SENSORY CHARACTERISTICS OF LOW YOLK SPONGE CAKES WITH STABILIZERS

by

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DEDICATION

To My Parents,

Mr. & Mrs. Ping-Tsao Lee,

Whose love will always be

an inspiration.

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THIS BOOK CONTAINS NUMEROUS PAGES WITH THE ORIGINAL PRINTING BEING SKEWED DIFFERENTLY FROM THE TOP OF THE PAGE TO THE BOTTOM.

THIS IS AS RECEIVED FROM THE CUSTOMER.

INTRODUCTION

Textural changes in baked products are inevitable when formulations are altered, particularly when functional ingredients are changed. Flavor and texture profile analyses have been developed and used to examine food products since texture, appearance, and flavor play important roles in the consumer's response to a product (Sherman, 1969; Bourne, 1978).

According to procedures for evaluating texture developed by General Foods, the food texture can be defined as that general class of characteristics, other than aroma, color and flavor, which makes up the appearance, mouthfeel and handling properties of foods. It's the sensory manifestation of the structure or inner make-up of foods.

The sensory methods of flavor or texture profile evaluation involve information on definitions of flavor or texture, panel techniques, and standardization of testing conditions. In addition, texture profile evaluation involves correlation with instrumental measurements (Brandt et al., 1963). Sensory flavor and texture profiling (Larmond, 1976) are especially useful in product development where they are used to obtain qualitative and quantitative descriptions of differences between experimental samples and the target.

In this study, whole egg and low yolk sponge cakes with stabilizers developed for persons concerned with cholesterol intake were evaluated for texture and flavor. Difference testing, specifically the triangle test, was utilized to detect differences among low yolk sponge cakes with and without different stabilizers and control cakes. Flavor and texture profile methods were used to describe these differences. The Instron Universal Testing Machine (IUTM) was used for instrumental evaluation of some textural parameters and compared with the human judgments.

REVIEW OF LITERATURE

Ingredients Used to Substitute for Egg Yolk

Egg yolk's multiple functional properties, including emulsifying, coagulating, leavening, and serving as a viscosity control agent, contribute to food quality. However, since the yolk contains a considerable amount of cholesterol, its consumption is a concern to many people. Emulsifiers, surfactants, or stabilizers which could help form emulsions, foams, and increase viscosity have been used as substitutes for egg yolk by some researchers.

Functional Properties of Egg and of Substitutes for Egg in Baked Products

Egg yolk and whole egg in the bakery are expected to provide emulsifying, coagulating, and leavening functions as well as to serve as viscosity control agents (Schultz and Forsythe, 1967; Forsythe, 1970; Bergquist, 1973; Pyler, 1973). In addition, egg serves as a coloring and flavoring ingredient.

Since egg yolk and whole egg are important functional ingredients in sponge cakes, cream puffs, and doughnuts (Forsythe, 1970), reducing the yolk level used affects the quality of these products. Commercial low cholesterol egg substitutes generally contain egg white without yolk, and when used in cakes decreased volume results (Leutzinger et al., 1977; Zabik and Lang, 1978). Egg yolk diluted with water or albumen has been used in sponge cakes but with unsuccessful results. Drastic decreases in volume were found, and the texture became more dense and tougher when the egg yolk levels were decreased. Although egg yolk diluted with water or albumen produced a greater foam volume, the foam stability, emulsifying capacity and final cake volume declined (Cunningham, 1972; Baker and Darfler, 1977).

Since lecithin in yolk contributes to the emulsifying ability of egg yolk, removing it will make emulsion formation more difficult. Such emulsifiers as soy lecithin, monoglycerides, and diglycerides, can be added to food to increase the stability by decreasing interfacial tension. In sponge cakes, surfactants and other stabilizers have been used to improve the whipping quality of whole egg, particularly when dried egg solids are used (Desrosier, 1977).

Influence of Stabilizers on Flavor

While most studies show improved functional properties, increased volume, and improved grain in baked products with stabilizers, few indicate what effects those stabilizers have on flavor. Desrosier (1977) indicated that while lecithin is one of the most active emulsifiers, its flavor is a limiting factor in the level of use. Kim (1979) has indicated undesirable flavors in sponge cakes when 10% lecithin was used.

Ganz (1977) reported that several investigators have studied the influence of gums on taste perception. Glicksman (1969) indicated that gums play a part in flavor release and flavor retention in foods and are used to stabilize and fix flavor emulsions. Sodium carboxymethyl cellulose (CMC) and xanthan gum (XG) may decrease perception of sweetness in hydrocolloid solutions (Vaisey et al., 1969; Ganz, 1977), and decrease the odor and flavor intensity of several flavorants, such as butyric acid and dimethyl sulfide (Pangborn and Szczesniak, 1974; Ganz 1977). No studies were reported on the effect on sweetness by gums or other stabilizers in baked products.

Christianson et al. (1974) used a scoring difference test to compare commercial batter-whipped breads and starch-XG breads each fortified with 15% and 10% soy isolate. No significant differences in scores for mouthfeel were found, but the flavor of the starch-XG breads was scored significantly lower than that of the batter-whipped breads. This was attributed to a lack of conventional wheat bread flavor, as the typical soy flavors were not detected even at the 15% replacement level.

Influence of Stabilizers on Texture

Stabilizers, such as lecithin, monoglycerides, diglycerides, and sodium stearoyl 2-lactylate (SSL), have been used in the baking industry to improve the texture of baked products for several years. Improved volume, texture, airiness, tenderness, eating and keeping quality are characteristics reported in baked products when such surfactants are used (Lowe, 1955; Knightly, 1966; Endres, 1967; Lawson, 1970; Bergquist, 1977). Stutz (1973) indicated batter aeration is more efficient with emulsifiers, which aid in incorporating small, uniformly sized air bubbles and in preventing tunnels, thus producing a uniform grain. Surfactants also have a role in the mouthfeel of the crumb, since emulsified fat gives a more palatable crumb without a gummy or greasy mouthfeel.

In addition, the anion surfactant, sodium lauryl sulfate (SLS), approved as a whipping aid (Forsythe, 1970; Bergquist, 1973; Bergquist, 1977), has been used to improve the whipping performance and/or volume of angel food cakes without adverse effects on cake texture (Forsythe, 1970).

Gums such as CMC, methyl cellulose and XG are useful in increasing the viscosity of the aqueous phase of oil in water emulsions (Paul and Palmer, 1972; Kelco, 1976). Mitchell (1969) showed that gums aid in improving foaming or whipping ability, imparting a smooth body and texture, providing thickening, preventing sticking, and stabilizing emulsions. Cellulose was whipped much like egg white and with a foam stability resembling that of egg white. The Kelco company (1976) reported the partial replacement of starch with XG and locust bean gum afforded a less pasty mouthfeel and improved texture in puddings and pie fillings.

Ganz (1977) mentioned CMC is of particular interest because of its ability to thicken and to modify food product texture. CMC modifies texture by reacting with water and protein, thus altering the structure.

XG gives starch doughs and batters the necessary strength and elasticity by forming foam cells and expanding with the air and carbon dioxide generated by the leavening agents (USDA, 1975). This was shown by Christianson et al. (1974) who found starch-XG breads had improved loaf volume and crumb structure when compared to starch breads.

Characteristics of Dried Egg Powders in Food Products

Eggs have a distinctive flavor and contribute to the flavor of products in which they are used (Bergquist, 1977). A slight change in flavor may be observed in eggs when they are dried. Under normal drying conditions, this change is not adverse, but is characterized as a slight loss of the characteristic egg flavor. However, undesirable flavor notes can develop under adverse drying conditions (Bergquist, 1973).

Effects of the Drying Process

Lipids, which make up approximately 45% of whole egg solids and 60% of yolk solids, undoubtedly play a prominent role in the flavor changes because of the drying process (Bergquist, 1973). Changes observed from drying whole egg and yolk are quite different from those observed with drying egg whites. Egg white contains only 0.2% fat, and has the free glucose removed before drying, so it can be stored indefinitely at room temperature. Any off-flavors which may be noted in dried egg whites are probably caused by the methods used for processing (Bergquist, 1977). The oxidation of phospholipid fatty acids can cause off-flavors in stored whole egg powders (Lightbody and Fevold, 1948; Privett and Romanus, 1964; Fennema, 1976; Bergquist, 1977). The off-flavor noted is usually described as "fishy" (Bergquist, 1973; Bergquist, 1977).

One of the most important factors contributing to lessened storage stability of dried egg products is the presence of natural glucose (Bergquist, 1973; Bergquist, 1977). Glucose, 0.32% of liquid eggs, enters into the Maillard non-enzymatic browning reaction with the amino groups of cephalin, one of the phospholipid constituents of egg, during drying and subsequent storage. This results in the formation of a brown, insoluble, and odoriferous product that detracts from the palatability of dried eggs (Paul and Palmer, 1972; Pyler, 1973; Fennema, 1976; Bergquist, 1977).

Flavor stability of whole egg powder can be improved somewhat be acidifying the liquid to a pH of 5.5 before drying. This slows the browning reaction involving the glucose and protein, but doesn't completely inhibit it. (Lightbody and Fevold, 1948; Romanoff and Romanoff, 1948; Bergquist, 1977).

Almost all the work reported between 1942 and 1948 referred to whole egg solids containing the natural glucose and the stability was affected by time and temperature of storage and by moisture content (Bergquist, 1977). More recently, Tuomy and Walker (1970) using eggs with the glucose removed, again showed that storage time, available oxygen and moisture levels do contribute significantly to the deterioration of the color and flavor of dehydrated egg mixtures. The deteriorative effects of moisture and storage time on egg powder texture also were significant, but the effect of available oxygen on texture was not significant.

Storage of dried egg powders is improved by drying to a low moisture content and packaging the product in an inert atmosphere of either nitrogen, carbon dioxide, or a mixture of the two. Off-flavor development is retarded as determined by flavor scores following several months' storage at 37.5°C (Paul and Palmer, 1972; Bergquist, 1977). Flavor scores of dried whole egg correlated better with ultraviolet absorption analysis of volatiles than with any other chemical test. Although oxidative deterioration is usually associated with phospholipids, it could result from the volatiles in egg (Privett and Romanus, 1964; Bergquist, 1977).

Kline and Sugihara (1964) and Kline et al. (1964) added sucrose and 24 and 42 dextrose equivalent (DE) corn syrup solids to whole egg at different levels before spray drying. Increased amounts of carbohydrate increased flavor stability until a maximum was reached. Further addition of carbohydrate caused a sharp decrease in flavor stability. This peak was reached in whole egg using about 5% sucrose, 10% 24 DE corn syrup solids, or 7½% 42 DE corn syrup solids.

Flavor Characteristics of Dried Egg Products

MacLeod and Cave (1976) collected and analyzed the volatile flavor components of eggs from different sources, and found dried egg samples did not differ greatly from those for the fresh egg. However, it was observed that some of the desirable components of egg flavor are produced to a lesser extent by the dried egg (e.g., some alkylbenzenes) and some of the less desirable components are found in larger quantities in dried egg; e.g., 3% pyrazines in dried eggs compared to 1% in shell eggs.

In 1961, Schlosser et al. used dried whole egg solids to make scrambled eggs, baked custards and yellow cakes, and found flavor to be an important quality of egg solids. Flavor scores were related closely to the acceptability scores for each of the food products. In early 1942, Bennion et al. had noted a definite and rather unpleasant flavor in a number of products from samples of dried egg tested in their laboratories. The eggs were unsatisfactory for scrambled eggs or custard. Janek and Downs (1969) found spray-dried, foam-spray-dried, and freeze-dried eggs used in scrambled eggs received significantly lower flavor scores than when fresh eggs were used. Dawson et al. (1956), however, found the difference in flavor quality of dried whole egg solids was less noticeable in sponge cakes than in baked custards or in scrambled eggs. Frank et al. (1969) found angel cakes made from frozen egg white received the higher scores for flavor when compared to cakes made with dried egg whites, and suggested that drying did affect the flavor of the egg used in cakes.

Miller et al. (1959) reported custards made with whole egg solids were significantly different in aroma and flavor from custards made from shell and frozen eggs; the samples were described as being "off-flavored, uncooked, over-heated, and eggy". Mastic (1959) also reported that the baked custard prepared with spray dried eggs were judged less acceptable in flavor than those prepared with shell eggs. Funk et al. (1969) used frozen, foam-spray, freeze- and spray-dried eggs to make custards, and they found no significant differences in flavor.

Textural Characteristics of Dried Egg Products

In the work thus far reported, some disagreement is found among investigators regarding the textural quality of products obtained when dried eggs were used for cooking. The variations in textural quality as well as flavor quality may be partially the result of differences in quality of the egg powders used.

In scrambled eggs, Janek and Downs (1969) reported spray-dried, foam-spray-dried, and freeze-dried eggs did not differ with respect to tenderness and syneresis. Jordan and Sisson (1943) compared the use of spray-dried whole egg with shell eggs in baked custards. They found dried egg custards were less firm than those made from shell eggs, but they were sufficiently firm to be desirable consistency.

McBride (1947) also found good quality dried whole egg produced baked custards comparable to those made with fresh or frozen eggs. In 1959, Miller et al. compared several dried egg custards and the gels appeared smooth in many samples. However, custards prepared with dried eggs were not as glossy as the gels of custards made with the other types of whole egg, and they were less firm.

In 1945, Ary and Jordan compared the effects of five spray-dried whole egg powders on the properties of plain butter cakes and baked custards. They concluded that plain butter cakes and baked custards were comparable in texture to similar products made with fresh eggs when using good quality, spray-dried whole egg powders.

Kelly et al. (1962) compared baked custards prepared from shell, freeze-and spray-dried eggs. Their consumer panel could detect no significant differences between products prepared with freeze-dried and shell eggs, but custards made with spray-dried eggs were preferred to either of the other two. Funk et al. (1969) further reported significant differences attributed to the type of processing in subjective evaluations of mouthfeel, body and texture of custards.

In 1968, Zabik et al. showed that whole egg sponge cakes prepared with frozen, foam-spray-dried or spray-dried eggs were all of acceptable quality; whereas, cakes prepared with freeze-dried egg exhibited a reduced volume with decreases in tenderness and general textural characteristics. When just the yolks were used, all three types of dried eggs produced sponge cakes of similar quality to those prepared with the frozen yolks.

Descriptive Sensory Methodology for Baked Products

Sensory evaluation of food quality by a panel of judges is essential to most studies of food to ascertain how a food looks, smells, feels, and tastes. The Sensory Division of the Institute of Food Technologists defines sensory evaluation as: "A scientific discipline used to evoke, measure, analyze, and interpret reactions to those characteristics of foods and materials as they are perceived by the senses of sight, smell, taste, touch, and hearing." (Prell, 1976; Campbell et al., 1979).

Three fundamental types of sensory tests have been developed: preference/acceptance tests, discriminatory tests and descriptive tests (Larmond, 1977; Campbell et al., 1979). Preference/acceptance tests are affective tests based on a measure of preference or a measure from which relative preference can be determined. The panelist's personal feeling toward the product directs his response. Discriminatory tests, such as triangle tests and duo-trio tests, are used to determine whether a difference exists between samples. The panelist doesn't allow his personal likes and dislikes to influence his response. Descriptive tests are used to determine the nature and intensity of the difference (Larmond, 1976b; Larmond, 1977).

Descriptive analysis is a valuable tool in product development work. It provides a complete description of sample differences and guides the product developer in modifying product characteristics to meet consumer demands. Two commonly known descriptive methods are the flavor profile and the texture profile

(Larmond, 1976a).

Flavor Profiling

The flavor profile method was developed at Arthur D. Little, Inc., in the late 1940's. First described by Cairncross and Sjöström in 1950, the technique provides a detailed, descriptive evaluation of the quantitative and qualitative attributes of complex flavors. The method was described more fully by Caul (1957).

"The flavor profile method of analysis is a descriptive method which takes into consideration the total impressions of, first, the aroma and then the flavor-by-mouth of a product, as well as the independently recognizable aroma and flavor factors, according to type, intensity, and order of perception" (Cairncross and Sjöström, 1950). The method has been applied to different foods and non-food products by many researchers. Arthur D. Little, Inc. alone has described and used successfully the profile technique with milk and other dairy products, cereals, beer, catsup, canned luncheon meats, pharmaceuticals, beef, coffee, baked goods, packaging problems, and in flavor and odor titration studies (Amerine and Pangborn, 1965). Through the flavor profile method we can get the whole picture of aroma and flavor of foods. It's possible to define food problems, measure the success or failure of small and large technological changes in formulation and production, interpret consumer reactions to foods, and design new products (Arthur D. Little, Inc.).

Koehler and Jacobson (1966) described the flavor of fresh whole egg, of fresh unfractionated yolk, and of fractions of yolk separated by ultracentrifugation. Caul and Vaden (1972) described the flavor of white bread held at room temperature at 24, 48, 72 and 96 hours. They found white bread flavor was more blended and complex in its early than in its later shelf life. Sweet, alcoholic, estery, yeasty, doughy, and wheaty describe crumb flavor of fresh bread. Sweet, caramel, browned flour, and wheaty depict its top crust flavor. With aging, some flavor components disappear, especially the sweet character; in the crumb, doughy was lost to starchy. New notes appeared; sourness in the crumb, papery in the crust.

Gardze et al. (1979) evaluated beef patties containing four soy and four salt levels by the flavor profile method. They found that salt masked the cereal flavor in some cases, and increased it in others. In addition, salt also decreased oily mouthcoating and a bloody, salty metallic (BSM) flavor note, altered the mouthfeel of various samples, and shortened the aftertaste duration and BSM note. Adding soy decreased oily mouthcoating and changed the mouthfeel from springy to mealy. Duration of the aftertaste was shortened when soy was added to the samples.

Texture Profiling

Textural characteristics also exert an important influence on the acceptability of foods by the consumer (Sherman, 1969).

Thus the development of a comprehensive sensory methods for evaluating food textures in quality control is a necessity (Brandt et al. 1963).

Prior to Szczesniak (1963), specific methods were designed to analyze one or two textural characteristics of a food; e.g., tenderness of peas, crispness of snacks, or gumminess of rice (Civille and Liska, 1975). Boggs and Hanson (1949) and Raffensperger et al. (1956) pointed up the lack of organized knowledge in this field. In 1936, Cover described a sensory method for evaluating the tenderness of two comparable samples of meat. In 1959, she assessed the influence of softness on the tenderness of rare steaks. Later, Harrington and Pearson (1961) discussed chew count as a measurement of tenderness of pork loins.

In 1963, Szczesniak stressed the need for a rational and consistent system for describing and translating textural qualities into precisely defined, measurable rheological properties. She classified textural characteristics into mechanical, geometrical and other categories, and developed rating scales. Brandt et al. (1963) elaborated on this classification of sensory qualities, and presented the texture profile method which represented a new approach to the sensory evaluation of food texture. The texture profile method provides "the sensory analysis of the texture complex of a food in terms of its mechanical, geometrical, fat and moisture characteristics, the degree of each present, and the order in which they appear from first bite through complete mastication.". This method allows the quantitative description of several textural characteristics (Civille and Szczesniak, 1973) and can be applied to many kinds of food products.

Brandt et al. (1963) used the texture profile method to obtain descriptive and quantitative sensory data on textural characteristics of rice, dry flake cereals, whipped toppings, and chemically leavened biscuits. With the two cereals, the appropriate mechanical parameter was brittleness. The two rice samples differed in the degree of hardness and geometrical characteristics resulting in differences in the rate and type of structural breakdown. The whipped toppings were similar in viscosity but differed in the geometrical characteristic of aeration. The chemically leavened biscuits were the examples used to illustrate the effect of processing and storage on qualitative and quantitative aspects of texture. Gumminess, an important characteristic of raw dough perceived at a high intensity during the masticatory stage, was almost totally destroyed by baking, being noticed in biscuits only during the residual stage and only at a very low intensity. It was totally destroyed by further firming up and drying out on storage at room temperature.

Later, Civille and Szczesniak (1973) thought it was necessary to develop procedures to expand the basic texture profile method for specific products. The procedure involved developing (a) an evaluation technique (b) appropriate terminology, and (c) specific time and order of appearance of applicable characteristics (Civille and Liska, 1975). They gave detailed texture profiles of different types of commodities including processed rice, plain vanilla cookies, whipped toppings and frankfurters. They found that in the early stages of cookie evaluation, the mechanical parameters of hardness and fracturability were the most important. However, as the sample broke down, the geometrical and moisture-absorbing properties became evident and were stressed. They pointed that the "number of chews to swallow" is not the same as the mechanical parameter of chewiness. Chewiness was related to the initial hardness, cohesiveness and elasticity (springiness) of a product, and the "number of chews to swallow" measured the time required to break down the product (hardness), hydrate it (moisture absorption), and disintegrate whatever mass might be bound with saliva (cohesiveness). The cohesiveness perceived in the cookie was the "cohesiveness of mass" and might not be related to the cohesiveness of the original cookie. In whipped topping, they reported that parameters such as "airiness" and "cooling" didn't apply to all semi-solids, and other parameters, such as "abruptness of disappearance" and "heaviness", were more applicable to some products than to others (e.g., more to whipped topping than to peanut butter). The frankfurter samples provided a wide-range of mechanical, geometrical, fat and moisture characteristics.

The texture profile method should be considered an objective sensory method (Civille, 1977). If a person's response is to define the characteristics of a product without a bias or regard for whether the product is preferred, liked or disliked, the sensory data are objective and the texture profile panel becomes an important link in bridging the gap between consumers, the subjective sensory respondents, and instruments, the objective instrumental tool.

Relating Instrumental and Sensory Texture Findings

Sensory techniques are time consuming and require the use of considerable amounts of trained labor. Thus in recent years interest has accelerated in instrumental measurement of textural characteristics of food to provide efficient and precise quantitative descriptions (Voisey, 1971).

A variety of texture measuring instruments have been designed for particular commodities. Instruments having multiple-purpose units can be used for performing a number of different textural tests and have become used more widely in recent years because of their versatility, flexibility, accuracy, and appealing design features. Most popular in that group are the IUTM and the Food Technology Corporation's Texture Test System, formerly the Kramer Shear Press (Szczesniak, 1972; Szczesniak, 1973).

Bourne et al. (1966) were the first to adopt the IUTM for measuring food texture, and they applied instrumental texture profile analysis to such foods as cherries, potato chips, apples, and peas. Relationships between textural evaluation and IUTM measurements have been studied by several researchers. Henry et al. (1971) used the IUTM to develop more detailed texture profile analyses on a series of commercial desserts (pudding, custards, and gelatin) and on whipped topping and marshmallow creme. These products also were evaluated by a taste panel for 15 sensory attributes related to texture by using a 7-point rating scale. They used multiple regression analysis to predict the essential sensory attributes from physical measurements.

Howard and Heinz (1970) found that compression measured with the IUTM correlated highly with hardness as judged by sensory compressing and flexing of carrots. IUTM values did not correlate shear with the sensory judgments. Loh and Breene (1977) evaluated ground beef-soy products and found a statistical correlation between sensory data and textural measurements using the IUTM fitted with Ottawa texture measuring system.

The study of textural attributes of squid with the IUTM and a profile panel was reported by Otwell and Hamann (1979). Panel evaluations indicated that two groupings of textural character notes best described cooked squid texture. Character notes assessing mantle strength correlated with the results of rheological tests. Character notes denoting mantle moisture were not explained by instrumental tests, but were an essential supplement describing the mouthfeel of cooked squid.

Sharma and Sherman (1973) measured texture notes of natural and processed cheese, nougat, marshmallow and fudge by the IUTM and by the texture profile panel. They noted the necessity of rationally selecting the test conditions if instrumental evaluations of textural properties were to be employed to predict sensory responses by a texture profile panel or by consumers.

Machines can provide instrumental readings quite reliably. However, they can't tell the researcher whether the consumer who tastes, bites and experiences the food will accept or reject it. No matter how strongly an experimenter can correlate instrumental measures with sensory measures in texture, there is still another level of perception--the hedonic level of the acceptance or rejection--that must be considered (Moskowitz, 1977).

EXPERIMENTAL PROCEDURES

Materials and Preparation

Commercial dried whole egg and egg white from Henningsen Foods, Inc. were used through the study. The experiment was designed to investigate the effect of some different additives on the sensory characteristics of the low yolk sponge cakes; low yolk cakes without additives designated LY1, low yolk cakes with SSL, lecithin (LEC), or CMC designated LY2, and low yolk cakes with SSL, SLS, and XG designated LY3. Cakes were prepared according to formulas and methods based on the work of Kim (1979). These are given in the Appendix, Tables A-1 and A-2.

Additives were mixed into the batter at the stage most compatible with their chemical or physical properties. SSL or CMC, when used in the LY2 cakes, was added to the flour mixture and incorporated into the batter. LEC was added with the oil. In the LY3 cakes, SLS was added to the egg, XG and SSL were added to the sugar incorporated with the egg.

For the triangle test procedures, cakes were cooled 1 hr, and frozen at -20^{o}C (-4^{o}F) in moisture, vapor-proof plastic bags for 1 month. Preliminary tests confirmed flavor-free characteristics of the bags. For the flavor profile studies, cakes were cooled 1 hr before evaluation. For the texture profile studies, cakes were cooled 1 hr in the pan, overwrapped with aluminum foil and stored at 3.5^{o}C (38.3^{o}F) for 18 $\pm$ 1 hr.

Measurements

Difference Testing

Triangle test. Cakes were removed from the freezer and allowed to thaw 1 hr before testing. Top crusts were trimmed and the cake cut into 1-in cubes. Cakes and top crusts, covered with wax paper to prevent drying, were presented for evaluation. The six experienced panelists were instructed in the test procedures. Usually, three evaluations with six triangles at each session were held each week for a ten-week period. Each panel member received a total of six series per session. The panelists evaluated the flavor of their samples in individual booths equipped with red lights to mask color differences.

Statistical design. A 6x6 Latin square design was used for the triangle test (Cochran and Cox, 1966). The six treatments, 1-whole egg (WE), 2-LY1, 3-LY2 with 0.5% SSL, 4-LY2 with 1% SSL, 5-LY2 with 1% LEC, and 6-LY2 with 1% CMC were presented in all possible combinations to each panelist as given in the Appendix, Table A-3. Two replications were used.

Flavor Profile Analysis

WE and LY3 cakes were subjected to flavor profile analysis. LY3 cakes were added for descriptive analyses, as they were developed by Kim (1979) after the triangle testing had started. Each panelist was given a china plate containing a 1x1x3-in slice for crumb evaluations and a thin layer, 1-in long section of top crust. All samples were protected from drying with a cover of wax paper. Aroma examinations, which preceded flavor examinations, were made of the cakes on several small pieces of top crust in a 50-ml covered beaker and several small pieces of crumb in a 100-ml covered beaker.

The seven panelists were trained in flavor profile methodology. They had been schooled previously in examining food aromas and flavors and in using descriptive flavor analysis.

Perceptible aroma and flavor notes (character notes) are defined in descriptive terms in Table 1, e.g., sweet (a taste) and eggy (an odor). Standardized techniques of sniffing and tasting permit panelists to observe the order in which character notes appear. The intensity or degree to which each note was perceived in the aroma and flavor was reported using the scale: X, threshold or just recognizable; 1, slight; 2, moderate; and 3, strong. Table 2 lists the reference materials panelists examined in order to describe aroma factors of the cakes.

During orientation, the panel decided to examine crumb and top crust separately because their characters differed widely. Tasting them together made it difficult to distinguish between them or to isolate individual character notes. Also, procedures were standardized for presenting samples, examining aromas, sampling crumbs, and examining flavors. Usually, two evaluation sessions were held each week with one sample evaluated at each session. The analysis was held for four weeks; four examinations were made of the WE cake and two of the LY3 cake.

Panelists recorded the aroma, flavor and aftertaste char-

Table 1. Explanation of flavor terminology.

<u>Aftertaste</u>:

Flavor factors (tastes, odors, and feelings) perceived in the mouth and nose after food has been swallowed - the final impression made, so it weighs heavily in the consumer's assessment of a product. Duration, strength and components of aftertaste help to determine acceptance.

<u>Aroma</u>:

Sum of odors and feelings perceived through sniffing a product or substance.

<u>Bitter</u>:

One of the so-called primary or basic factors of taste. solutions of quinine, caffeine, and magnesium sulfate taste bitter.

<u>Browning-sweet</u>:

This was a typical top crust note. Odor implying the reaction of sugar and amino compound.

<u>Caky</u>:

Generic term of identity.

<u>Flavor</u>:

Sensations perceived by tongue, mouth, throat and nose when food is eaten; e.g., tastes, feelings, odors and aftertastes but not texture or consistency.

<u>Odor</u>:

Identifying or character note perceived by the nose (excluding burn, sting and other feelings) through sniffing or

Table 1. Continued.

when food is in the mouth.

Off-note:

Undesirable character note in flavor or aroma.

Salty:

Another of the four tastes. Represented by sodium chloride solution.

Sour:

Taste caused by acids.

Starchy:

Connoting undercooked white flour or starch.

Sweet:

The basic taste factor produced on the tongue by most sugars; found in both top crust and crumb of cakes. Also a fragrance from crust and crumb of cakes. Sweet fragrance is part of the browning-sweet aroma.

Taste:

Sensation perceived by taste buds: sweet, sour, salty and bitter are the so-called primary tastes or taste factors.

Table 2. Reference materials for evaluating aromatic factors in sponge cakes.

Ingredients in cake formula

Dried egg powder
Dried white
Reconstituted egg powder
Reconstituted egg plus egg white powders
Lemon extract
SSL
SLS
XG

Food products

Hard-cooked egg
Soft-cooked egg
Scrambled egg prepared with fresh egg
Scrambled egg prepared with reconstituted egg
French toast prepared with reconstituted egg
Hard meringue
Lemon candy
Lemon pudding
Whipped fresh egg white

Others

Raw egg
Vanilla extract
Baking powder
Evaporated milk
Cooked milk
Nonfat dry milk

acteristics as perceived. Intensities of each note were also recorded. The notes agreed upon by all were indicated as part of the flavor profile, while components not perceived by the whole panel were listed in the "other" category.

Texture Profile Analysis

Differences in texture, in particular, were noted in the comments by panelists during the triangle testing. Therefore, texture profiles of WE, LY1, LY2 with SSL (LY2-SSL) and LY3 cakes were made. Three examinations of each cake were used.

Cakes were prepared for serving 30 min prior to evaluation. A 1-in slice with top crust and 5/8 X 1 X 1-in cube without crust were cut and covered with aluminum foil until evaluation.

The panel consisted of five persons familiar with sensory evaluation procedures. They were acquainted with the texture classification system of Szczesniak (1963) and further trained in the use of descriptive texture analysis. Panelists established the standard procedures for evaluating sponge cakes, appropriate scales for references and agreed upon the terminology to be used. Masticatory and residual characteristics of sponge cakes were established. Firmness, cohesiveness of mass, adhesiveness, extensibility and moisture were determined to be important, and standardized rating scales developed for these characteristics are given in Table 3; the terminology used for these cakes is given in Table 4.

The standardized procedure for presenting the sample,

Table 3. Standard rating scales developed for sponge cakes.

Scale value	Product	Brand or type	Manufacturer	Sample size	Temp.
Standardized Firmness Scales:					
X	Cream cheese	Philadelphia	Kraft Foods	½" cube	45-55°F
1	Münster cheese	Safeway	-	½" cube	50-65°F
2	Frankfurters	Large, uncooked, skinless	Seitz	½" round	50-65°F
2+	Gouda cheese	Safeway	-	½" cube	50-65°F
3	Thuringer	Burger's Ozark	Country Cured Hams, Inc.	½" cube	50-65°F
Standardized Cohesiveness of Mass (Gumminess) Scales:					
1	Cheese spread	Yellow, American pasteurized process	Kraft Foods	½ tsp	45-55°F
1+	Cream cheese	Philadelphia	Kraft Foods	½" cube	45-55°F
2	Fruit slice	Orange flavor	-	½" cube	Room
3	Square jelly	Brach's brand strawberry flavor	-	½" cube	Room
Standardized Adhesiveness Scales:					
1	Cheese spread	Yellow American pasteurized process	Kraft Foods	½ tsp	45-55°F
2	Cream cheese	Philadelphia	Kraft Foods	½" cube	45-55°F
2+	Marshmallow topping	Fluff	-	½ tsp	45-55°F
3	Peanut butter	Skippy, smooth	Best Foods	½ tsp	45-55°F

Table 3. Continued.

Scale value	Product	Brand or type	Manufacturer	Sample size	Temp.
Standardized Extensibility Scales:					
0	Corn muffin	Jiffy corn muffin mix	-	½" cube	Room
1	White bread	Country Fair brand	-	½" cube	Room
2	Untoasted English muffin	Mrs. Wright's brand	-	½" cube	Room
2 +	Angel cake	Dolly Madison	Interstate Brands Corporation	½" cube	Room
3	Toasted English muffin	Mrs. Wright's brand	-	½" cube	Room
Standardized Stickiness Scales:					
1	Gelatin cube	Knox blocks	General Foods	½" cube	45-55°F
2	Cheese spread	Yellow, American pasteurized process	Kraft Foods	½ tsp	45-55°F
3	Marshmallow topping	Fluff	-	½ tsp	45-55°F
Standardized Graininess of Mass Scales:					
0	Cheese spread	Yellow, American pasteurized process	Kraft Foods	½ tsp	45-55°F
3	Cream of wheat	Nabisco	National Biscuit Co.	1 tsp	Room

Table 4. Definitions of texture terms used to evaluate sponge cakes (Civille and Szczesniak, 1973; Civille and Liska, 1975; Jowitt, 1974).

Mechanical Properties:

Adhesiveness (stickiness): the force required to remove material that adheres to the mouth, generally the palate, during the normal eating process.

Cohesiveness of mass (gumminess): a denseness that persists throughout mastication; the energy required to disintegrate a cake to a state ready for swallowing.

Extensibility: the degree of crumbliness or thoughness before the cake reptures.

Firmness (hardness): the force required to compress the cake between the incisor teeth to a given deformation or penetration.

Elasticity (springiness): the amount of recovery from a deforming force; the rate at which the deformed cake returns to its undeformed condition after the deforming force is removed.

Density: the compactness or fluffiness of the cross section of cake as felt by the incisors before biting.

Geometrical Property:

Graininess of mass: the property manifested by an absence or presence of detectable solid particle.

Other:

Moisture adsorption: the sensation of an increase or reduction of the free fluids in the oral cavity.

examining texture and the form for recording findings are given in Table 5 and Figure 1. Discussion sessions followed the sample examination and were an integral part of the methodology to be certain panelists agreed on the meaning of the terms. Panelists agreed that if a characteristic was not present, it would be designated zero (0). Just noticeable, slight, moderate and high levels of the characteristics were designated X, 1, 2, and 3, respectively.

Usually, two evaluation sessions were held each week with two samples evaluated at each session for a five-week period. The panelists were seated at a circular table to facilitate discussion of the samples after individual evaluations were made.

Physical Measurements

Specific gravity. Specific gravity was measured according to procedures given by Campbell et al. (1979) for cake batters.

Standing height. The index to volume used for this study was determined according to procedures given by Tinklin and Vail (1946). Values were determined for five points on a center slice.

Compressibility. The IUTM, model 1122, fitted with the 50 cm^2 compression anvil, A 372-17 and platform 1372-24 was used to measure compressibility and is shown in Figure 2. All attachments were mounted to the 500 kg load cell of the IUTM. Values for WE, LY1, LY2-SSL and LY3 formulations were determined. Five representative samples, 1.6 X 2.5 X 2.5 cm, of the crumb from each cake were evaluated. Samples were compressed to 0.6 cm (compressi-

Table 5. The standardized procedures for evaluating sponge cakes.

I. Place cake in mouth; feel surface with tongue and lips.

Evaluate for:

- Crust stickiness (adhesiveness).
- Moisture (degree of wetness or oiliness).

II. Compress partially between incisors; release, then bite througl

Evaluate for:

- Elasticity: degree to which sample returns to original shape.
- Density: compactness of the cross section.
- Firmness: force required to go through.

III. Bite and pull with incisors.

Evaluate for:

- Extensibility: degree of crumbliness or toughness before ruptures (tensile strength).

IV. Chew a 5/8 X 1 X 1-in cube with molar teeth.

Evaluate for:

- Chewiness: number of chews necessary to prepare sample for swallowing.
- Moisture adsorption: degree to which the sample mixes with saliva (0, doesn't need more saliva; 3, needs more saliva).
- Cohesiveness of the mass: degree mass holds together after 10-15 chews (gumminess).
- Graininess of mass: degree to which sample contains small distinct particles (0, smooth; 3, coarse granular).

Table 5. Continued.

V. Swallow the chewed sample.

Evaluate for:

- Ease of swallow: degree to which sample can be readily swallowed (0, difficult; 3 easy).
- Adhesiveness of crumb: amount of material left in and around molar teeth.

Figure 1. The form used for recording sensory texture profiles of sponge cakes.

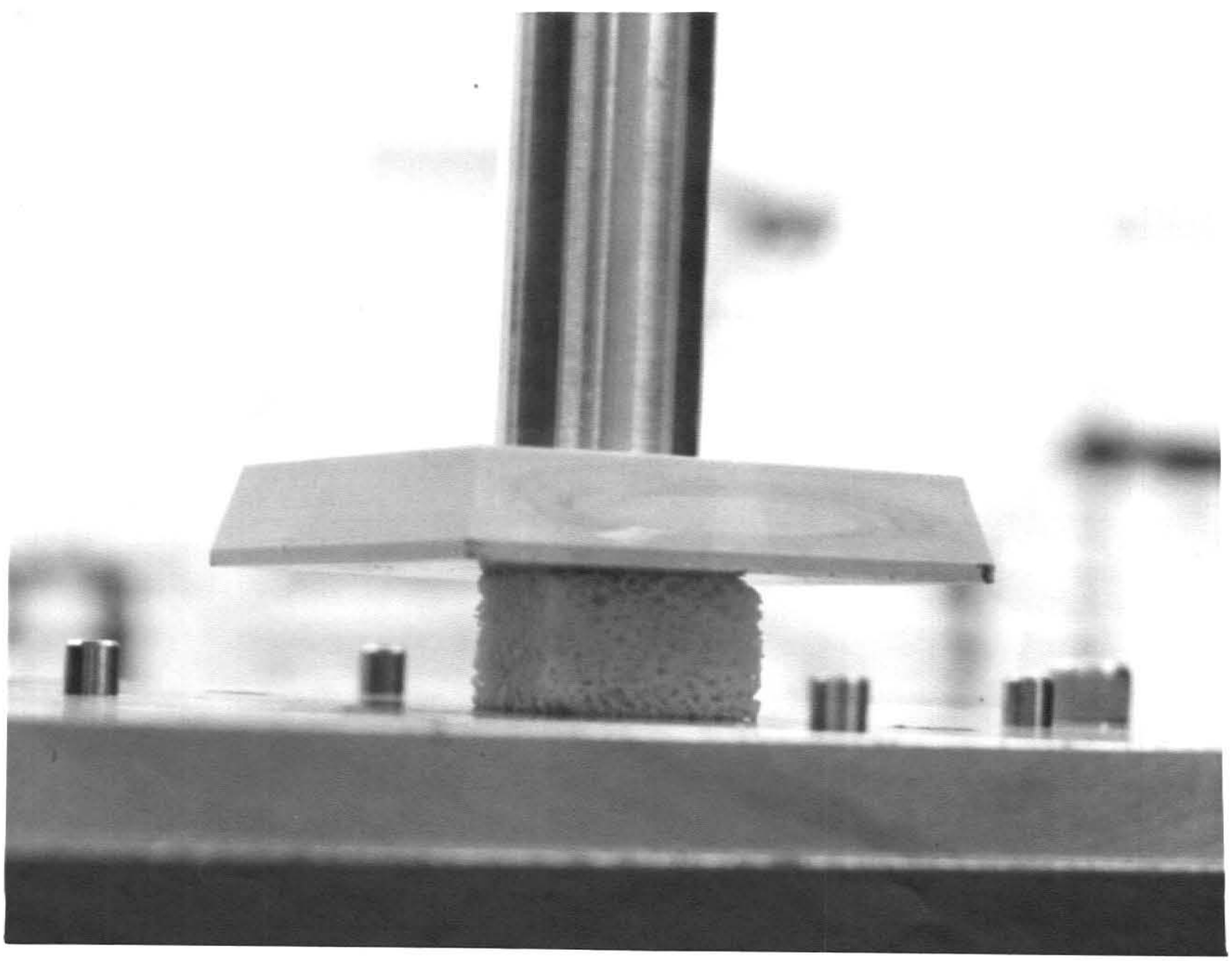
Name________________________________ Date______________

Sample______________________

Characteristic
Stage 1
Crust stickiness
Moisture
Stage II
Elasticity
Density
Firmness
Stage III
Extensibility
Stage IV
Moisture adsorption
Cohesiveness of mass
Graininess of mass
Number of chews
Stage V
Ease of swallowing
Adhesiveness of crumb

Additional comments:

Figure 2. The Instron Universal Testing Maching (IUTM), model 1122, fitted with the 50 cm^2 compression anvil, A 372-17 and platform 1372-24 used to measure compressibility.



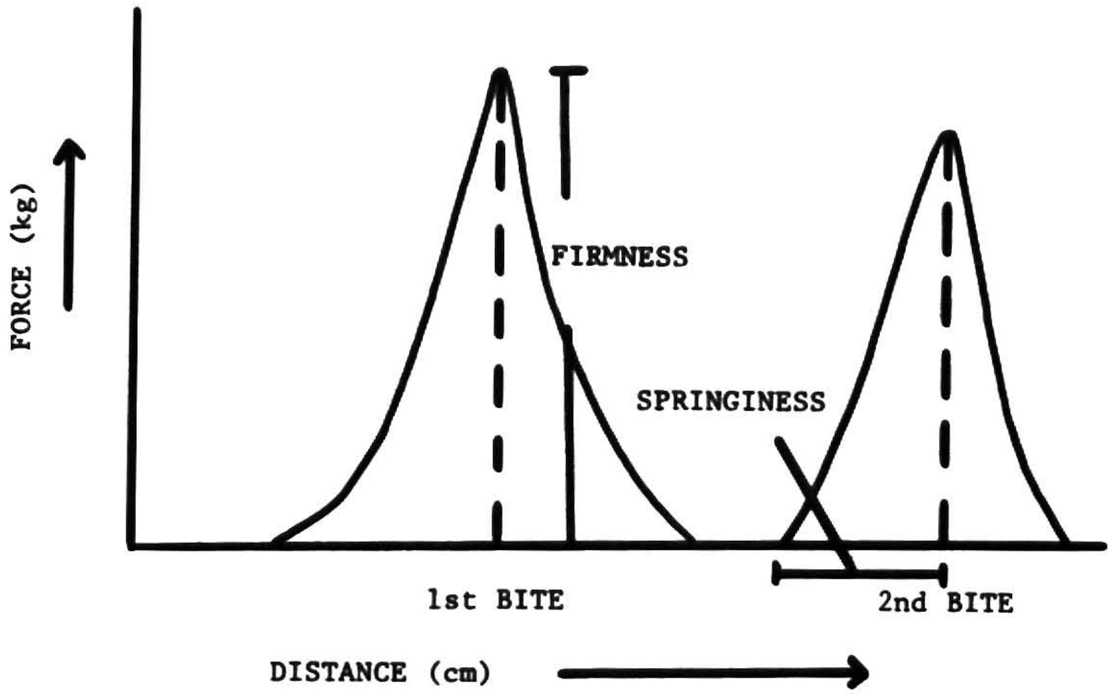
bility ratio = 60%) using a 0.2 kg load for WE and LY3 cakes, and 0.5 kg load for LY1 and LY2-SSL cakes. A crosshead speed of 100 mm/min and a chart speed of 50 mm/min was used. The compression was carried out in two consecutive cycles. Values for firmness and springiness were taken from these curves. Firmness is defined as the peak force during the compression cycle ("first bite") and expressed in kg of force. Springiness (corresponding to elasticity) is defined as amount of recovery of the food during the time elapsed between the end of the first compression cycle and the start of second compression cycle and also is expressed as distance (cm) as shown in Fibure 3a. Four replications were evaluated.

Extensibility and breaking strength. The IUTM, fitted with polyethylene-coated tensile grips fabricated for these experiments, is shown in Figure 4a. They were attached to a probe chuck assembly 2830-006 used with a 0.1 kg load. These were used with the modified support system from the Kramer shear cell 2380-008. Samples were cut from 1.27 cm cake slices with a special cutter (Figure 4b), 7 cm long and 4 cm wide at the ends tapering to 2.5 cm in the center. Values from two to four slices of each of four replications of the cakes were determined. Extensibility is defined as the distance from when force is applied to when the sample is extended to its breaking point and is expressed in cm. The breaking strength, expressed in kg of force, is the point at which the sample breaks. A typical curve is shown in Figure 3b.

Figure 3. a) Force-distance curve obtained of sponge cake using the IUTM. The test consists of two complete compression-decompression cycles.

b) Typical curve obtained from deformation and rupture of sponge cake crumb. The distance from the time force is applied until rupture is the extensibility and the peak force applied is the breaking strength of the cake.

a.


FORCE (kg)
FIRMNESS
SPRINGINESS
1st BITE
2nd BITE
DISTANCE (cm)

b.

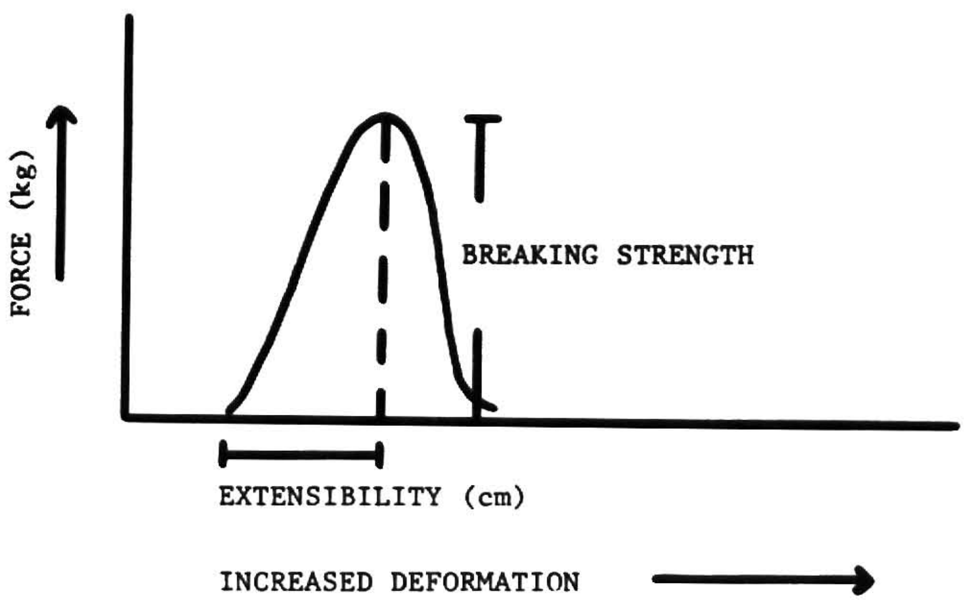
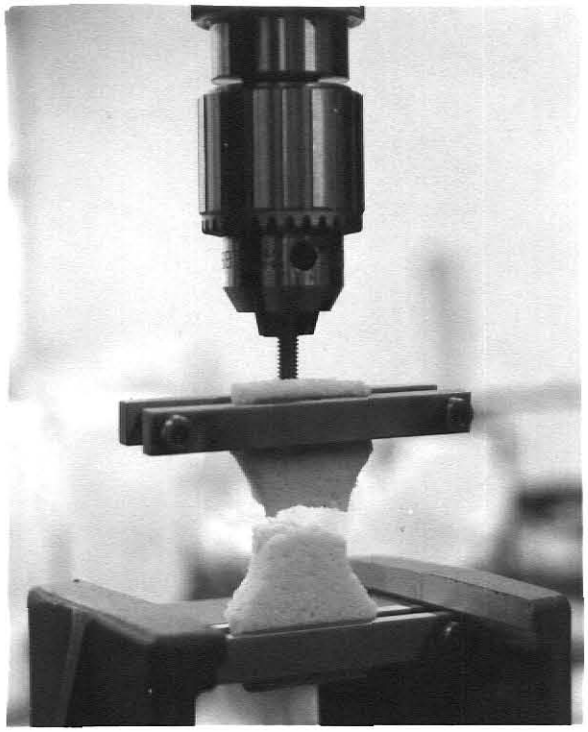
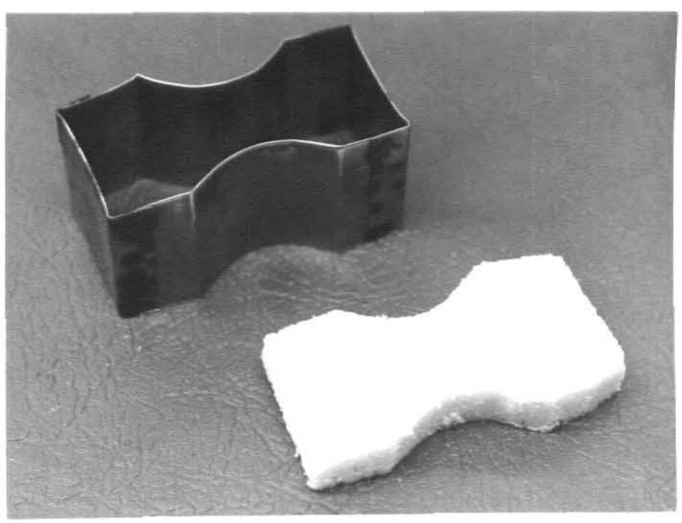

FORCE (kg)
BREAKING STRENGTH
EXTENSIBILITY (cm)
INCREASED DEFORMATION

Figure 4. a) The IUTM, fitted with polyethylene coated tensile grips fabricated for measuring extensibility and breaking strength.

b) The cutter used for sampling the sponge cakes for these evaluations.





Statistical analysis. A completely randomized statistical design was used. The effective error mean square was used to determine significant treatment effects. LSD's were used to determine differences among treatments.

RESULTS AND DISCUSSION

Triangle Test

The data from the triangle tests for the 72 responses of six panelists are given in the Table 6. This difference testing confirmed a perceived difference does exist between WE and all LY sponge cakes with or without stabilizers. No difference was perceived between LY2 cakes with 0.5% SSL and with 1.0% SSL; between LY1 cakes and LY2 cakes with 1.0% SSL and between LY2 with 1.0% LEC and LY2 with 1.0% CMC cakes. Panelists indicated the differences, when perceived, were both in texture and in flavor.

Although we used several stabilizers, such as SSL, LEC, and CMC, to improve the quality of LY sponge cakes, panelists could detect some differences among these cakes. Panelists couldn't differentiate between the two levels of SSL. The panelists made several comments about flavor and texture; flavor characteristics of eggy, sweet, lemony, off-flavor and floury and texture characteristics of elastic, rubbery, and gummy were noted.

Flavor Profile Findings

The profile panel tentative findings for WE and LY3 sponge cakes are shown in Table 7. Browning-sweet and eggy notes are the major aroma and flavor components of sponge cakes. But the intensity and kind of eggy notes depend on cake formula differences and the resulting top crusts and crumbs. Usually the crumb

Table 6. Results from triangle difference tests.

Test Samples[a]	Correct Responses[b] (No.)	Correct Responses[b] (%)
1-2	71	98.6
1-3	68	94.4
1-4	69	95.8
1-5	68	94.4
1-6	69	95.8
2-3	53	73.6
2-4	37*	51.4
2-5	41	56.9
2-6	41	56.9
3-4	31*	43.1
3-5	40	55.6
3-6	41	56.9
4-5	43	59.7
4-6	44	61.1
5-6	37*	51.4

*No significant difference.

[a]The treatments were designated: 1, WE; 2, LY1; 3, LY2-0.5% SSL; 4, LY2-1% SSL; 5, LY2-1% LEC; 6, LY2-1% CMC. The test sample 1-2 refers to the WE and LY1 sponge cake series. Each series had six orders of presentation.

[b]In this study, six panelists were used, with two replications giving 72 responses for each series.

Table 7. Composite flavor prefiles of sponge cakes.

	WE Sponge Cake Character Notes	WE Sponge Cake Intensities	LY3 Sponge Cake Character Notes	LY3 Sponge Cake Intensities
		AROMAS		
Crumb:	eggy	1-3	eggy	1 +
	light brown-sweet	1-2	light brown-sweet	1
	others: caky	1-2	others: lemony	)(- 1+
	lemony	)(-1	caky	)(- 1
	cooked milk	1	xanthan gum	)(
	vanilla		sodium stearoyl lactylate	2-
	fragrance			
	French toast			
	scrambled egg			
Crust:	browning-sweet	1-3	eggy	1
	eggy	1-2	browning-sweet	)(-2
	others: caky	)(-2	others: lemony	)(-1
	citrus	)(-1	caky	)(
	(lemony, orange)		powdery aromatic	)(
	vanilla	)(	xanthan gum	)(
		FLAVORS		
Crumb:	light brown-sweet	1-2	light brown-sweet	1
	eggy	1-2	(lingering)	
	others: lemony	)(-1	eggy	1
	caky	1	others: lemony	1
	cooked milk		caky	)(
	sweet fragrance besides sugar		bitter	)(
	vanilla		starchy	1-2
			off-note	)(

Table 7. Continued.

	WE Sponge Cake Character Notes	Intensities	LY3 Sponge Cake Character Notes	Intensities
Crust:	browning-sweet	1-2	browning-sweet (long-lasting)	1-1+
	eggy	1-2	eggy	)(-1
	others: lemony	)(-2	others: sour	)(-1
	vanilla	)(	milky	1
	caky	1-2	starchy	)(-1
	sour	1	lemony	)(-1
	bitter	)(-1	bitter, salty, gummy, powdery, flat, sticky	
	cooked milk			
		AFTERTASTES		
Crumb:	sweet, lemony		sweet, lemony sour, eggy	
Crust:	sweet, bitter, lemony, sour		sweet	

has less intense brown aroma than the top crust; the top crust, losing moisture easily, attains higher temperatures, thus greater browning results in that portion. WE sponge cake had more eggy aroma than the LY sponge cake, as expected since it has the lower yolk content.

In WE sponge cake, the eggy aromatic was reported as dried whole egg or reconstituted egg by most panelists. A few even described it as fresh egg. Others used such descriptions as French toast or scrambled egg which were related to the eggy and browning characteristics in the crumb, and added the term fragrance as well. Lemony character was found in the crumb aroma and flavor, but two panelists thought of it as orange in the crust aroma. The crumb flavor provided a sweet fragrance in addition to the sweet taste; sweet, sour and bitter tastes, sensed in the crust by some panelists, lasted into the aftertaste. Probably the bitterness was due to the "browned" character. Comments such as tasteful, delicious also were offered by some panelists. The flavor of WE sponge cake was regarded as having more aroma and more fragrant aroma than the low yolk product.

Although the eggy aroma was of lower intensity in the LY3 sponge cake than in the WE sponge cake, it was perceived first during the aroma evaluation. Probably this was because the browning-sweet note was not as strong as in the WE formula, although it was long lasting. The flavor of LY3 cake was regarded as flat by some panelists. Ganz (1977) noted XG reduces sweet intensity in some products; some of the cake flavor notes (e.g., sweet fragrance, vanilla-like) might have been repressed by the XG. The eggy aroma was detected as dried egg white or reconstituted egg plus egg white. Vanilla-like aromatic had disappeared; the powdery, SSL and XG aromas, which were described as off-notes by a few panelists, apparently replaced or overpowered this sweet fragrance. The intensity of the caky note was also lower. Starchy aroma, reported by some panelists, also might be related to less browning. A bitter note occurred in the flavor. In addition, the textural parameters of stickiness and gumminess were reported occasionally.

In summary, yolk contributes to the aromatics of the flavor. The flat flavor of LY3 sponge cakes might be ascribed to 1) less protein available for adequate browning reaction 2) XG decreased some aromatics and sweetness, and 3) the yolk diluted by albumen was not enough to contribute to the expected level of flavor.

Texture Profile Findings

Figures 5 and 6 show the composite sensory texture profiles of WE, LY1, LY2-SSL, and LY3 sponge cakes. All the following parameters are referred to these figures.

In the early stages of the cake evaluations, moisture of the top crust and the mechanical parameters of springiness and firmness were regarded to be the most important. However, as the sample disintegrated, the geometrical graininess of the mass and moisture adsorption became evident and more important.

Crust stickiness. All LY sponge cakes had stickier top

Figure 5. Composite diagrams of the textural attributes of whole egg and low yolk sponge cakes without additives at all five stages of evaluation:

I. Feel with tongue and lips.

II. Compress.

III. Bite and pull.

IV. Chew.

V. Swallow.

The distances from the center represent mean values for the attributes.

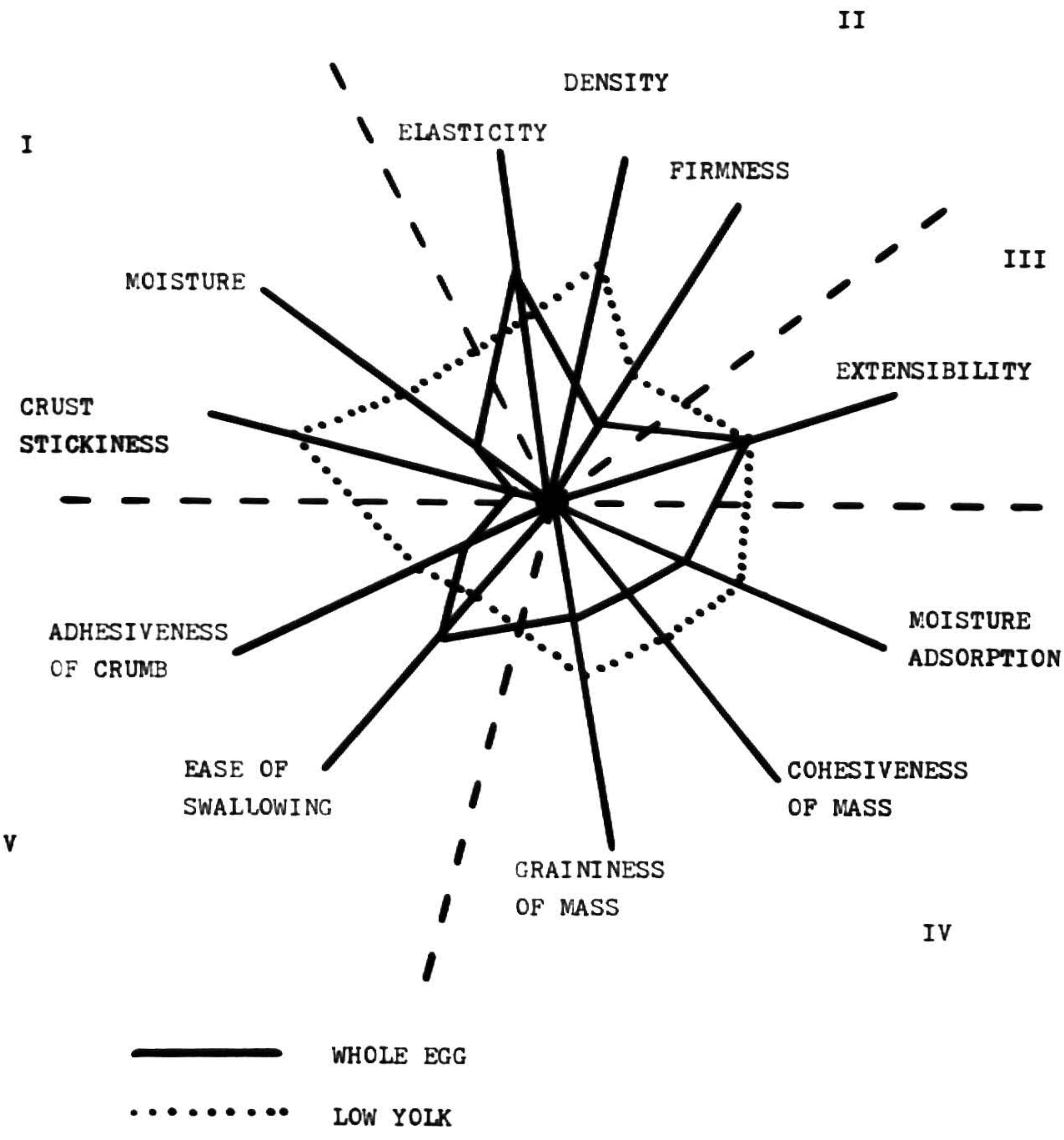

II
DENSITY
ELASTICITY
I
FIRMNESS
III
MOISTURE
EXTENSIBILITY
CRUST
STICKINESS
MOISTURE
ADSORPTION
ADHESIVENESS
OF CRUMB
EASE OF
SWALLOWING
COHESIVENESS
OF MASS
V
GRAININESS
OF MASS
IV
WHOLE EGG
LOW YOLK

Figure 6. Composite diagrams of the textural attributes by low yolk sponge cakes with SSL and low yolk sponge cakes with SSL, SLS and XG at all five stages of evaluation:

I. Feel with tongue and lips.

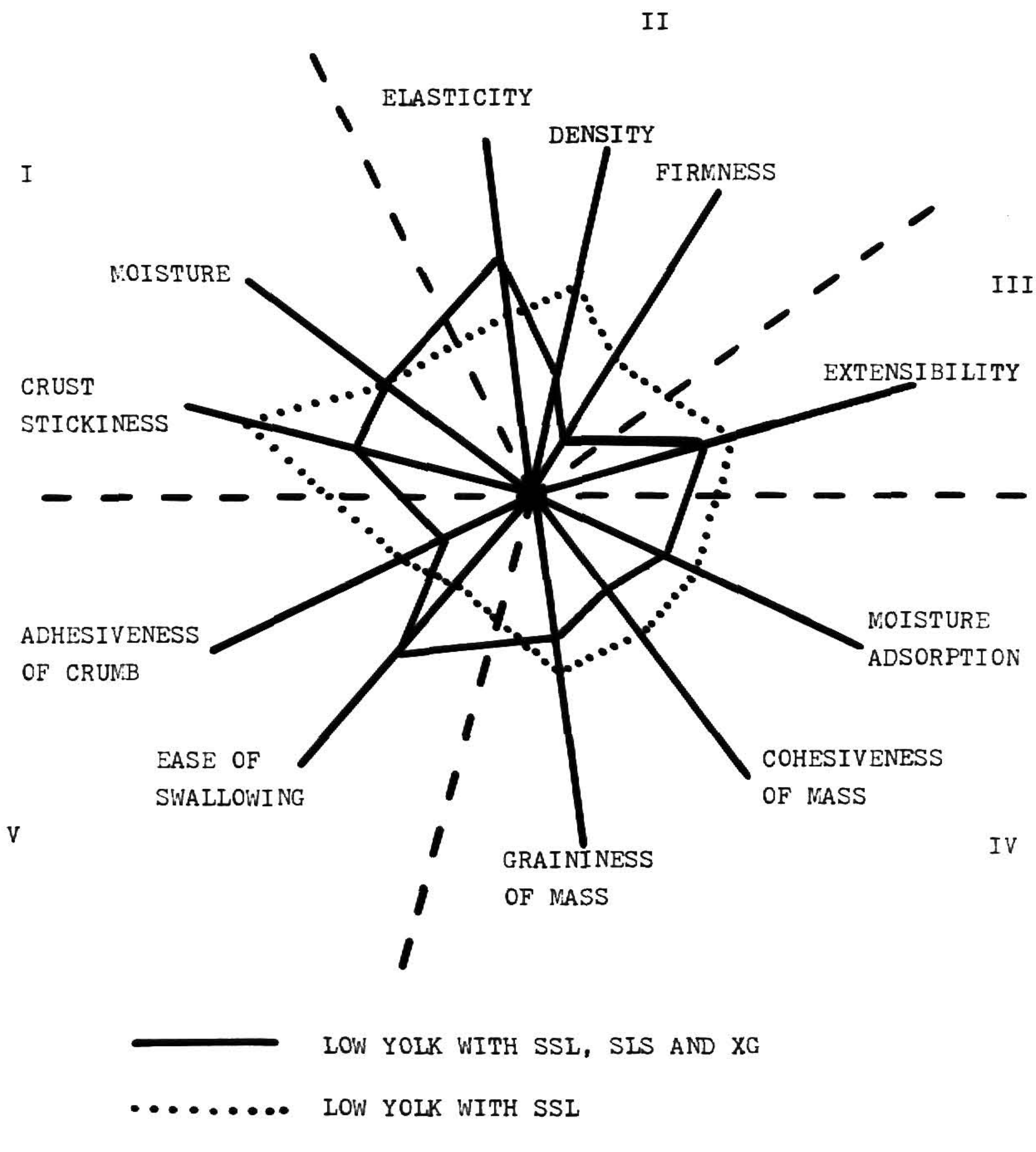
II. Compress.

III. Bite and pull.

IV. Chew.

V. Swallow.

The distances from the center represent mean values for the attributes.


II
ELASTICITY
DENSITY
FIRMNESS
I
MOISTURE
III
EXTENSIBILITY
CRUST
STICKINESS
MOISTURE
ADSORPTION
ADHESIVENESS
OF CRUMB
EASE OF
SWALLOWING
COHESIVENESS
OF MASS
V
IV
GRAININESS
OF MASS
LOW YOLK WITH SSL, SLS AND XG
LOW YOLK WITH SSL

crusts (Figure 7) than WE sponge cakes, probably because of the increased water added and the lower protein content. With less protein, less water is adsorbed. In addition, XG functions as a moisture-retaining agent in baked goods, adsorbing large amounts of water and could have been a factor in the LY3 cakes.

Moisture. All low yolk sponge cakes had a higher degree of moisture (Figure 7) in the crumb than WE sponge cakes, apparently because more of water used in the formula.

Elasticity. The WE and LY3 sponge cakes were more elastic or springier than the LY1 and LY2-SSL cakes, see Figure 7. This property apparently is related to forces of attraction acting between particles and opposing disintegration. In the LY3 cakes, XG may have given the batter stability for the expanding air cells to stretch with the steam formed during baking. According to the report of Cornford et al. (1964), the elastic modulus increased for bread baked without fat as opposed to that prepared with fat. Since no oil was added in the WE and LY3 cakes (see Appendix,Table A-1) , perhaps the fat also contributes to the elasticity of cakes.

Density. The LY1 cakes were more dense than all other cakes (Figure 7). Stabilizers decreased the density, especially the combination of SSL, SLS, and XG. SLS serves as whipping aid, and provides a more aerated structure. SSL also contributed a little to the lightness and aeration of cakes. The WE cakes had enough egg yolk for sufficient aeration and leavening.

Firmness. Firmness, as shown in Figure 8, tended to be

Figure 7. Texture profile findings for crust stickiness, moisture, elasticity and density of sponge cakes: WE, whole egg; LY1, low yolk without additive; LY2, low yolk with 1% SSL; LY3, low yolk with 0.75% SLS + 1% SSL + 1% XG.

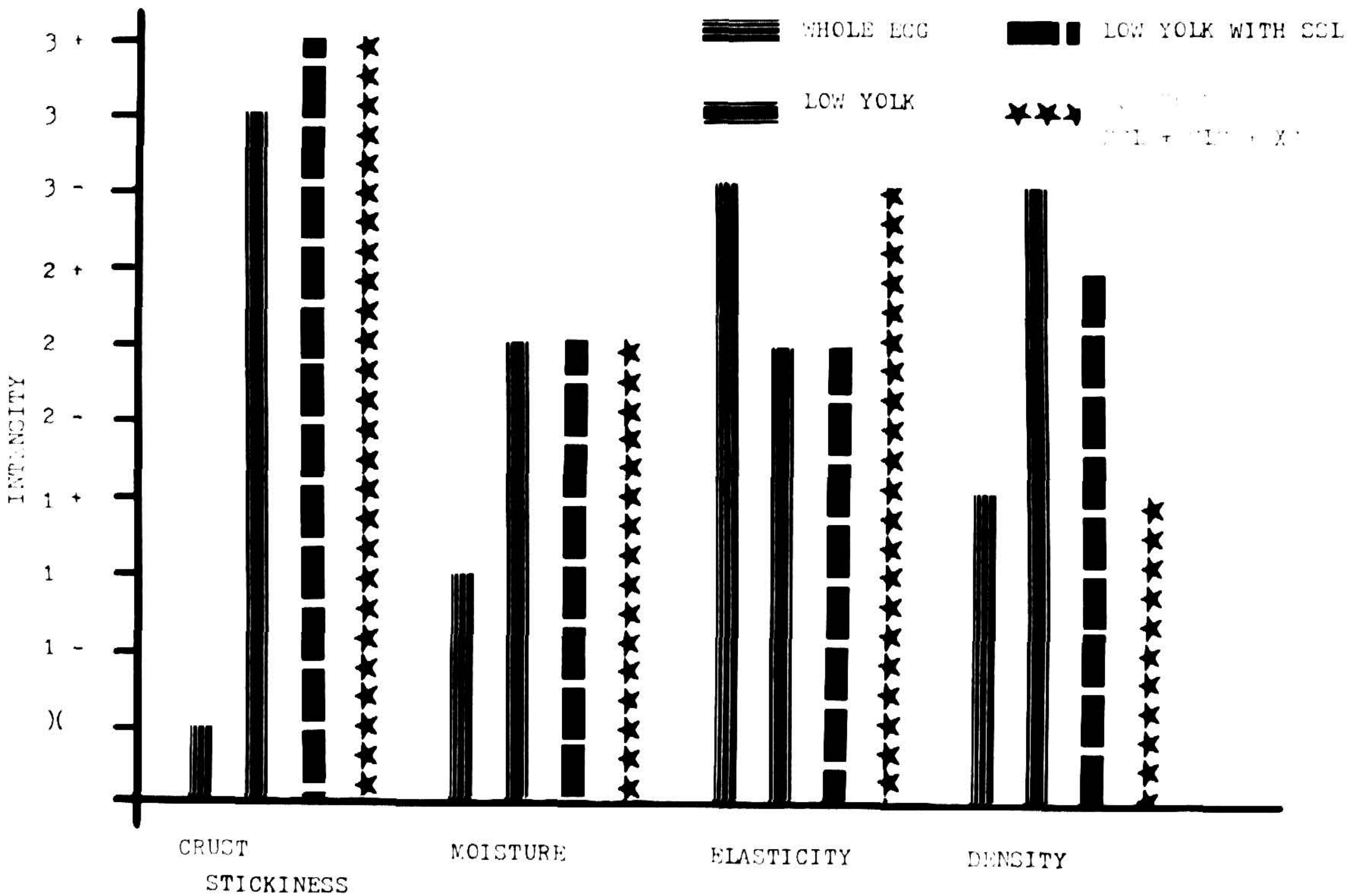
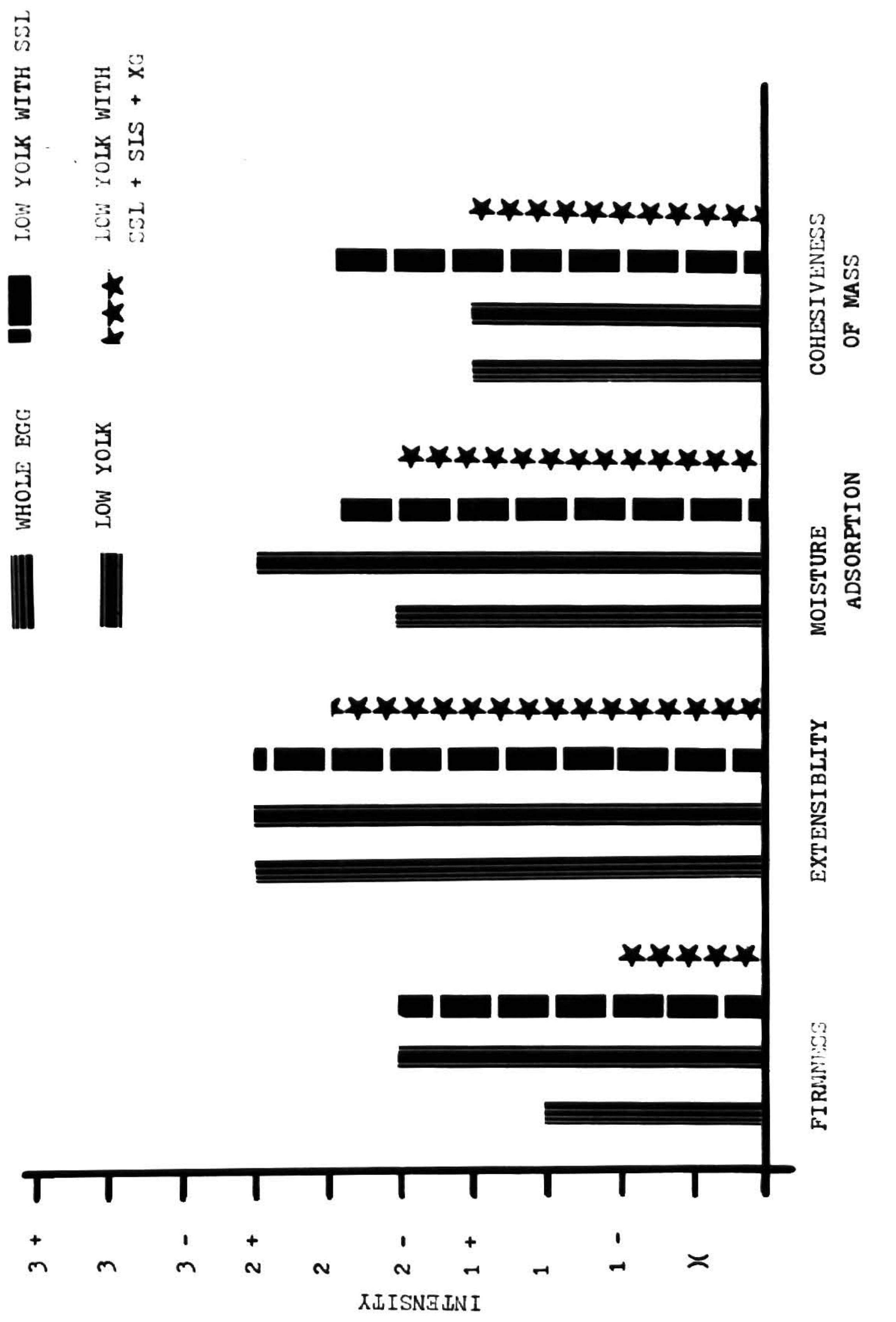

WHOLE EGG
LOW YOLK
LOW YOLK WITH SSL
INTENSITY
3 +
3
3 -
2 +
2
2 -
1 +
1
1 -
)(
CRUST
STICKINESS
MOISTURE
ELASTICITY
DENSITY

Figure 8. Texture profile findings for firmness, extensibility, moisture adsorption and cohesiveness of mass of sponge cakes: WE, whole egg; LY1, low yolk without additive; LY2, low yolk with 1% SSL; LY3, low yolk with 0.75% SLS + 1% SSL + 1% XG.


WHOLE EGG
LOW YOLK
LOW YOLK WITH SSL
LOW YOLK WITH
SSL + SIS + XG
FIRMNESS
EXTENSIBLITY
MOISTURE
ADSORPTION
COHESIVENESS
OF MASS
INTENSITY
3 +
3
3 -
2 +
2
2 -
1 +
1
1 -
X

similar to density, LY1 and LY2-SSL cakes were firmer than the others. The WE and LY3 cakes were more aerated; with increased numbers of air bubbles and less attractive forces between molecules; these cakes could be deformed more easily by applied forces.

Extensibility. All sponge cakes were rated very similarly for extensibility (Figure 8). The LY3 cakes were slightly less extensible than the other cakes.

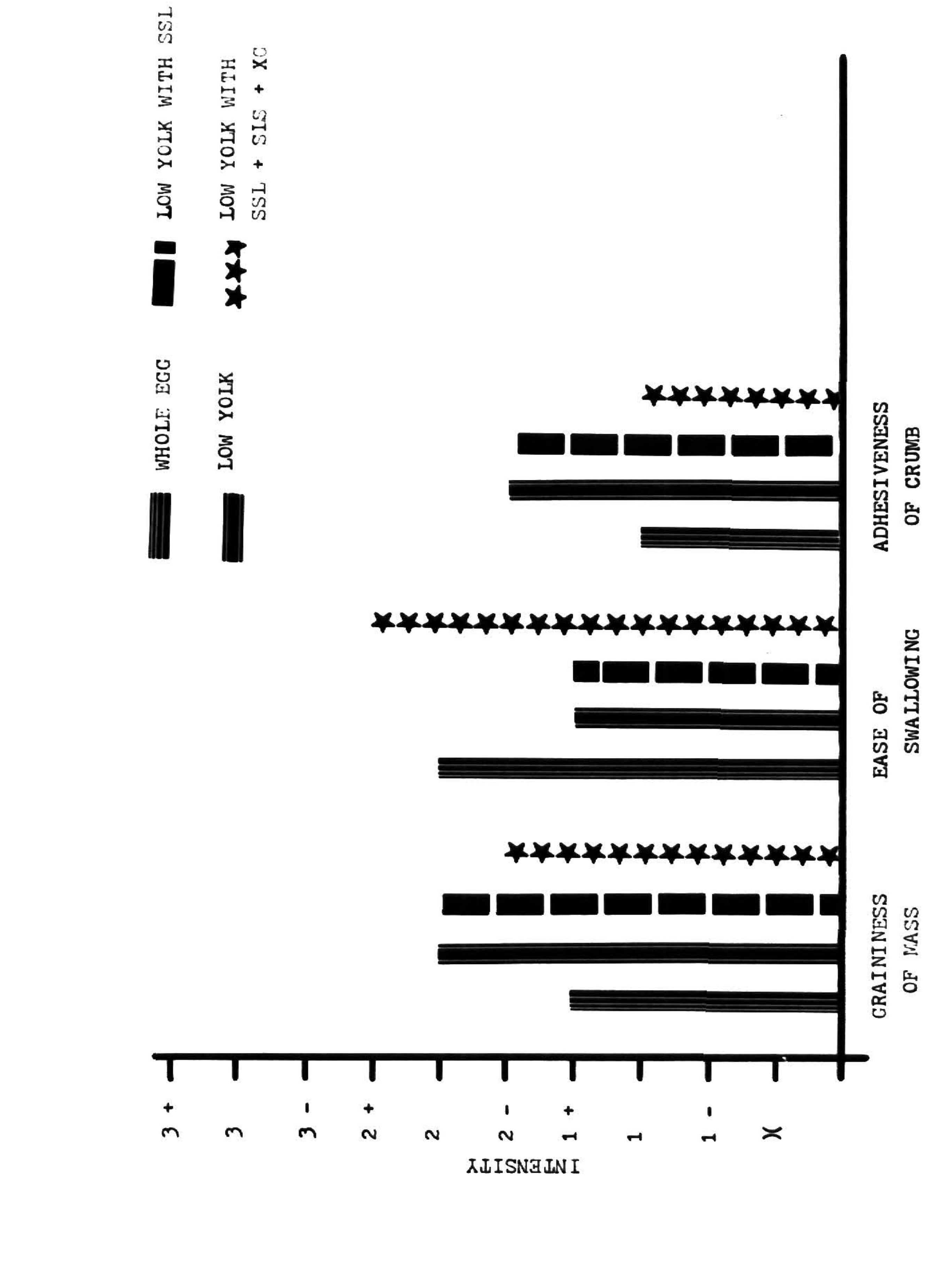
Moisture adsorption. The LY1 and LY2-SSL cakes took up more moisture from saliva than the WE and LY3 cakes, as shown in Figure 8.

Cohesiveness of mass. This parameter is related to gumminess and to the denseness which persists throughout the masticatory stage. The LY1 and LY2-SSL cakes were considered to be more cohesive and gummier than the WE and LY3 cakes (Figure 8). Interestingly, the added XG did not increase the cohesiveness of the mass in the LY3 cakes; however, the levels used were quite low. In this case, cakes which were more cohesive were less elastic.

Graininess of mass. The property is related to the particle size of cake as it is masticated. LY1 and LY2-SSL cakes had the most grainy feel in the mouth as shown in Figure 9. LY3 cakes were more grainy than WE cakes.

Ease of swallowing. The LY3 cakes were easiest to swallow (Figure 9), which is probably related to the moist crumb and lower cohesiveness. WE cakes were the next easiest to swallow; they also had lower cohesiveness.

Figure 9. Texture profile findings for graininess of mass, ease of swallowing and adhesiveness of crumb of sponge cakes: WE, whole egg; LY1, low yolk without additive; LY2, low yolk with 1% SSL; LY3, low yolk with 0.75% SLS + 1% SSL + 1% XG.


WHOLE EGG
LOW YOLK
LOW YOLK WITH SSL
LOW YOLK WITH SSL + SLS + XG
INTENSITY
3 +
3
3 -
2 +
2
2 -
1 +
1
1 -
X
GRAININESS OF MASS
EASE OF SWALLOWING
ADHESIVENESS OF CRUMB

Adhesiveness of crumb. As the cake was swallowed, LY1 and LY2-SSL cakes tended to stick to the molar teeth more than WE and LY3 cakes, as shown in Figure 9.

In summary, the texture profile findings indicated composite texture profiles (Figures 5 and 6) of LY3 sponge cakes were similar to the WE sponge cakes except that LY3 sponge cakes had a stickier crust and moister crumb. The LY1 and LY2-SSL cakes were similar; SSL did not alter the textural qualities of the cake very much. The combination of SSL, SLS, and XG did improve the texture of the low yolk sponge cakes.

Physical Measurements

Table 8 presents the adjusted mean values and the significant differences between treatments for physical measurements; the raw data are given in the Appendix, Table A-4.

Specific gravity. The specific gravity of foams of LY1 and LY2-SSL sponge cakes were significantly ($P \leq 0.05$) higher than that of WE and LY3 sponge cakes. WE cakes also were significantly ($P \leq 0.05$) different from LY3 cakes. Three stabilizers in the cake allowed more air to be incorporated than even the WE did. LY1 and LY2-SSL cakes didn't show this difference.

Standing height. Although the LY3 cake foams had the lowest specific gravity, the final cakes did not have as good finished volume as the WE cakes as estimated by standing height. LY3 cakes had significantly ($P \leq 0.05$) higher standing height values than LY1 and LY2 cakes. The standing heights of LY1 and LY2-SSL cakes were

Table 8. Adjusted means for four replications with LSD values of physical measurements of sponge cakes.

Treatment*	Specific gravity	Standing height (cm)	Firmness (kg)	Springiness (cm)	Extensibility (cm)	Breaking strength(kg)
WE	0.39^{a}	6.1^{a}	0.06^{a}	1.93^{ac}	2.0^{a}	0.018^{a}
LY1	0.55^{b}	3.3^{b}	0.33^{b}	1.80^{b}	2.7^{b}	0.042^{b}
LY2-SSL	0.53^{b}	3.6^{c}	0.24^{b}	1.83^{ab}	2.7^{b}	0.039^{b}
LY3	0.31^{c}	5.4^{d}	0.07^{a}	2.03^{c}	2.5^{b}	0.017^{a}
LSD.05	0.02	0.2	0.09	0.13	0.4	0.006

*The treatments were: WE, whole egg; LY1, low yolk without additive; LY2, low yolk with SSL; LY3, low yolk with SSL, SLS, and XG.

abcdMeans in same line with different superscript indicate significant differences ($P \leq 0.05$).

significantly different ($P \leq 0.05$).

Firmness. The LY1 and LY2-SSL sponge cakes were firmer than the WE and LY3 sponge cakes. This agreed with the sensory panel findings. The IUTM data indicated no significant differences between WE and LY3 sponge cakes, although the panel reported WE cakes were slightly firmer than LY3 cakes.

Springiness. The IUTM results were similar to the human responses for springiness (elasticity). LY3 cakes gave significantly ($P \leq 0.05$) higher springiness values than LY1 and LY2-SSL cakes. WE cakes also were significantly ($P \leq 0.05$) different from LY1 cakes. The LY1 and LY2-SSL cakes did not return to the original shape as much as WE and LY3 cakes.

Extensibility. According to the IUTM data given in Table 8, the WE sponge cakes had significantly lower extensibility than the other three cakes ($P \leq 0.05$). This result was somewhat different from the sensory data for extensibility. Those results indicated the LY3 cakes were least extensible.

Breaking strength. These results indicate WE and LY3 cakes had the lowest breaking strengths ($P \leq 0.05$). LY1 and LY2-SSL cakes required greater force to break. The sensory panelists likely were rating a combination of breaking strength and extensibility, but correlating instrumental measurements to human judgments is difficult because instruments measure but do not perceive.

SUMMARY

Because textural and flavor changes in baked products are likely when formulations are altered, sensory characteristics of sponge cakes containing the whole egg or with lowered yolk levels with or without stabilizers were evaluated by difference and descriptive tests. Sensory difference testing indicated significant differences between WE and all LY cakes and among LY cakes except as indicated. No difference was perceived between LY2 cakes made with 0.5% SSL and with 1.0% SSL; between LY1 cakes and LY2 cakes with 1.0% SSL and between LY2 with 1.0% LEC and LY2 with 1.0% CMC cakes. Panelists indicated the differences, when perceived, were in both texture and in flavor.

Flavor profile findings on WE and LY3 sponge cakes indicated that browning-sweet and eggy were regarded as the major aroma and flavor components of sponge cake. The intensity and kind of eggy note depended on cake formula differences and the resulting top crusts and crumbs. Usually the crumb had less intense brown aroma than the top crust; LY3 cakes had less intense eggy notes than WE cakes. The flavor of LY3 cakes was regarded as flat.

Texture profile findings showed the combination of the different stabilizers, SSL, SLS, and XG, improved the textural quality of low yolk cakes and made them similar to the WE cakes except for a stickier top crust and moister crumb. If only SSL was used, texture was not changed much from the LY1 cakes.

The IUTM indicated there was a relationship with sensory texture profile findings for firmness and springiness when WE,

LY1, LY2-SSL, and LY3 sponge cakes were measured, but not for extensibility. Other physical measurements confirmed the relationship between specific gravity of the foam and the standing height of cakes.

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APPENDIX

Table A-1. Basic cake formula and variations.

	Basic[a]		LY1[a]		LY2[a]		LY3[a]	
	Amts		Amts		Amts		Amts	
Ingredients	(g)	(%)	(g)	(%)	(g)	(%)	(g)	(%)
Whole egg powder	58	121	20.4	43	20.4	43	20.4	43
Dried white	0	0	15.2	32	15.2	32	15.2	32
Water	96	200	133.2	278	133.2	278	133.2	278
Sugar[b]	56	117	69	144	69	144	69	144
Flour	48	100	48	100	48	100	48	100
Lemon juice	7	15	7	15	7	15	7	15
Salt	-	-	0.5	2	0.5	2	0.5	2
Corn oil	-	-	10.4	22	10.4	22	-	-
Sodium stearoyl 2-lactylate[c]	-	-	-	-	0.24 or 0.48	0.5 or 1	0.48	1
Sodium lauryl sulfate	-	-	-	-	-	-	0.36	0.75
Xanthan gum	-	-	-	-	-	-	0.48	1

[a]Basic, LY1, LY2, LY3 cakes refer to WE sponge cakes, low yolk sponge cakes without additives, cakes with SSL, LEC, or CMC, and cakes with SSL, SLS and XG, respectively.

[b]54% was added to flour, remainder was added with egg.

[c]1.0% CMC or LEC was used in some cakes instead of SSL.

Table A-2. Mixing method for sponge cake.

Mixing Step		Speed Setting[a]	Time(min)
1. Wet egg[b], scraping at intervals		1	1.0
2. Beat		10	1.5
3. Scrape, add portion of sugar to egg		10	2.0
4. Scrape			
5. Beat:	WE	10	3.0
	LY1	10	12.0
	LY2	10	12.0
	LY3	10	10[c]
6. Scrape			
7. Add lemon juice		10	0.5
8. Scrape			
9. Add previously sifted flour + remaining sugar		1	1.5
10. Scrape			
11. Beat, add oil here when used		1	1.0
12. Weight 220 gm batter into 18.8 x 9.3 x 5.7 cm pan. Bake at 177°C (350°F) for 30 min			

[a]Hobart Kitchen - Aid Mixer, model K5-A.

[b]For cakes used in triangle tests, prepared 18-20 hr preceding baking period and stored in covered beakers at 3.5°C (38.3°F).

[c]Eggs were beaten to specific gravity of 0.38, 0.54, 0.54, and 0.31 ± 0.03 for WE, LY1, LY2, and LY3 cakes, respectively.

Table A-3. Treatment combinations used in triangle testing.

Test Samples[a]	Order of Presentation					
	A	B	C	D	E	F
1-2	112[b]	121	211	122	221	212
1-3	113	131	311	133	331	313
1-4	114	141	411	144	441	414
1-5	115	151	511	155	551	515
1-6	116	161	611	166	661	616
2-3	223	232	322	233	332	323
2-4	224	242	422	244	442	424
2-5	225	252	522	255	552	525
2-6	226	262	622	266	662	626
3-4	334	343	433	344	443	434
3-5	335	353	533	355	553	535
3-6	336	363	633	366	663	636
4-5	445	454	544	455	554	545
4-6	446	464	644	466	664	646
5-6	556	565	655	566	665	656

[a]The test samples referred to in the presentation order are as follows: 1 - whole egg; 2 - low yolk; 3 - low yolk with 0.5% SSL; 4 - low yolk with 1% SSL; 5 - low yolk with 1% LEC; 6 - low yolk with 1% CMC.

[b]112 refers to presentation in the following order - whole egg, whole egg, and low yolk; 121 refers to whole egg, low yolk, and whole egg, etc.

Table A-4. Data from physical measurements of sponge cakes.

Observation	Treatment[a]	Replication	Specific gravity	Standing height(cm)	Firmness (kg)	Springiness (cm)	Extensibility(cm)	Breaking strength(kg)
1	1	1	0.39	5.7	.	.	1.4	0.015
2	1	2	0.38	5.9	.	.	2.2	0.020
3	1	3	0.37	6.1	.	.	2.0	0.019
4	1	4	0.38	6.0	.	.	2.5	0.017
5	2	1	0.51	3.3	.	.	2.8	0.043
6	2	2	0.54	3.3	.	.	2.6	0.044
7	2	3	0.56	3.3	.	.	2.7	0.036
8	2	4	0.51	3.3	.	.	2.8	0.043
9	3	1	0.51	3.4	.	.	2.8	0.042
10	3	2	0.54	3.5	.	.	2.7	0.046
11	3	3	0.54	3.6	.	.	2.5	0.036
12	3	4	0.51	3.6	.	.	2.7	0.033
13	4	1	0.32	5.2	.	.	2.8	0.018
14	4	2	0.32	5.3	.	.	2.6	0.019
15	4	3	0.27	5.7	.	.	2.2	0.014
16	4	4	0.28	5.3	.	.	2.5	0.016
17	1	1	0.41	6.2	0.06	1.9	.	
18	1	2	0.40	6.2	0.07	2.0	.	
19	1	3	0.40	6.3	0.06	1.9	.	
20	1	4	0.40	6.4	0.06	1.9	.	
21	2	1	0.57	3.6	0.27	1.7	.	
22	2	2	0.56	3.2	0.25	1.8	.	
23	2	3	0.56	3.0	0.42	1.8	.	
24	2	4	0.56	3.3	0.39	1.9	.	

Table A-4. Continued.

Obser-vation	Treat-ment[a]	Repli-cation	Specific gravity	Standing height(cm)	Firmness (kg)	Springi-ness (cm)	Extensi-bility(cm)	Breaking strength(kg)
25	3	1	0.52	4.1	0.16	2.1	.	
26	3	2	0.54	3.5	0.18	2.0	.	
27	3	3	0.55	3.2	0.33	1.9	.	
28	3	4	0.54	3.6	0.30	2.1	.	
29	4	1	0.34	5.4	0.09	1.9	.	
30	4	2	0.32	5.5	0.06	1.7	.	
31	4	3	0.32	5.1	0.06	1.8	.	
32	4	4	0.32	5.3	0.08	1.9	.	

[a]The treatments referred to are as follows: 1, whole egg; 2, low yolk; 3, low yolk with SSL; 4, low yolk with SSL, SLS, and XG.

SENSORY CHARACTERISTICS OF LOW YOLK SPONGE CAKES WITH STABILIZERS

by

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AN ABSTRACT OF A MASTER'S THESIS

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ABSTRACT

Dried egg has been used in food products for a long time, although drying will change the flavor and texture. In this study, sensory characteristics of sponge cakes containing dried whole egg and dried egg with lowered yolk levels, with and without stabilizers, were evaluated by difference and descriptive tests. Cakes made with whole egg (WE), low yolk without additives (LY1), low yolk with one additive (LY2), and low yolk with three additives (LY3) were evaluated.

WE, LY1, LY2-0.5% SSL, LY2-1% SSL, LY2-1% LEC, and LY2-1% CMC cakes were evaluated by the triangle test method to determine if differences existed. WE cakes were found to be different from all LY cakes in both texture and flavor.

WE and LY3 sponge cakes were evaluated by flavor profile methods. Browning-sweet and eggy notes were the major aroma and flavor components of sponge cake. The intensity and kind of eggy note depended on cake formula differences and the resulting top crusts and crumbs. Usually the crumb had a less intense brown aroma than the top crust; LY3 cakes had a lower intensity of eggy note than WE cakes. The flavor of LY3 cakes was thought to be flat.

Texture profile findings on WE, LY1, LY2-SSL and LY3 sponge cakes indicated WE cakes were similar in texture to LY3 cakes; LY1 and LY2-SSL cakes also were similar to each other. Springiness, and firmness were important mechanical properties, and

after the sample broke down, geometrical graininess of the mass and moisture adsorbing properties became evident. The top crust of all low yolk cakes was stickier than the WE cakes; LY3 cakes were springier than LY1 and LY2 cakes. LY1 and LY2 cakes were denser and firmer than the others. LY1 and LY2 cakes had a coarser texture, more adhesive crumb, were gummier, and took longer to chew and to swallow. All cakes were rated similarly for extensibility.

In the physical measurements of sponge cakes, the standing height was related somewhat to specific gravity of foam; LY1 and LY2 cakes had higher specific gravities and lower standing heights than the others. Instron Universal Testing Machine findings were similar to the sensory texture profile findings for compressibility and springiness, but not for extensibility.