ found that successful cakes could be produced when the starch was allowed to gelatinize in a range between 87.5 and 92°C. Later these results were confirmed by Kim and Walker^{26,28} who made cakes with different commercial starches (wheat, corn, and potato).

Sugar acts as a bulking agent dissolved in water, and thus it can increase the viscosity, which aids air incorporation and stabilize the emulsion and foam. Depending on the sugar source, the viscosities of sugar-water solutions will be different. The viscosity of dextrose solutions approximate those of sucrose at the same concentration, whereas lactose is approximately one-tenth as soluble as sucrose at room temperature²⁹. This low solubility of lactose makes it more effective in increasing viscosity, which may benefit cake batter stability through an increase in total solids. The reported final solubilities³⁰⁻³² in water of sugars at different temperatures are shown in Fig. 1.

The effect of lactose on the quality of bakery foods has long been the subject of discussion and some disagreement³²⁻³⁴. However, when lactose is added to formulations under optimum conditions, significant improvements can be gained in the final products. It has been reported that its emulsifying properties aided in the creaming of cake batters and promoted greater efficiency from shortening, resulting

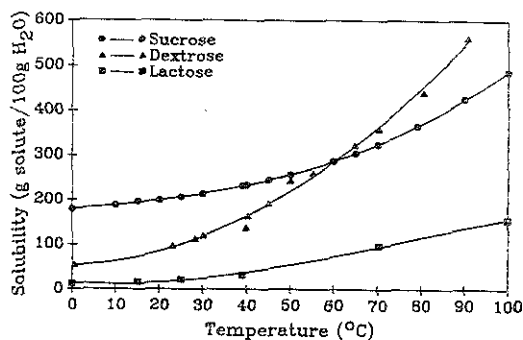


Fig. 1. Solubility of sucrose, dextrose, and lactose at different temperatures.

in better volume, grain, and texture, in addition to richness of flavor^{26,35,36}. Brack and Bretschneider³⁵ suggested that the lower lactose sweetness is particularly advantageous in high-sugar recipes, reducing the obtusive sweetness of some baked products. The use of 75% and 100% of high fructose corn syrup (HFCS) as a replacement for a sucrose increases the viscosity of cake batter, but problems with HFCS in cakes, such as excessive browning, loss of tenderness, bitter taste³⁷, and lower volume owing to lower onset temperature for starch gelatinization³⁰ must be considered.

Egg and milk proteins

Soluble proteins from eggs or milk could affect aeration of cake batter by decreasing interfacial tension at the interface of air and water with different rheological film properties. During the initial heating stage, during which the loss of cake batter viscosity takes place, denatured egg proteins increase the viscosity and stabilize air bubbles with strong viscoelastic protein films at the air-water interface, decreasing the rupture of liquid lamellae and lamellae thinning, which increases the thermal stability of cake batters. Cake setting begins between 65 and 70°C, where starch would not yet be expected to gelatinize in the high sugar concentrations of cake systems, and thus the initial viscosity increase must be caused by protein denaturation⁸.

Chemical leavening agents

Double acting baking powder is usually used to leaven the cake. Air cells entrained during mixing are enlarged by the first leavening acid. The large cells can be more easily subdivided into smaller cells and total number of air cells increased^{3,48}. The second leavening acid reacts during the baking stage, producing carbon dioxide which then diffuses into air cells. The leavening action must be timed so that the gas is produced while the batter can still expand. Chemical leavening agents can be a source of polyvalent metal ions (sodium aluminum-sulfate or -phosphate) and serve to stabilize oil and water interfaces¹.

Water

Sufficient liquid is necessary to dissolve the sugar

and still provide adequate moisture for starch gelatinization. The water amount, by itself, can control the starch gelatinization temperature, cause the initial increase in consistency and affect the degree of gelatinization³⁹. Therefore, the setting points of corn and potato starch cakes were controlled by the water and baking time adjustments resulting in no gummy layers or sunken contours²⁶. The high sucrose concentration of a cake batter provides the main influence upon starch gelatinization. Total liquid should exceed the amount of sugar by 25 to 35%⁴⁰. Too little liquid results in layers with sunken appearance, and too much liquid leads to a peaked cake.

Shortening

The performance of plastic shortening is important for trapping air dispersed in the fat phase^{3,48}. Thus, shortening acts as a leavening agent, providing sites for the incorporated air cells, that are ultimately responsible for the grain and texture in the baked cake. The fat properties important to its ability to incorporate and retain air are: enough free liquid to envelope the air bubbles, and the right proportion and type of crystals to stabilize the oil-water interface⁴⁹. At this point, the beta crystal form of plastic shortening is the most suitable for producing small and uniform air cells, because it consists of small needle-shaped crystals that readily absorb oil and produce a smooth creamy shortening. Shortening also acts as a tenderizer. It coats protein and starch particles, thereby disrupting the continuity of their structure that makes up the cake crumb^{4,48}.

Emulsifiers

In recent years, emulsifiers, amphiphilic substances which possess both hydrophilic and lipophilic properties, have become essential to the cake industry. Emulsifiers improve the emulsion stability of cake batters and thus improve cake crumb structure, cake volume, eating quality and other qualities.

The most prominent emulsifying agents used in the cake industry are mono- and diglycerides, lactylated glycerol, propylene glycol monoester, sorbitan fatty acid ester, polysorbate fatty acid esters, ethoxylated monoglycerides, polyglycerol ester, and stearyl-2-

lactylate²⁹. In general, hydrophilic emulsifiers outperform lipophilic emulsifiers because they are more soluble in the aqueous phase than in the oleaginous phase, and create the oil-in-water emulsion required for cake making. The functions of emulsifiers in the dispersion of a layer cake batter system can be classified as follows ; a) decreasing the surface tension at the oil and water interface, stabilizing the cake batter emulsion^{8,41,42}, b) controlling the crystal transformation of fats to make air bubbles become smaller and uniform size^{8,41,42}, c) helping the shortening become more finely and uniformly dispersed in the batter, enhancing a fine distribution of the air dispersed in the fat particles^{3,8,41,42}, d) promoting air incorporation by decreasing film thinning with increased viscosity of water phase, especially with highly hydrophilic emulsifiers^{8,41}, and e) by their ability to complex with starch molecules, affecting gelatinization^{26,28,43} with decreased amylose solubility, thus delaying rupture of the starch granule. This allows a decrease in the cementing substance between proteins and starch granules which compose the walls of the cake crumb air cells resulting in a more tender product.

Like pure triglycerides and commercial shortenings, most emulsifiers are also polymorphic. In emulsion, the oil, water and emulsifier are often associated with each other in the form of a liquid crystalline structure at the interface^{2,8,42}. It has been reported that the viscosity and the elasticity of the interfacial film are dependent on the mesomorphic behavior of the emulsifier⁴³. The type of mesophase formed depends on the structure of the emulsifier, the ratio of emulsifier to water, and the temperature^{42,45,46}.

It has long been recognized that emulsifier combinations develop a better and wider range of activity than a single emulsifier, improving air incorporation, lowering specific gravity, increasing cake volume and producing a higher quality cake^{26,47}. Multiple component systems will probably give synergistic functionality during emulsification, providing complementary quality improvements owing to their differences in functionality mode. Knightly⁴⁸ suggested that the surface is covered better by a combination of various emulsifiers with different structures because more emulsifier molecules can be concentrated at the surf-

ace and thus form a better protective layer with fewer gaps. Knightly⁴⁹ also emphasized that particularly effective emulsifier combinations consist of both lipophilic emulsifiers and hydrophilic emulsifiers ; the latter aids the dispersion of the former, in addition to providing improved emulsion stability on their own. If the emulsifier is not adequately dispersed, its efficiency per unit weight is reduced. The wide range in melting points of the liquid-crystalline phases of different emulsifiers might be considered an advantage of emulsifier combinations, extending the stabilization of the cake emulsion at the interface by increasing the viscosity and elasticity of the interfacial film as the temperature rises during the initial baking stages.

MIXING AND CAKE BATTER STABILITY

Mixing

The purposes of batter mixing are primarily to bring about a complete and uniform dispersion and homogeneous emulsification with minimum gluten development, and to incorporate many finely divided air bubbles to produce good light cakes. The narrower the original bubble size distribution in the batter, and the smaller the average bubble size diameter, and the finer the texture of the cake⁶⁰. The final cake volume depends on the initial number of air bubbles in the batter during the mixing²⁰. A batter with a high number of nucleations, and subsequently small bubbles would have less migration and therefore less gas loss resulting in a higher cake volume.

The size and number of air bubbles, stability of the air bubbles and the type of batter emulsion are affected by the type of formula, ingredients, mixing method, mixing intensity, and speed.

Multi-stage mixing method

The first stage consists of a creaming operation, entrapping air in the fat phase. The fat incorporates all of the air, so that no bubbles are found in the aqueous phase⁵¹. Later, the addition of water and other ingredients changes the emulsion type from a water-in-fat emulsion to a fat-in-water emulsion. As cake batter is heated and the shortening melts, the air cells are

released into the aqueous phase, where leavening gases and water vapor can diffuse into them and thereby leaven the cakes^{8,42,51}). The addition of monoglyceride emulsifying agents results in a much larger number of fat lakes per unit area of batter, as observed by light microscopic studies of cake batters⁵¹).

However, the mechanism of transfer of the air cells from the fat phase to the aqueous phase, and their stabilization in the aqueous phase, is poorly understood.

Single-stage mixing method

All of the ingredients are introduced into the mixing at one time. Air cells are incorporated directly into the liquid phase^{8,42,52}). For this to occur, it has been suggested that alpha-tending emulsifiers and hydrophilic emulsifiers are vital for cake making^{1,2,42}). An emulsifier or lipid-emulsifier combination which is alpha-tending in the crystalline form was used to immobilize the fat with a thick, strong, rigid plastic-like film, and thus not to break the soluble protein foam, facilitating indirect air incorporation⁵²). When mixed with water, alpha-tending emulsifiers do not form any type of mesophases, although they do have some hydrophilic properties. These emulsifiers allow the use of shortenings or oils with single-stage mixing in the cake industry. Wootton *et al.*⁵²) found that soluble proteins in an aqueous phase were directly involved in aeration. This effect is seen only where the alpha-tending additives are sufficiently concentrated to crystallize and to form strong plastic-like interfacial films.

Cake batter stability

In a liquid of a given viscosity, the rate of bubble movement due to its buoyancy is proportional to the radius and inversely proportional to the viscosity⁵³). Large bubbles would have sufficient buoyancy to rise to the surface and be lost³³). Therefore, the loss in cake volume is related to the formation (bubble to bubble diffusion) and migration (viscosity dependent) of the large bubbles^{8,53}). A higher viscosity keeps the air bubbles from colliding with sufficient force to coalesce into large bubbles. Thus, the viscosity of the continuous aqueous phase can have an effect on impr-

ovement of cake batter stability at room temperature. Viscosity will be affected by the ratio of liquid to dissolved sugar, protein and other solids in the recipe, and by the suspended flour particles and their water absorption characteristics. However, in the early stages of baking, the viscosity of the batter's aqueous phase will first decrease and then later increase as the flour starts to absorb water and egg proteins are denatured. Therefore, a good cake batter must retain sufficient viscosity during initial heating.

THERMAL SETTING

The important stage in cake baking is thermal setting, when the batter changes from a fluid, aerated emulsion to a solid, porous structure which will not shrink appreciably or collapse after the cake is removed from the oven. For this to occur, most of the "free water" present in the system must first be absorbed, forming a discontinuous and porous structure. At this point, the setting of cakes in the oven appears to be the result of starch gelatinization. Thus, the gelatinization properties of the starch become important in the control of the cake's final physical properties. Generally, it has been recognized that starch gelatinization and pasting during baking is controlled not only by temperature and time, but also by availability of the water.

Some investigators evaluated various types of unmodified starches in cake system^{7,12,28,54}). They showed that variations in cake baking performance observed for different starches were related to the gelatinization temperatures. The extremes in performance were shown by the potato starch cake^{7,26}), which set very early, yielding a cake of low volume because of early gelatinization, and the rice starch cake⁷) and corn starch cake^{1,26}), which never reached the point of a "set" structure within the standard baking time of 25 min and at the temperature used. Their cakes had inferior volumes and textures, with gummy cake centers and an uncooked appearance, as compared to those containing wheat starch. This also was apparently due to the lack of gelatinization. Wilson and Donelson⁴⁰) described a satisfactory cake as one that had sufficient but not excessive starch gelatinization.

The formula controls the temperature at which the cake batter changes from a fluid to a solid. The molar concentration of sugar in the formula controls the gelatinization temperature of starch⁵⁵⁻⁵⁹. If the sugar concentration is too high, the starch does not gelatinize during baking, resulting in a collapse. Sugar, then, could be used to control the gelatinization temperature of starch and, thereby, the setting point of cakes. Bean and Osman⁵⁵ found that disaccharides have greater effect in retarding swelling than monosaccharide. Therefore, Glover *et al.*¹² and Kim and Walker²⁶ improved the volume of cakes in which wheat starch had been replaced with sorghum starch or corn starch, by substituting dextrose for sucrose, thus lowering the gelatinization temperature.

When various sugars were added to starch slurries to be heated using the Rapid-Visco Analyzer^{43,60}, monosaccharide (dextrose) produced less effect on the decrease in paste consistency whereas higher molecular weight sugars (sucrose or polydextrose) exerted more pronounced effects. Their extents varied depending on various starch sources used. The deleterious effects of other sources of starch might be corrected therefore, by using different types of sugars and changing their concentrations, to get a proper gelatinization pattern for satisfactory cake structure. Bean and coworkers⁵⁶ suggested a gelatinization temperature around 90°C, as measured by loss of birefringence under a polarized hot stage microscope, to produce successful cakes. This coincides with the 89°C crystal melting peak temperature (Fig. 2) measured by DSC (differential scanning calorimeter) in the wheat-sucrose-water mixture (1:1.5:1.5), typical formula of high-ratio cakes²⁶. Without flour treatment by chlorination or heat, high-ratio cakes tend to collapse. Jacobsberg and Daniels⁵⁷ examined the gelatinization of treated and untreated flour-water-sugar batters by DSC. There were no significant differences in gelatinization temperatures in comparable batters prepared from untreated, chlorinated or heat-treated flour. However, when gel strengths of untreated and chlorinated flour samples were tested by Frazier *et al.*⁶¹, gel strength increased rapidly with temperatures above 60°C and a very highly significant difference between untreated and chlorinated samples became appar-

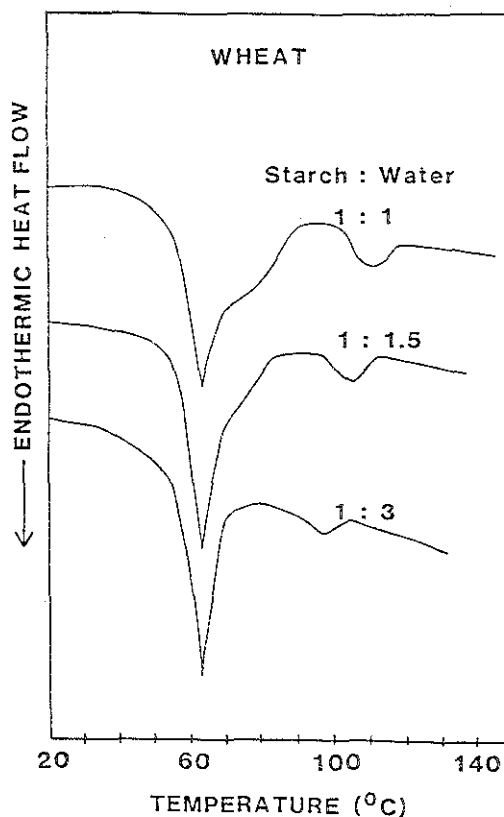


Fig. 2. DSC-thermograms of wheat starch(2.0mg, top line) at a starch-water ratio of 1 : 1.5, and of a starch(2.0mg) sugar-water mixture(1 : 1.5 : 1.5, middle and bottomline).

ent and was maintaining throughout the total heating time as the temperature approached 90°C (Fig. 3.). Their results provide strong support for the hypothesis that the collapse of a high-ratio cake is due to insufficient physical strength of the starch-protein gel structure, and that both chlorination and heat treatment improve cake flour performance by increasing gel strength. The potato cake expands well initially, but it collapses while still inside the oven. A weak gel structure, which was not able to withstand the gas pressure built up inside the cells, may have formed during baking²⁶.

Therefore, it is important to get a non collapsing cake structure. The degree of gelatinization of the starch granule, the control of gelatinization temperature, and sufficient gel strength are all important, enabling the cake to resist the stresses exerted upon it as it cools.

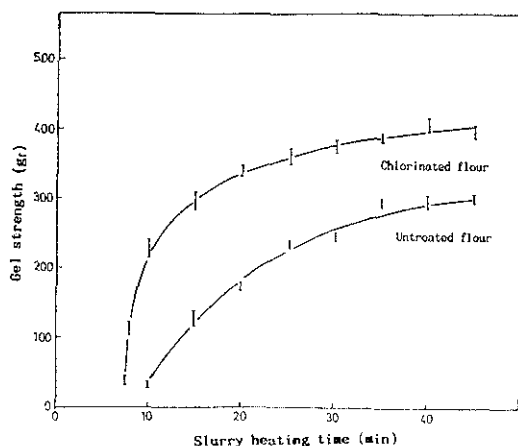


Fig. 3. Gel strength measurements on slurries from chlorinated and unchlorinated flours after different heating times.

Lengths of the vertical lines indicate the standard errors of the mean experimental point.

SUMMARY

Cake batter viscosity and the control of starch gelatinization in high-ratio cake systems were emphasized in obtaining a non collapsing porous cake structure. The viscosity of the continuous aqueous phase have an improving effect on cake emulsion stability at room temperature. Viscosity will be affected by the ratio of liquid to dissolved sugar, protein and other solids in the formula, and by the suspended flour particles and their water absorption characteristics with increasing temperatures. However, in the latter stages of baking, there will be changes in some factors. The viscosity of the aqueous phase will first decrease, and then later increase, as the flour starts to absorb water. Therefore, a good cake batter must retain viscosity during initial heating. Emulsifier combinations are necessary to improve overall high-ratio layer cake qualities, with their cooperative and synergistic effects on orientation at the interfacial film, or interaction with starch molecules. To prevent collapsed cake structure, the degree of gelatinization of the starch granules, control of the gelatinization temperature, and protein denaturation are important in providing sufficient strength to resist the stresses resulting from cooling. The leavening action must also be properly timed to get the proper layer cake volume and texture.

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고당배합 케이크에서의 원료의 역할과 열에 의한 케이크 구조의 고정화

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요 약

최근에는 밀가루보다 많은 양의 당을 이용하는 고당배합 케이크가 선호되고 있는데, 이는 케이크 제조시의 원재료 중 당의 사용량(밀가루의 140%)을 밀가루 보다 많게 하므로써 부드러운 케이크의 구조를 형성하게 되는데 있다. 적당량의 부피를 가진 가벼운 케이크를 위해서는 케이크 반죽을 혼합하는 과정에서 우선 많은 수의 작은 기포가 보유 되어져야 한다. 이러한 케이크 구조의 고정화는 전분호화가 주역할을 하며, 케이크 반죽의 배합비는 반죽이 액체상태에서 고체화로 되는 온도를 조절하는 요인이 된다. 특히, 배합비 중 많은 양을 차지하는 당은 전분의 호화를 지연시켜 케이크의 형태가 고정되기 전에 탄산가스나 수증기에 의하여 기포가 적당히 팽창되도록 한다. 오븐에서 고당배합 케이크를 구운 후 케이크의 팽창된 구조를 유지하는 데는 전분입자의 적당한 호화 정도, 호화 온도 조절, 젤의 강도가 중요한 역할을 한다. 본 논문에서는 최근 선호되는 가볍고 부드러운 케이크의 원재료인 밀가루, 당, 단백질, 화학 팽창제, 물, 유지 및 유화제의 각각의 역할에 대하여 고찰하였다.