CHAPTER I

INTRODUCTION

The population of elderly adults, 60 years of age and older, in the United States is growing. This growth will impact the food and foodservice industries because it creates a need for food products designed for elderly consumers (Dicther, 1992). Nutrition and diet affect the progress of age-related degenerative diseases, such as osteoporosis, which is characterized by reduced bone mass and fractures to the vertebrae, hip, forearm, and other bones. Insufficient dietary intakes of calcium, phosphorus, and vitamin D throughout the life cycle contribute to development of that disease (Wardlaw, 1993).

The Food and Nutrition Board (1989) states that elderly adults can obtain the Recommended Dietary Allowance (RDA) of 800 mg of calcium per day if dairy foods are a regular part of their diet. However, reports indicate that elderly adults have suboptimal intakes of calcium and consume less than the recommended two servings of dairy foods per day (Fischer et al., 1995). Two factors that can adversely affect their consumption of dairy foods include chemosensory losses and lactose intolerance. Chemosensory losses refer to reductions in taste and smell acuity. These losses can be functions of the normal aging process or the consequence of disease, drug therapy, surgical intervention, and environmental insult (Tepper and Genillard-Stoerr, 1991). Chemosensory losses can diminish enjoyment of food because food tastes bland and unappealing.

Lactose maldigestion is the inability to digest all or part of lactose, the principal sugar in milk, because of absence or deficiency of the intestinal enzyme, β-galactosidase (Houts, 1988). Lactose intolerance often accompanies lactose maldigestion and occurs when an individual experiences abdominal distention, cramping, gas, and/or diarrhea after consuming foods containing lactose. Scrimshaw and Murray (1988) reported that in North American adults lactose maldigestion is found in approximately 75% of African-Americans, 71% of Native Americans, 51% of Hispanics, and 21% of Caucasians. Lactose maldigestion also is associated with environmental factors, such as antibiotic therapy, surgery, and ionizing radiation.

Although a lactose-restricted diet might be recommended for lactose-intolerant individuals, it is difficult to maintain because lactose is a common food ingredient. Lactose is used as a bulking agent, browning agent, and as a flavor carrier in food products. Whole, skim, low-fat milks and buttermilk contain 4-5% lactose. Custards, puddings, cream pies and cream soups are prepared with milk products containing lactose (Houts, 1988; Scrimshaw and Murray, 1988). Lactose-reduced dairy foods are alternatives for lactose intolerant individuals; however, the supply of these foods is limited. Lactose-reduced milk, yogurt, cottage cheese, American-style cheese, and ice cream are available, but in limited markets and usually at higher retail prices than traditional dairy foods (Best, 1993).

Baked custard, a nutrient dense dairy dessert, is frequently served to elderly adults in foodservice establishments because it is a source of calories, high-quality proteins, calcium, and other vitamins and minerals (Kalpalathika et al., 1993). Baked custard, traditionally, is prepared with whole milk, egg, sugar, salt and vanilla. It is characterized by bland flavor and soft texture (Penfield and Campbell, 1990). Modifications, such as reduction in the amounts of lactose, fat and cholesterol, might increase the appeal of baked custard to elderly adults who have dietary restrictions and experience lactose intolerance. These modifications also might increase its appeal to young adults who typically are not consumers of baked custard.

Wu et al. (1996) examined elderly and young adults' acceptance of lactose-reduced baked custard and their interest in modifications of the custard. The researchers found that elderly adults (59+ years of age) liked the custard more than young adults (18-35 years of age), but both groups of adults were interested in a low-fat, low-cholesterol version of the product. Availability of low-fat, low-cholesterol products has increased dramatically within the past decade; this increase can be attributed, in part, to availability of suitable fat substitutes.

Recently, The NutraSweet Company developed a dried egg yolk product (Eggcellent™) that is low in fat and cholesterol (Bringe and Cheng, 1995). A supercritical carbon dioxide extraction process is used to remove fat and cholesterol. The company reports that the product contains 74% less fat and 90% less cholesterol than commercial egg yolk products when reconstituted with water on an equal protein basis (Bringe and Cheng, 1995). Although the company recommends that it can be used to replace egg yolk in egg-based products, few studies have been reported in which its effects on product quality have been examined.

A study was conducted to examine the effects of type of milk (whole; nonfat; nonfat, 70% lactose-reduced) and type of egg (fresh, whole egg; egg substitute) on the quality of baked custards. The egg substitute was a combination of dried egg white solids; dried low-fat, low-cholesterol egg yolk solids; and xanthan gum. The custard formulations served as prototypes for use in studies conducted in the Department of Food Science and Technology, Virginia Tech. In those studies, the effects of processing parameters on the quality of lactose-reduced baked custards were examined. The goal of all the studies was to develop shelf-stable lactose-reduced custard mixes that have potential for use in the foodservice industry.

Two experiments were conducted in the study. In Experiment I, the quality of a dessert type baked custard was examined. This was a vanilla flavored baked custard made with sucrose. In Experiment II, the quality of an entree type baked custard was examined. This was a cheddar cheese flavored baked custard made without sucrose. Two different custard formulations were used in the study because the formulations have different foodservice applications. Also, the researchers suspected that the different types of milk and egg would affect the quality of the custards differently. The following were the objectives of each experiment:

1. To examine the effects of replacing whole milk with nonfat milk or nonfat, 70% lactose-reduced milk on lactose, galactose, protein, total fat and cholesterol contents of the custard mix.
2. To examine the effects of replacing whole milk with nonfat milk and nonfat, 70% lactose-reduced milk on gel strength and Hunter "L", "a" and "b" values of baked custards.

3. To examine the effects of replacing whole milk with nonfat milk and nonfat, 70% lactose-reduced milk on appearance, flavor and texture of baked custards.

4. To examine the effects of replacing fresh, whole eggs with an egg substitute on lactose, galactose, protein, total fat and cholesterol contents of the custard mix.

5. To examine the effects of replacing fresh, whole eggs with an egg substitute on gel strength and Hunter "L", "a" and "b" values of baked custards.

6. To examine the effects of replacing fresh, whole eggs with an egg substitute on appearance, flavor and texture of baked custards.

The following were the null hypotheses tested in each experiment:

Ho: There is no difference in the lactose, galactose, protein, total fat and cholesterol contents of custard mix prepared with the different types of milks.

Ho: There is no difference in gel strength and Hunter "L", "a" and "b" values of baked custard prepared with the different types of milks.

Ho: There is no difference in appearance, flavor and texture of baked custards prepared with the different types of milks.

Ho: There is no difference in the lactose, galactose, protein, total fat and cholesterol contents of custard mix prepared with fresh, whole egg and egg substitute.

Ho: There is no difference in gel strength and Hunter "L", "a" and "b" values of baked custard prepared with fresh, whole egg and egg substitute.

Ho: There is no difference in appearance, flavor and texture of baked custards prepared with whole egg and egg substitute.

CHAPTER II

REVIEW OF THE LITERATURE

1. LACTOSE INTOLERANCE

Classification

Lactose maldigestion refers to incomplete digestion and absorption of lactose, the principal sugar in milk, as a result of absence or deficiency of the intestinal lactase enzyme,β-galactosidase (Shah, 1993). Lactose intolerance (LI) is the symptomatic response to lactose maldigestion. Some people, but not all, who are diagnosed with lactose maldigestion develop uncomfortable symptoms associated with lactose intolerance. Some of the possible symptoms are abdominal distention, cramping, gas, and diarrhea (Anonymous, 1979; Newcomer and McGill, 1984). Symptoms vary with a number of factors including the amount of loss of lactase activity and the manner in which lactose is consumed, e.g., as milk alone or with other foods, all at once or in smaller quantities over a longer time period (Scrimshaw and Murray, 1988).

Lactose intolerance can be classified into three groups: genetic, acquired and transitory. Genetic LI manifests in newborns congenitally (Kocian, 1988). During aging, lactase activity declines 80-90% before adulthood. Acquired LI can be secondary after inflammation of the intestinal mucosa (enteritis) or mucosal damage from chemical, viral, bacterial and parasitic causes; sprue; and action of some medications (especially those which interfere with protein synthesis) and radiation. It also can occur after partial gastrectomy, pyloroplasty or disorders of milk clotting in the stomach (Kocian, 1988). Transitory LI originates in acute diseases of the intestinal mucosa where the lactase containing layer is damaged (Kocian, 1988). Lactose is not hydrolyzed to glucose and galactose in LI patients and is not absorbed. Thus, the intestinal osmotic load is enhanced and a considerable amount of water is secreted into the intestinal lumen. The unabsorbed lactose is then fermented by the intestinal microflora producing CO_2 and H_2O. Lactose also can be split by bacteria to short-chain organic acids. The unabsorbed gas causes distention; the acids irritate the intestinal wall and cause enhanced motility and water content in the lumen (Kocian, 1988).

Diagnosis

Several diagnostic methods for lactose intolerance exist and a few will be defined. These methods include the lactose tolerance test (LTT), radiographic assessment, histochemistry and breath analysis.

The lactose tolerance test (LTT) is the traditional method of diagnosis (Alliet et al., 1989). A rise of less than 20-26% in blood glucose in response to an oral load of lactose of a 1-2g/Kg body weight is considered abnormal (Bayless et al., 1975; Gudmand-Hoyer and Folke, 1970). Radiographic assessment also can be done. After a barium meal with lactose the gastric emptying is slowed down; the intestinal motility is enhanced; the small intestine appears empty

(Pirk and Skala, 1972); and there is increased pneumatosis of the large bowel (Gudmand-Hoyer and Folke, 1970).

The intestinal mucosal can be studied histologically with special staining of lactase in the brush-border of the small intestine and by biochemical analysis. Lactase activity usually is expressed as units representing micromoles of substrate hydrolyzed per gram of protein in the tissue homogenate per minute (Dahlquist, 1964). The normal range for lactase varies between 38+4u/g protein in newborns and 18+4u/g protein after the age of 5 years (Alliet et al., 1989).

In breath analysis, excreted $^{14}CO_2$ can be measured in the breath 2 h after administration of lactose with labeled ^{14}C. The lactose is hydrolyzed, absorbed, and oxidized to $^{14}CO_2$ (Arvanitakis et al., 1977).

The hydrogen (H_2) breath test is the diagnostic method of choice for lactose intolerance. After overnight fasting (4-8 hours for infants and toddlers), 2g/Kg of lactose (up to 50g) is administered in a 20% aqueous solution. Gas-liquid chromatography then is used for hydrogen analysis (Ostrander et al., 1983).

Prevalence of Lactose Maldigestion

Populations originating from Northwest European countries, some pockets of the Mediterranean, Near East, Africa, and the India Subcontinent, who share the longest known tradition of dairying, have a low incidence of lactose maldigestion (0-30%) (Simoons, 1978). Population groups displaying high proportions of lactose maldigestion (60-100%) generally are found in geographic areas in which dairying or adult milk usage has never been a part of the culture (Simoons, 1978). Approximately 30-60% of African-Americans, African-Arab mixes, Eskimo-Finnish people, and Mexican-Americans tend to have lactose maldigestion (Simoons, 1978).

Studies specific to U.S. population groups have found American whites (assumed to be predominantly of Northwest European ancestry) to have lactose maldigestion incidence rates of 6-25%, while African-Americans show rates of 45-81% (Simoons, 1978). Mexican-Americans have been found to have rates of 47-74% (Simoons, 1978), and the few studies on American Indians, Aleuts, and Eskimos have rates of 75% among the genetically purest and 50% among those of mixed Indian-Eskimo-European ancestry (Johnson et al., 1978; Simoons, 1978). Among American Orientals, McElroy and Townsend (1985) reported rates of 95%, and Simoons (1978) reported rates of 65-100%. On the basis of these data, more than a third of the total world population is possibly unable to properly digest and utilize fresh milk products (Houts, 1988).

Treatment

Primary treatment of lactose intolerance is omission of milk and dairy products from the diet. However, this deprives the individual of protein, fat, calcium and other vitamins and minerals. Protein and fat can be replaced by meat, eggs and other sources, but some of the rich non-milk sources of calcium (poppy seed, nuts, sardines, etc.) cannot be given to patients with certain gastrointestinal diseases (Kocian, 1988). An alternative is lactose-reduced dairy products. Lactose can be hydrolyzed into glucose and galactose by adding commercially available lactase to milk. A ready to drink pretreated milk also is available (Kocian, 1988).

2. LACTOSE-REDUCED MILK

Production

Lactose hydrolysis can be carried out by treatment of milk with acid at elevated temperatures, but this procedure is viable only for the processing of protein-free streams such as permeate. Adjustment of pH can be made either by direct addition of acid to the system or by treatment of the permeate with an ion exchange resin. Conditions employed are pH 1.2 and a hydrolysis temperature of up to 150˚ C for a brief period. Because this procedure is limited to hydrolysis of protein-free streams, it has not been commercially adopted to any significant extent (Zadow, 1986).

The enzymes used for hydrolysis may be extracted from a number of sources; those from *Kluyveromyces* and *Aspergillus* species of mold are most commonly employed. In general, the enzymes are effective only over a limited pH range. Three techniques may be employed for enzymatic hydrolysis. These are the soluble or 'single-use' system (beta-galactosidase is used only once); lactase re-use system (generally based on membrane recovery of beta-galactosidase to allow its re-use); and immobilized enzymes (Zadow, 1986). In the lactase re-use system process, hydrolysis is carried out on a protein-free stream such as the permeate from ultrafiltration (UF) of milk or whey. The enzyme is recovered from the UF retentate of the reaction mixture and the permeate containing the hydrolyzed lactose is remixed with the milk or whey retentate. However, the complexity of the process has not made it commercially attractive (Zadow, 1986).

Immobilized systems utilize an enzyme from *Aspergillus oryzae* immobilized on an ion exchange support as its base. Optimum pH of this enzyme is about 5; but it retains about 50% of its activity at pH 6.8, and thus may be economically used for the hydrolysis of lactose. The activity of the immobilized enzyme per liter appears to be significantly higher than other immobilized enzyme systems when compared at optimum pH. However, the operating temperature of the system (35-40 ^{0}C) can result in rapid growth of microorganisms in dairy products (Zadow, 1986).

In the U.S. the current process for hydrolysis of lactose in milk is 'single-use' enzyme system. The commercial lactose-reduced milk (Lactaid Inc., Pleasantville, NJ) is made by simply adding lactase to milk before packaging (Anonymous, 1989).

Characteristics

Lactose hydrolysis converts lactose, with a low sweetening power relative to sucrose, into glucose and galactose. At 80% hydrolysis the sweetness is equal to 75-80% of sucrose. This permits sugar and caloric savings in sweetened milk products (Repelius, 1983).

The hydrolysis of lactose increases its solubility. The upper limit of lactose solubility is 18%; the hydrolytic products will not crystallize even at 50% total solids. Therefore, it is possible to increase the solids content of the final product, which will yield important economic savings for products that are transported over long distances (Repelius, 1983).

The hydrolytic products tend to be more active in the Maillard reaction. Careful control of the temperature during condensation and spray-drying of these products as well as the temperature during transportation is necessary to avoid loss of nutritional value (Repelius, 1983).

3. BAKED CUSTARD

Baked custard is a nutritious food. A cup of homemade baked custard (100 g) contains 105 Kcal, 5.0 g of protein, 10.7 g of carbohydrate, 4.7 g of fat and 87.2 g of cholesterol (Pennington, 1994). Coagulation of the protein of egg is responsible for the gel structure of a baked custard. Avoiding the application of excessive heat is the key in custard making. Excessive heat results in overcoagulation of egg protein and syneresis of the custard (Penfield and Campbell, 1990). Scalding the milk used in custards shortens cooking time and also may improve the flavor and texture of the product (Jordan et al., 1954). Sucrose influences baking time or end-point temperature and quality of baked custard. The addition of 10% sucrose increases heat stability of proteins (Woodward and Cotterill, 1983). Salt is necessary for gelation of an egg custard mixture (Penfield and Campbell, 1990).

Sutton et al. (1995) examined the effects of lactose hydrolysis on the quality of a vanilla flavored baked custard. Milk (1% milkfat) and two types of lactose-reduced milks (1% milkfat, 70% lactose-reduced and 1% milkfat, 87.2% lactose-reduced) were used in the study. The researchers found that lactose hydrolysis had no significant effect on the sweetness, firmness, syneresis, water activity, and Hunter "L", "a", and "b" values of the custards.

Wu et al. (1996) examined possibilities for development of a lactose-reduced baked custard that would appeal to elderly and young adults. The researchers found that elderly adults (59-90+ years of age) liked a vanilla flavored baked custard made with nonfat, 70% lactose-reduced milk more than young adults (18-35 years of age). Both elderly and young adults were interested in a low-fat, low-cholesterol version of the custard and in the addition of flavors, such as banana, lemon, chocolate, and amaretto.

4. LOW FAT, LOW CHOLESTEROL EGG YOLK AS AN EGG SUBSTITUTE

Production

Recently, there has been a trend of removing triacylglycerols and cholesterol from egg yolk and using the remaining highly functional components (e.g., lipoprotein) as ingredients in foods (Carrell et al., 1992; Cully and Vollbrecht, 1994). The value of egg yolk phospholipids in the human diet also draws growing attention. Egg yolk phosphatidylcholine and sphingomyelin provide sources of choline which are important to brain development, liver function, and cancer prevention (Zeisel, 1992).

A low fat, low cholesterol dried egg yolk ingredient (LFLC Yolk) (Eggcellent™, The NutraSweet Company, Mt. Prospect, IL) is now being marketed as a replacement for fresh or dried egg yolk. On an equal protein basis, it contains 74% less fat and 90% less cholesterol than commercial egg yolk. It still has proteins, phospholipids, pigments, minerals, and other minor components of egg yolk, which may enable it to function like full-fat yolk in many traditional egg-based products (Bringe and Cheng, 1995).

Supercritical CO_2 is used to extract fat and cholesterol from the product. At conditions above the critical point (31˚C, 73 atm pressure), CO_2 becomes a supercritical fluid with a density approaching that of a liquid and a low viscosity similar to that of a gas. When supercritical CO_2 is passed through dried egg yolk it dissolves neutral lipids and cholesterol. Fat and cholesterol are no longer soluble and drop out of the CO_2 when the pressure is reduced within the extraction vessel (Bringe and Cheng, 1995).

Supercritical CO_2 extraction is a process that is nonflammable, nontoxic, and leaves no solvent residues. Applied to egg yolk, it can selectively extract neutral fats and cholesterol, but leaves functional phospholipids and proteins intact (Froning et al., 1990).

The LFLC yolk is a free flowing, dry ingredient that is primarily protein (58%) and phospholipid (23%). It has higher protein content (58%) than native (33%) egg yolk. The viscosity of the LFLC yolk is greater than that of native egg yolk, compared on an equal solids basis (Bringe and Cheng, 1995).

The LFLC yolk is made from USDA-certified pathogen-free ingredients and meets all USDA guidelines for pathogen testing (Bringe and Cheng, 1995). It is free of cholesterol oxidation products (<1 ng/g) as confirmed by tests of four lots of commercial products using the methods of Park and Addis (1985).

Impact on Food Quality

In egg yolk containing foods, flavor compounds, such as aldehydes, are formed in unique concentrations and variety when egg yolk is heated (Umano et al., 1990). In addition, antioxidant properties attributed to phosvitin and yolk granules (Lu and Baker, 1986) are especially important to fat foods to limit the development of off flavors (Roozen et al., 1994).

In a consumer acceptance test, the taste of scrambled eggs made with the LFLC yolk was liked as well as that of scrambled fresh eggs and better than that of a leading egg substitute (Bringe and Cheng, 1995). The LFLC yolk also significantly improved the flavor of other egg-containing products such as cakes, ice cream, and mayonnaise products (Bringe and Cheng, 1995).

Comparing low fat cakes made with the LFLC yolk and egg white, the cake made with LFLC yolk had larger volume and was more tender than the cake made with egg white, according to rapeseed displacement tests and penetration force measurements (Bringe and Cheng, 1995). The tenderizing effects of the LFLC yolk might be caused by disruption of the gluten-gluten and gluten-starch interactions (Martin and Hoseney, 1991).

The flavor quality of the LFLC yolk can be maintained for at least 1.5 years in unopened containers under -20° F. The recommended shelf life is 6 mo. when stored under refrigeration (Bringe and Cheng, 1995). It performs similar to whole egg yolk in emulsions formed under a variety of conditions of pH and salt concentrations (Bringe et al., 1996). The heat stability of an emulsion with the LFLC yolk can also compete with that of native yolk (Bringe et al., 1995).

The LFLC yolk retains some of the natural pigments of native egg as judged by the color of cooked eggs. It is reported that its color imparts a rich appearance to low-fat foods, such as ice cream, pound cake, and mayonnaise (Bringe and Cheng, 1995).

Cholesterol reduction of 80-100% can be achieved in food products where the LFLC yolk is substituted on an equal protein basis for egg yolk, leading to no cholesterol (<2 mg/serving) or low cholesterol (<20 mg/serving) claims if the saturated fat contents are less than 2 g/serving (Bringe and Cheng, 1995).

5. NUTRITION AND THE ELDERLY

Nutrient Requirements and Malnutrition

During the 20th century, the U.S. elderly population has increased in size much more rapidly than the younger population. Statistics show that by the year 2030, 21.1% of the U.S. population will be over 65 (Morley, 1986). Not only has the population over 65 increased but the population of those over 80 also has expanded. By the year 2050, this group will increase to 26 million (Pitts, 1986). Population demographics indicate that a large proportion of the elderly is White (13%) while African-Americans and Hispanics constitute 8% and other minority groups constitute 79% (US Senate Special Committee on Aging, 1990). The ratio of elderly women to elderly men varies with increasing age. A census conducted in 1989 indicated that for adults between the ages of 65 and 69 years, there are 83 men for every 100 women. However, as this population approaches 85 years of age, the ratio of men to women decreases drastically from 83 to 39 (US Bureau of the Census, 1989).

Aging produces important physiologic changes that may affect the need for certain nutrients. The Food and Nutrition Board of the National Academy of Sciences has established RDAs for nutrients (1989). The RDAs for selected nutrients are listed in Table 1. However, the RDAs have many limitations. They do not consider the heterogeneity among the elderly, the disease states or other problems prevalent in the elderly that will affect their nutritional needs (Schneider et al., 1986).

Elderly people are especially prone to developing protein calorie malnutrition (PCM). Poor dietary intake due to low socioeconomic status, loss of dentition, gastrointestinal maldigestion, and other functional impairments are some of the causes of PCM (Dworkin, 1980). Some of the usual manifestations of PCM include weight loss; pallor; flaky, dry skin; and loss of muscle mass (Gupta et al., 1988). In order to maintain an appropriate nitrogen balance, approximately 0.8g/Kg body weight of protein should be ingested, representing 12 to 14% of the total calorie intake (Gupta et al., 1988).

Lactose intolerance, common in elderly African-Americans and Orientals, is a specific example of carbohydrate maldigestion. This may lead to the avoidance of milk and other dairy products, resulting in lower intakes of protein, calcium, and vitamin D (Gupta et al., 1988). The cause of lactose intolerance in the elderly is thought to be a decrease in lactase activity that occurs during the aging process (Kocian, 1988).

Table 1-Recommended Dietary Allowances for persons ages 51 and older for protein, calcium, phosphorus and vitamin D[a]

	Gender	
Nutrient	Males	Females
Protein (g)	63	50
Vitamin D (ug)[b]	5	5
Calcium (mg)	800	800
Phosphorus (mg)	800	800

[a] Recommended Dietary Allowance, 10th ed., 1989.
[b] As cholecalciferol: 10 ug cholecalciferol = 400 IU of vitamin D.

Calcium and Vitamin D Deficiencies

Decreased intake of calcium has been widely recognized in the elderly and contributes to the high prevalence of osteoporosis (Morley, 1986). To avoid skeletal depletion, elderly adults need to maintain a state of calcium balance by ingesting an adequate amount of calcium to offset calcium losses. Elderly women not taking estrogen are recommended to consume 1,500 mg of calcium per day (Office of Medical Application of Research, 1984). This amount of dietary calcium is thought to decrease bone remodeling and slow age-related bone loss (Wardlaw, 1993).

Morris and Peacock (1976) found vitamin D deficiency in elderly adults who were living in institutions and in those still in communities. Even though dietary intake of vitamin D has been found to be lower in the elderly, diminished sunlight exposure and declining ability to metabolize vitamin D at both hepatic and renal levels are also important reasons for marginal vitamin D status in many older people (Murno, 1984). Vitamin D deficiency causes bone pain, fractures, loss of height and eventually osteoporosis (Gupta et al., 1988).

Consumption of Dairy Products

Determinants of food choices in the elderly are complex. Income, household composition, food preferences, time, technology, education, good health, attitude, physiological changes in vision, hearing, taste and smell, and psychological and sociological factors all affect food choices of the elderly (Briley, 1989). The majority of the elderly population do not meet the current recommendations of 2 servings of dairy products per day. About 30% consume less than one serving of milk per week. Only 20% of those in their 60s and 30% of those in their 80s and 100s consume the recommended two servings of dairy products per day (USDA, 1990). Mean calcium intake is 759 mg/day for both men and women, but intake ranges from 122 to 2,339 mg/day (Fischer et al., 1995). African-Americans consume more whole milk and less low fat milk than whites (Fischer et al., 1995). However, no racial difference in frequency of milk consumption exists between these groups (Marrs, 1978).

Women consume a wider variety of dairy products than men (Fischer et al., 1995). Elderly living alone usually consume dairy products more frequently than those living with others, maybe because dairy products are easy to prepare and consume (Fischer et al., 1995).

Dietary attitudes have a strong influence on dairy products selection. The health-seeking behavior “avoid too many high cholesterol foods” is associated with lower ice cream consumption, but not with low total milk or dairy products intake. Consumption of a low cholesterol diet is associated with less frequent consumption of whole milk and ice cream and more frequent consumption of skim milk (Fischer et al., 1995).

Chemosensory Changes and Aging

Loss of chemosensory function can be a consequence of the normal aging process, disease, drug therapy and environmental insults. Social, psychological and nutritional variables also play important roles (Tepper and Genillard-Stoerr, 1991). Medical conditions or medications can disrupt taste and odor perception (Schiffman, 1983). A variety of medical conditions, including cancer, viral infections, diseases of the liver and kidneys and endocrine and nervous system disorders alter chemosensory function. In addition, many drugs, including antihistamines, oral hypoglycemics, antihypertensive agents and diuretics, disrupt taste and odor perception (Tepper and Genillard-Stoerr, 1991). Since many elderly people have multiple disabilities and may be taking several medications simultaneously, chemosensory losses due to aging may be compounded by similar changes associated with disease and drug treatment (Tepper and Genillard-Stoerr, 1991).

The slow process of renewal of taste buds and decrease of the number of those buds can diminish sensitivity to taste (Shiffman, 1993). Functional changes in the taste cells in aging are also related to taste loss (Miller, 1989). Another cause of loss of taste perception is disease or damage to the relevant nerves (Shiffman, 1993).

Threshold detection or suprathreshold identification intensity perception has been used for measurement of taste acuity. The detection threshold measures the absolute sensitivity to a taste stimulus and is the point at which a taste can be distinguished from water (Tepper and Genillard-Stoerr, 1991). Schiffman (1986) reported that the average detection threshold for elderly people is 2.72 times higher for sweetness, 11.58 times higher for bitter compounds, 2.48 times higher for amino acids, and 5.04 times higher for glutamate salts than in younger adults.

Olfactory changes with aging are more pervasive and severe than those for taste (Murphy, 1986; Shiffman, 1986). Detection thresholds for a wide variety of odors may increase between 5 and 11 fold (Stevens, 1989). The changes are generally uniform across most odor types (Stevens and Cain, 1985). The ability to identify and discriminate between various food aromas and pureed foods is also diminished (Shiffman and Warwick, 1988), declining gradually in the sixth decade of life and markedly by the seventh decade (Doty, 1989).

The addition of flavor enhancers to foods, such as simulated pea odor to peas or beef odor to cooked beef, has been shown to increase both the recognition and hedonic appeal of both pureed samples and normal foods in healthy elderly subjects (Schiffman and Warwick, 1988). Flavor enhancement also might be useful for overcoming anorexia and general malnutrition in hospitalized elderly patients (Shiffman and Warwick, 1988).

A variety of pharmacological agents are known to modify taste function. Such agents include caffeine (and other methyl-xanthines), 5'-ribonucleotides, inosine, and bretylium tosylate (Shiffman, 1993). These agents potentate the tastes of a broad range of compounds, including salts, amino acids, and carbohydrate and non-nutritive sweeteners (Tepper and Genillard-Stoerr, 1991).

CHAPTER III

EXPERIMENT 1: QUALITY OF A DESSERT TYPE LACTOSE-REDUCED BAKED CUSTARD

1. INTRODUCTION

In Experiment I, the quality of a dessert type baked custard was evaluated. This was a vanilla flavored baked custard prepared with sucrose. A commercially available nonfat, 70% lactose-reduced milk was used to reduce the amounts of lactose and total fat, and an egg substitute was used to reduce the amounts of total fat and cholesterol. The substitute was a combination of dried egg white solids, dried low-fat, low-cholesterol (LFLC) egg yolk solids (Eggcellent™), and xanthan gum. The effects of the different types of milk and egg on the chemical, physical, and sensory characteristics of the custard were examined. Consumer testing also was conducted to evaluate the degree to which young and elderly adults liked custards made with lactose-reduced milk.

2. MATERIALS AND METHODS

Baked Custard Formulations and Preparation

Formulations

Six baked custard formulations (Table 2) were evaluated in the study. A standard formula described by Penfield and Campbell (1990) was modified and used to develop the formulations. Variations included 100% replacement (wt/wt) of whole milk (Kroger Co., Cincinnati, OH) with either nonfat milk (Kroger Co., Cincinnati, OH) or nonfat , 70% lactose-reduced milk (Lactaid™, H.P. Hood, Inc., Boston, MA). Variations also included 100% replacement (wt/wt) of fresh whole egg with an egg substitute. The egg substitute was a combination of dried egg white solids (Henningsen P-39, Henningsen Foods, Inc., White Plain, NY); dried LFLC egg yolk solids (Eggcellent™, The NutraSweet Co., Deerfield, IL) and xanthan gum (Germantown USA Co., PA). See Appendix A for specifications for the dried egg white solids. The xanthan gum was added to stabilize the custard mix. The amount of xanthan gum was determined in preliminary testing. See Appendix B for information on prelimary testing.

Preparation

Procedures described by Penfield and Campbell (1990) for preparation of baked custard were modified and used. For preparation of custards containing fresh, whole eggs, milk was heated to 60 ^{o}C in a double boiler. Speed 2 of a KitchenAid mixer (Model 45, Troy, OH) was used to beat the whole egg for 2 min. Sugar and salt then were added to the beaten egg and mixed for 5 min. Vanilla (McCormick & Co., Inc., Hunt Valley, MD) and the heated milk were added gradually to the beaten egg mixture and mixed for 2 min. Approximately 100 g of the custard mix were then poured into 3 (50 g) glass custard cups. The cups were placed

Table 2-Formulations for dessert type baked custard

Ingredient (g)	Formulation					
	WM[a]-WE[b]	NFM[c]-WE	LRM[d]-WE	WM-ES[e]	NFM-ES	LRM-ES
WM	250.0	____	____	286.5	____	____
NFM	____	250.0	____	____	286.5	____
LRM	____	____	250.0	____	____	286.5
WE	50.0	50.0	50.0	____	____	____
LFLC-EYS[f]	____	____	____	4.6	4.6	4.6
EWS[g]	____	____	____	8.9	8.9	8.9
Xanthan gum[h]	____	____	____	0.2	0.2	0.2
Vanilla[i]	1.2	1.2	1.2	1.2	1.2	1.2
Sugar	25.0	25.0	25.0	25.0	25.0	25.0
Salt	0.3	0.3	0.3	0.3	0.3	0.3

[a] WM = whole milk (Kroger Co., Cincinnati, OH)
[b] WE = whole egg (Kroger Co., Cincinnati, OH)
[c] NFM = nonfat (skim) milk (Kroger Co., Cincinnati, OH)
[d] LRM = lactose-reduced (70%), nonfat milk (Lactaid Inc., Pleasantville, NJ)
[e] ES = egg substitutes
[f] LFLC-EYS = Low fat, low cholesterol egg yolk solids (NutraSweet Co., Deerfield, IL)
[g] EWS = Egg white solids (Henningsen Foods Inc., White Plain, NY)
[h] Xanthan gum (Germentown U.S.A. Co., PA)
[i] Vanilla (McCormick & Co., Inc., Hunt Valley, MD)

in a water bath, and the mix was baked in an oven for 40 min at 177°C. Baked custards were cooled at ambient (18-20 °C) temperature for 1 h, covered with film and refrigerated at 4-7 °C.

Similar procedures were followed for preparation of custards containing the egg substitute. The substitute was prepared by mixing the dried egg white solids, dried LFLC egg yolk solids and xanthan gum in 36.5 g of cold (4-7 °C) milk. Speed 4 of the KitchenAid mixer was used to beat the mix for 10 min. The substitute then was incorporated into the custard mix in the same manner as previously described for the fresh, whole egg.

Chemical Analyses

Lactose and Galactose Concentrations

Lactose and galactose concentrations were measured spectrophotometrically with samples of custard mix that had been stored for approximately 18 h at 4-7 °C. For analysis, 2 ml of liquid custard mix were added to 18 ml of 12% (w/v) trichloroacetic acid, mixed, and centrifuged at 6000 rpm for 20 min. The pH of the clear supernatant (10 ml) was adjusted to 7.0 with 1N NaOH and 0.1 N NaOH. The sample was brought to a 25-ml volume with distilled H_2O. Lactose and galactose concentration were assayed with the Boehringer-Mannheim Test Kit (Gene-trak, Framingham, MA). A spectrophotometer (Model 1001, Fisher Scientific, Inc., Pittsburg, PA) was used in analysis. Wavelength was set to 340 nm.

Protein Concentration

Approximately 400 mg sample of custard mix for each formulation was used in analysis of protein. Samples were stored at 4-7 °C for approximately 18 h prior to analysis. For analysis, the Association of Analytical Chemists (AOAC) method 24.024 was used to determine nitrogen content, and the 6.25 conversion factor for protein was used (AOAC, 1984). A Buchii B-343 apparatus (Brinkmann Instruments, Inc., Westbury, NY) was used in the analysis.

Total Fat Concentration

One-gram samples of custard mix containing whole egg and 6-g samples of mix containing the egg substitute were used for analysis of total fat. All samples were stored at 4-7 °C for approximately 42 h prior to analysis. The chloroform and methanol extraction method described by Bligh and Dyer (1959) was used to determine total fat concentration.

Cholesterol Concentration

One milliliter of fat solution (in chloroform) obtained from the procedure for total fat determination was used to determine cholesterol concentration. Cholesterol concentration was measured spectrophotometrically with the procedure described by Kates (1986). Samples of custard mix that had been stored for approximately 48 h at 4-7 °C were evaluated. The SIGMA serum cholesterol (99%) (ST. Louis, MO) was used to make standard solutions with concentrations of 50 mg/g, 100 mg/g, 200 mg/g, 250 mg/g, 300 mg/g and 500 mg/g. A Perkin-Elmer uv/vis spectrophotometer (Model lambda 3B, Norwalk, CT) was used in analysis. Wavelength was set to 550 nm.

Physical Analyses

Color

A Minolta Chromameter (Model CR-200, Minolta Camera Co., Ltd., Osaka, Japan) was used to measure Hunter "L", "a" and "b" values of the baked custards. Measurements were obtained at the center of both the top and bottom surfaces of the custards. The Minolta Calibration Plate was used as described by the manufacturer to calibrate the instrument prior to analysis. Measures were obtained on baked custards that had been stored for approximately 18 h at 4-7 ^{o}C.

Gel Strength

A Steven L.F.R.A. Texture Analyzer (Model TA-1000, Texture Technologies Corp., Scarsdale, NY) was used to evaluate gel strength (g force) of the baked custards. The TA-2 cone attachment, operated at a speed of 2 mm/sec and at a distance of 5 mm, was used in the analysis. Measurements were obtained at the center of the top surface of custards that had been stored for approximately 18 h at 4-7 ^{o}C.

Sensory Evaluation: Descriptive Analysis

Panel Recruitment

Nine subjects (6 females; 3 males) were recruited to serve as panelists for descriptive analysis of baked custards. Panelists were students in the Department of Human Nutrition, Foods and Exercise, and the Department of Food Science and Technology at Virginia Tech. Availability and interest in serving as panelists were the criteria used for recruitment. Sensory evaluation was approved by the Institutional Review Board for Research Involving Human Subjects at Virginia Tech. See Appendix C for the informed consent forms.

Methodology

Procedures of The Spectrum Method™ of analysis were modified and used to train a panel for descriptive analysis of baked custards (Meilgaard et al., 1991). Training included development of sensory terms, scaling techniques, and general evaluation procedures.

Panel Training

Panelists participated in five training sessions prior to sensory evaluation of the baked custards. Each session was approximately 45 min. In session 1, panelists first received basic information pertaining to the sensory characteristics of foods. They then evaluated two different samples of baked custards to identify the appearance, flavor and texture characteristics important to baked custard. Samples that were evaluated were formulations used in the study. One was the formulation for custard containing whole milk and whole egg, and the other was the one for custard containing whole milk and the egg substitute (Table 2). The panelists also defined the characteristics they identified and discussed the importance of each one. The panel agreed on 6 characteristics that were most important, and these characteristics along with definitions are shown in Table 3.

In session 2, panelists began the development of scales for the six characteristics. Reference standards were evaluated for each characteristics. At least two reference standards were used for each characteristic; one to represent each extreme of a characteristic. Panelists also

Table 3-Sensory terminology and reference standards for dessert type baked custard

Term	Definition	Reference Standard	Serving Size
Appearance			
Brightness	Purity of yellow color	Cheese cake (Jell-O^{TM} Cheese cake mix, Kraft General Foods, White Plains, NY)	20 g
		Vanilla pudding (Jell-O^{TM} Vanilla pudding mix, Kraft General Foods, White Plains, NY)	20 g
Evenness	Distribution of yellow color	Scrambled eggs (Kroger Co., Cincinnati, OH)	20 g
		Vanilla pudding (Jell-O^{TM} Vanilla pudding mix, Kraft General Foods, White Plains, NY)	20 g
Flavor			
Egg flavor	Intensity of flavor from egg perceived while the sample is in the mouth	Non dairy whipped topping (Cool Whip^{TM}, Kraft General Foods, White Plains, NY)	20 g
		Scrambled eggs (Kroger Co., Cincinnati, OH)	20 g
Aftertaste	Intensity of any flavor perceived after the sample is swallowed (it maybe egg flavor, sweetness or a combination of the two)	Whole milk (Kroger Co., Cincinnati, OH)	20 g
		Cheese cake (Jell-O^{TM} Cheese cake mix, Kraft General Foods, White Plains, NY)	20 g
Texture			
Firmness	Force required to break down the custard between the tongue and palate	Vanilla pudding (Jell-O^{TM} Vanilla pudding mix, Kraft General Foods, White Plains, NY)	20 g
		Scrambled eggs (Kroger Co., Cincinnati, OH)	20 g
Graininess	Amount of particles perceived on the surface of the tongue	Vanilla pudding (Jell-O^{TM} Vanilla pudding mix, Kraft General Foods, White Plains, NY)	20 g
		Cream of wheat (Nabisco Inc., East Hanover, NJ)	20 g

developed terms for these extremes, and these terms then were used as word anchors for the sensory scales. Reference standards are shown in Table 3, and word anchors are shown in Appendix D on an Instruction Sheet used in sensory testing.

The objective of session 3 was to reinforce definitions of the sensory characteristics and the use of reference standards and word anchors. Panelists also received instructions in the use of 15-cm line scales which were used in sensory evaluation of the baked custards. A scorecard (Appendix D) was developed based on the characteristics, definitions, scales and word anchors. Procedures for evaluating custard samples were developed. These procedures are indicated on the Instruction Sheet (Appendix D) which was used in sensory evaluation.

In sessions 4 and 5, panelists gained experience in using the scales to evaluate the sensory characteristics of baked custard samples. Panelists evaluated two different samples in the sessions. The samples were modifications of the formulation for the control containing whole milk and whole egg (Table 2). The formulation was modified to alter the appearance, flavor and texture of baked custard. One modification included increasing the level of whole milk, and the other included increasing the level of whole egg. These formulations are shown in Table 4. Panelists used the 15-cm scales to evaluate the characteristics of the samples. Scores for the characteristics were obtained, and consistency of the scores for the two sessions for each panelist and appropriate use of the scales were evaluated. Results then were discussed with the panelists to reinforce their understandings of the characteristics, definitions and scales.

Sensory Testing

Sensory evaluation of the custard formulations was conducted in five sessions. Each session was approximately 10-15 min., and all sessions were completed in 2 weeks. Panelists were seated in individual booths and testing was done under white lighting.

Baked custards were prepared according to procedures described previously. Custards were held at 4-7 ^{o}C for 18-24 h prior to evaluation. For evaluation, 20-g samples of the custards were prepared for each panelist. Sample were served to panelists in opaque plastic soufle cups at 4-7 ^{o}C. Panelists evaluated six samples (one for each formulation) at each session. Samples were presented to the panelists one-at-a-time, and a random order of presentation was used. Panelists drank room temperature water to rinse the palate between samples. The scorecard and evaluation procedures (Instruction Sheet) used in testing are included in Appendix D.

Experimental Design and Statistical Analyses

Chemical and Physical Analyses

A completely randomized design with a 2 x 3 factorial was used for collection and analysis of the data from the chemical and physical tests. This design included type of egg as one factor and type of milk as the second factor. There were two levels for type of egg, including fresh, whole egg and egg substitute. There were three levels for type of milk, including whole milk, nonfat milk, and nonfat, 70% lactose-reduced milk. There were three replications (i.e. chemical and physical characteristics were evaluated for each type of custard three times).

Table 4-Formulations for dessert type baked custard used in training of sensory panelists

Ingredient (g)	Formulation 1	Formulation 2
Whole milk[a]	250.0	300.0
Whole egg[b]	100.0	50.0
Vanilla extract[c]	1.2	1.2
Sugar	25.0	25.0
Salt	0.3	0.3

[a] Kroger Co., Cincinnati, OH
[b] Kroger Co., Cincinnati, OH
[c] McCormick & Co., Inc., Hunt Valley, MD

The Statistical Analysis System (SAS Institute Inc., 1988) was used in data analysis. The PROC ANOVA procedure was used for two-way analysis of variance (ANOVA) of the data. Dependent variables were measures for the chemical and physical characteristics, and independent variables (main effects) were type of egg and type of milk. Main effects and two-way interactions were tested. Tukey studentized range test (HSD) was the multiple comparison test used to determine significance ($p<0.05$) when appropriate.

Sensory Evaluation

A split plot design was used for collection and analysis of the data from sensory evaluation of baked custards. This design included judges as the split plot factor and a 2 x 3 factorial as the whole plot factor. The 2 x 3 factorial included type of egg as one factor and type of milk as the second factor. There were two levels for type of egg, including fresh, whole egg and egg substitute. There were three levels for type of milk, including whole milk, nonfat milk, and nonfat, 70% lactose-reduced milk. There were five replications (i.e. each judge evaluated each type of custard 5 times) for sensory evaluation of the custards.

The Statistical Analysis System (SAS Institute Inc., 1988) was used in data analysis. General linear models (PROC GLM) were used for two-way analysis of variance (ANOVA) of the data. Dependent variables were ratings for the sensory characteristics, and independent variables (main effects) were type of egg and type of milk. Main effects and two-way interactions were tested. Because of the split plot design, replication x type of egg x type of milk was the error term used in performing F tests to determine significance ($p<0.05$) of the main effects in the models. Tukey studentized range test (HSD) was the multiple comparison test used to determine significance ($p<0.05$) when appropriate.

Sensory Evaluation: Consumer Testing

Custard Formulations

Two baked custard formulations were used in consumer testing. One was the custard prepared with fresh, whole egg and nonfat, 70% lactose-reduced milk, and the other was the custard prepared with the egg substitute and nonfat, 70% lactose-reduced milk (Table 2). All custards were prepared with the same procedures described previously in the subsection on baked custard preparation. Custards were stored at 4-7 ^{o}C for approximately 18 h prior to testing.

Subjects

Forty-eight young (18-44 years of age) and twenty-five elderly (55+ years of age) adults served as subjects. Young adults were students, faculty, and staff at Virginia Polytechnic Institute and State University, Blacksburg. Young adults were recruited with the intercept method from a central location on campus where testing was conducted during the afternoon hours. Elderly adults were recruited with the intercept method from a central location at New River Valley Mall, Christiansburg, VA, where testing was conducted from 10:30 a.m. to 1:00 p.m.

Sensory Evaluation

For sensory evaluation, adults received a 20-g sample of each type of baked custard. Samples were served at approximately 4-7 ^oC in opaque plastic souffle cups. A balanced presentation order was used. Adults used 9-point hedonic scales (1 = dislike extremely; 9 = like extremely) to indicate how much they liked the samples (Meilgaard et al., 1991). Adults also were asked to provide the following information: 1) demographics; 2) frequency of consumption of baked custard (several times a week, several times a month, several times a year, never); and 3) experience with symptoms of lactose intolerance (frequently, sometimes, never) (Appendix E).

Experimental Design and Statistical Analysis

The Statistical Analysis System (SAS Institute, Inc., 1988) was used for data analysis. General Linear Models (PROC GLM) were used for two-way analysis of variance of the data. Dependent variables were hedonic ratings of the custards, and independent variables were type of custard and age group. Main effects and two-way interactions were tested (O'Mahony, 1986). Least-square means were computed, and Tukey's studentized range test (HSD) was used to determine significant ($p<0.05$) main effects. Descriptive statistics also were computed.

3. RESULTS AND DISCUSSION

Composition

Lactose and Galactose Concentrations

There were differences in the lactose and galactose concentrations of the dessert type baked custard mixes. Results of the ANOVA indicate that the two-way interactions (type of milk x type of egg) were not significant ($p>0.05$). Interaction means are shown in Appendix F and represent means for the six custard formulations. Type of milk, however, affected the concentrations (Table 5). Mixes made with the nonfat, 70% lactose-reduced milk had significantly ($p<0.05$) less lactose and more galactose than mixes made with either the whole milk or nonfat milk. There were no differences in lactose and galactose concentrations between custard mixes made with whole milk and mixes made with nonfat milk. These results can be attributed to the process used in the production of the lactose-reduced milk. In the production of this type of milk, the enzyme, β-galactosidase, is used to hydrolyze lactose, a disaccharide, to the monosaccharides, glucose and galactose. As expected, type of egg did not affect lactose and galactose concentrations of the custard mixes (Table 5) because lactose is a disaccharide found in milk.

Protein Concentration

Results of the ANOVA indicated that the two-way interaction (type of milk x type of egg) was not significant ($p<0.05$) for protein concentration. See Appendix F for the interaction means. Type of milk also did not significantly affect protein concentration of the custard mixes, indicating that neither reduction of milk fat nor reduction of lactose affected protein concentration (Table 5).

Table 5-Means ± standard deviations for nutrient composition of dessert type baked custard mixes

	Type of Milk [a]			Type of Egg [b]	
Nutrient	WM	NFM	LRM	WE	ES
Lactose (g/l)	32.84 ± 3. 91[c]	33.11 ± 4. 87 [c]	9.77 ± 1.75 [d]	24.55 ± 10.97[c]	25.93 ± 13.20 [c]
Galactose (g/l)	0.11 ± 0.14 [c]	0.17 ± 0.13 [c]	13.14 ± 1.74 [d]	4.31 ± 6.30 [c]	4.63 ± 6.83 [c]
Protein (g/100 g)	5.30 ± 0.82 [c]	5.52 ± 0.75 [c]	5.43 ± 0.83 [c]	4.70 ± 0.15 [c]	6.14 ± 0.19 [d]
Total fat (g/100 g)	3.19 ± 1.09 [c]	1.27 ± 0.95 [d]	1.08 ± 0.76 [d]	2.69 ± 1.12 [c]	1.01 ± 0.94 [d]
Cholesterol (mg/100 g)	75.97 ± 45.05 [c]	45.37 ± 44.62 [d]	38.38 ± 36.33 [d]	88.15 ± 30.09 [c]	18.33 ± 17.02 [d]

[a] WM = whole milk; NFM = nonfat milk; LRM = nonfat 70% lactose-reduced milk

[b] WE = whole egg; ES = egg substitute

[c, d] N = 6 for type of milk; n = 9 for type of egg; means in a row within a subgroup followed by different letters differ significantly at $p<0.05$

Type of egg had a significant effect ($p<0.05$) on protein concentration of the mixes (Table 5). Mixes made with the egg substitute contained significantly ($p<0.05$) more protein than mixes made with fresh, whole egg. The increase in protein might be attributed to several factors. First, the amount of dried egg white solids and dried LFLC egg yolk solids used in the substitute was not based on the amount of protein in native egg white and egg yolk. Also, there was 36.5 g more milk (about 5% protein) in the formula containing the egg substitute. This milk was use to hydrate the ingredients used in the egg substitute.

Total Fat Concentration

The two-way interaction (type of milk x type of egg) was not significant ($p>0.05$) for total fat concentration (Appendix F); however, type of milk and type of egg significantly ($p<0.05$) affected fat concentration (Table 5). Results indicate that reduction of milk fat affected total fat in the custard mixes. Mixes made with whole milk had significantly more fat than mixes made with either nonfat milk or nonfat, 70% lactose-reduced milk. There was no significant difference in total fat for the latter two types of mixes. Mixes made with the egg substitute had significantly less total fat than mixes made with fresh, whole egg. There was a 62.5% reduction in total fat due to replacement of whole egg with the egg substitute. This reduction is due to the reduced fat content of the LFLC egg yolk powder, which contains 74% less fat than whole egg yolk (Bringe and Cheng, 1995).

Cholesterol Concentration

The two-way interaction (type of milk x type of egg) was not significant ($p>0.05$) for cholesterol concentration of the custard mixes (Appendix F); however, type of milk and type of egg significantly ($p<0.05$) affected the cholesterol concentration (Table 5). Results indicate that reduction of milk fat affects the cholesterol concentration. Mixes made with whole milk had more cholesterol than mixes made with nonfat milk and nonfat, 70% lactose-reduced milk. These results were expected because nonfat milk does not contain cholesterol.

Type of egg had a significant effect on cholesterol concentration of the mixes (Table 5). Mixes made with the egg substitute had significantly less cholesterol than mixes made with fresh, whole egg. The decrease in cholesterol concentration was 79.2%. This reduction is due to the reduced cholesterol content of the LFLC egg yolk powder, which contains 90% less cholesterol than fresh egg yolk (Bringe and Cheng, 1995).

In general, results of the analyses of total fat and cholesterol indicate that either nonfat milk or the egg substitute can be used to reduce the amount of total fat and cholesterol in the custards. However, the egg substitute would be more effective than nonfat milk. This can be seen by examining the means for the six formulations in the experiment (Appendix F).

Physical Properties

Color

Hunter "L", "a", and "b" values were evaluated for the top and bottom surfaces of the baked custards. In the Hunter color system, L represents dark to light (0-100), a represents red (+) to green (-), and b represents yellow (+) to blue (-). Values were obtained for the top and bottom surfaces because the researchers suspected that there might be an increased amount of browning in custards made with lactose-reduced milk. Those custards would have higher concentrations of reducing sugars than custards made with either whole or nonfat milks. These sugars could potentially participate in the Maillard browning reaction. Higher concentration of reducing sugars would be present in custards made with lactose-reduced milk becuase lactose, a disaccharide, had been hydrolyzed to the monosaccharides, glucose and galactose.

For the top surface of the custards, the two-way interaction was significant ($p<0.05$) for Hunter "L" values (Figure 1 and Appendix F). In general, the top surface of custards made with the egg substitue was darker than the top surface of custards made with fresh, whole egg. However, for custards containing the egg substitute, the top surface surface of custards made with whole milk tended to be lighter than those of custards made with either nonfat milk or nonfat, 70% lactose-reduced milk.

Hunter "a" values were negative for top surfaces of all types of custards, and Hunter "b" values were positive, indicating that the custards were yellow in color (Table 6). Top surfaces of custards made with nonfat milk had significantly ($p<0.05$) larger negative "a" values than those of custards made with either whole or nonfat, lactose-reduced milks. Also, the top surface of custards made with the egg substitute had significantly lower "b" values than those made with fresh, whole egg. These results indicate that the egg substitute affected the yellow color of the baked custards. Custards made with the egg substitute had less intense yellow color than custards made with the fresh, whole egg.

Similar results were obtained for bottom surfaces of the custards (Table 6 and Figure 2). Hunter "b" values, however, were different. There was a significant ($p<0.05$) two-way interaction for "b" values (Figure 3). Type of milk had a greater effect on "b" values for custards made with the egg substitute than on custards made with fresh, whole egg. For custards made with the egg substitute, "b" values were higher for custards made with whole milk than for custards made with either nonfat or nonfat, lactose-reduced milk.

Although differences were noted in Hunter "L", "a", and "b" values for the top and bottom surfaces of the custards, these difference might not be due to an increased amount of Maillard browning in custards made with the lactose-reduced milk. Increased browning in those custards would have been noted by lower "L" values, lower negative "a" values, and higher positive "b" values, but this was not the case. Differences in Hunter values might be attributed to effects of the egg substitute on color of the custards. Top and bottom surfaces of custards made with the egg substitute were darker than those of custards made with fresh, whole egg. Also, top and bottom surfaces of custards made with the egg substitute had a less intense yellow color than those of custards made with fresh, whole egg. Effects of the egg subtitute might be attributed to differences in the type and/or amount of carotenoid pigments present in the dried LFLC egg yolk solids and the yolks of the fresh, whole eggs. Egg yolk contains xanthrophylls (lutein and zeaxanthin) which are fat-soluble pigments (Penfield and Campbell, 1990). The supercritical CO_2

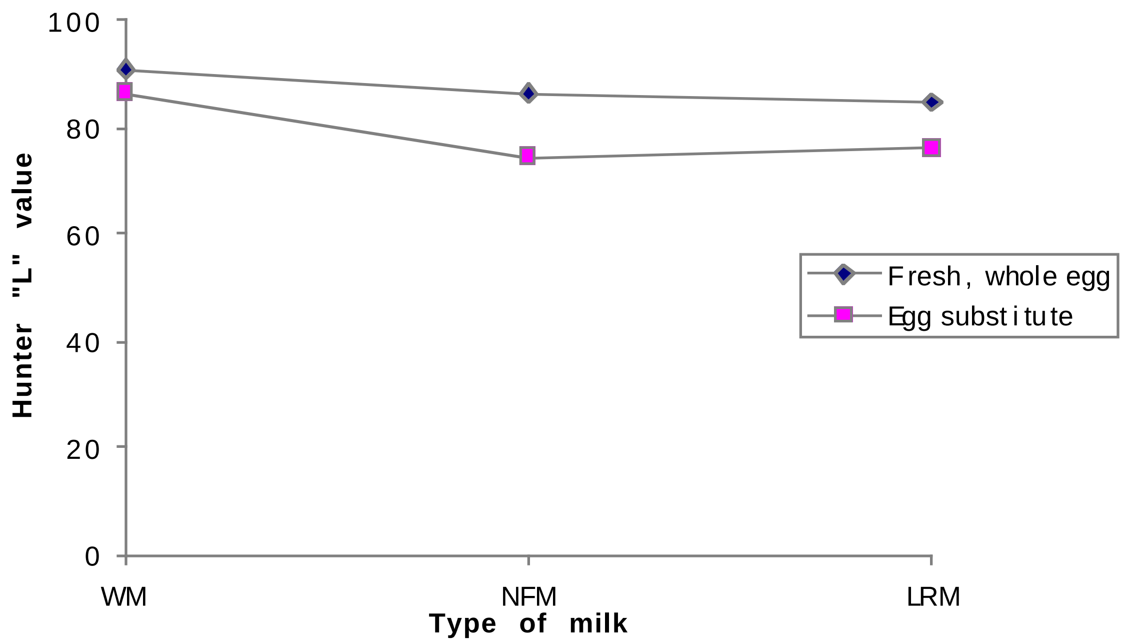

Fig. 1-Interaction between type of milk and type of egg for Hunter "L" values for top surface of dessert type baked custards (n = 3) (WM = whole milk; NFM = nonfat milk; LRM = nonfat, 70% lactose-reduced milk)

Table 6-Means ± standard deviations for physical properties of dessert type baked custards

	Type of Milk [a]			Type of Egg [b]	
Property	WM	NFM	LRM	WE	ES
Top surface					
Hunter "L"	88.53 ± 2.41	80.26 ± 6.62	80.16 ± 4.97	87.19 ± 2.88	78.78 ± 5.75
Hunter "a"	-7.35 ± 1.00 [c]	-9.47 ± 0.86 [d]	-8.33 ± 0.51 [c]	-8.35 ± 0.61 [c]	-8.41 ± 1.60 [c]
Hunter "b"	31.36 ± 4.35 [c]	24.45 ± 8.87 [c]	27.07 ± 8.35 [c]	32.85 ± 1.88 [c]	22.41 ± 7.63 [d]
Bottom surface					
Hunter "L"	90.08 ± 1.94	82.35 ± 5.56	83.33 ± 4.59	88.89 ± 2.26	81.61 ± 5.14
Hunter "a"	-6.57 ± 0.43 [c]	-8.15 ± 0.57 [d]	-7.32 ± 0.51 [e]	-7.10 ± 0.57 [c]	-7.59 ± 0.98 [d]
Hunter "b"	19.60 ± 3.79	15.65 ± 8.95	17.23 ± 6.95	23.26 ± 1.86	11.74 ± 4.13
Gel strength (g force)	27.50 ± 12.47 [c]	23.00 ± 10.28 [c]	23.67 ± 9.31 [c]	15.56 ± 2.13 [c]	33.89 ± 5.71 [d]

[a] WM = whole milk; NFM = nonfat milk; LRM = nonfat 70% lactose-reduced milk

[b] WE = whole fresh egg; ES = egg substitute

[c, d] N= 6 for type of milk; n = 9 for type of egg; means in a row within a subgroup followed by different letters differ significantly at $p<0.05$

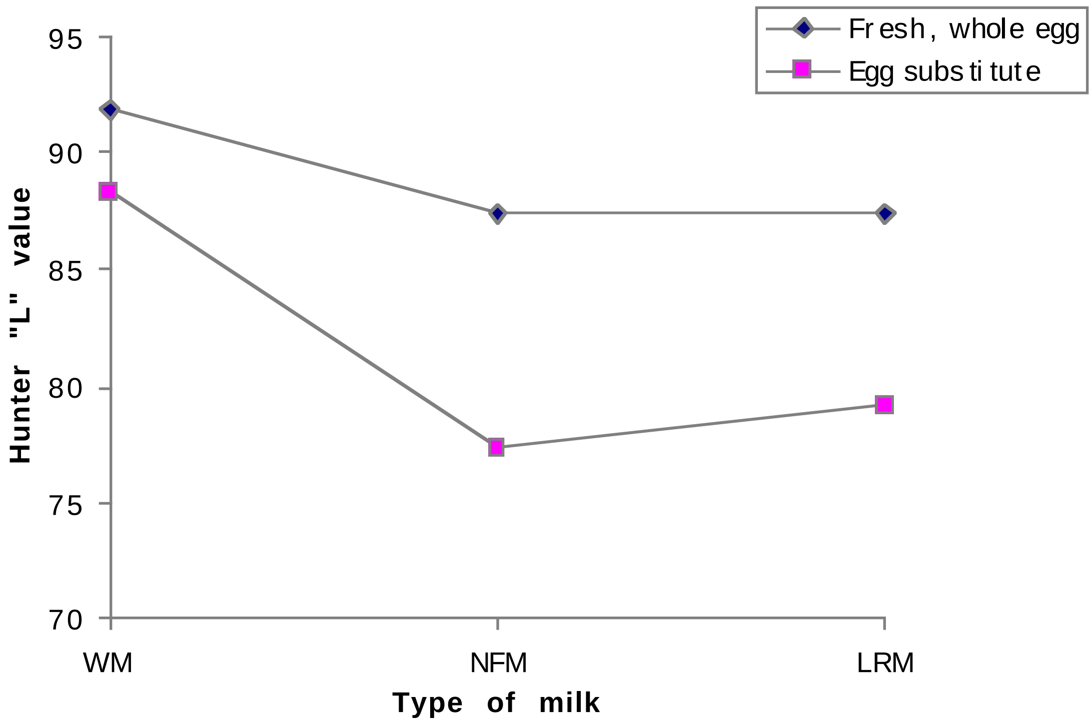

Fig. 2-Interaction between type of milk and type of egg for Hunter "L" values for bottom surface of dessert type baked custards (n = 3) (WM = whole milk; NFM = nonfat milk; LRM = nonfat, 70% lactose-reduced milk)

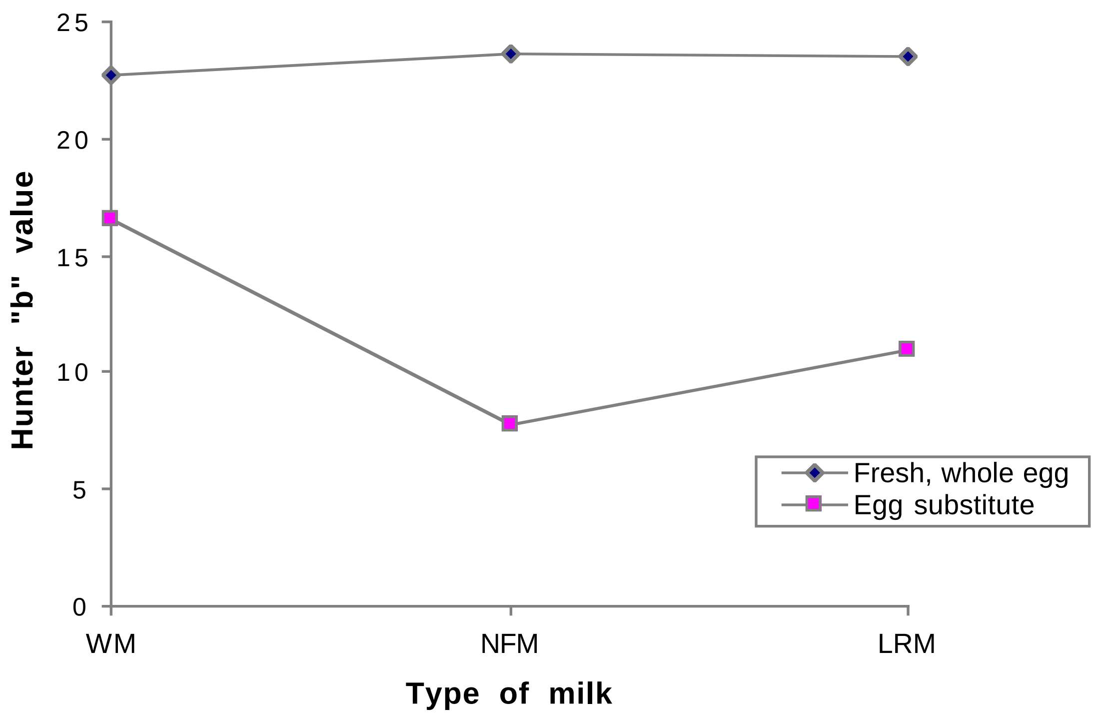

Fig. 3-Interaction between type of milk and type of egg for Hunter "b" values for bottom surface of dessert type baked custards (n = 3) (WM = whole milk; NFM = nonfat milk; LRM = nonfat, 70% lactose-reduced milk)

extraction process used to reduce the amount of fat and cholesterol in the egg yolk solids might have extracted or degraded the pigments in the yolk.

Gel Strength

Results of the ANOVA indicate that the two-way interaction (type of milk x type of egg) was not significant ($p>0.05$) for gel strength of the custards (Appendix F). Type of milk also did not significantly affect gel strength of the custard, indicating that neither reduction of milk fat nor reduction of lactose affected gel strength (Table 6). Type of egg had a significant effect ($p<0.05$) on gel strength of the custards (Table 6). Custards made with the egg substitute had greater gel strength than custards made with fresh, whole egg. The stronger gel strength might be due to the use of xanthan gum, a thickening agent, in the egg substitute. It also might be due to the higher protein content of custards made with the egg substitute.

Greater gel strength might be a desirable attribute if the custard mix is to have foodservice applications. In foodservice establishments, greater gel strength would help prevent syneresis, an undesirable characteristic of baked custard caused by extensive handling or mishandling.

Sensory Characteristics

Appearance

Sensory panelists perceived differences in the appearance of baked custards. Results of the ANOVA indicate that two-way interactions (type of milk x type of egg) were not significant ($p>0.05$) for appearance characteristics (Appendix F); however, type of milk and type of egg significantly ($p<0.05$) affected the characteristics (Table 7). Results indicate that reduction in lactose of the milk affected the appearance of baked custard, but reduction of milk fat did not. Custards made with the nonfat, 70% lactose- reduced milk were significantly brighter in color than custards made with either whole milk or nonfat milk. Brightness of color of custards made with whole milk was similar to that of custards made with nonfat milk. In comparison, type of milk did not affect evenness of color of the custards.

Type of egg had a significant effect on brightness and evenness of color of the custards (Table 7). Custard made with fresh, whole egg were brighter than custards made with the egg substitute. Custards made with the fresh, whole egg also were more even in color. These results might be attributed to difficulty in incorporating the dried egg white and the dried LFLC egg powders into the custard mix. The powders enhanced the foaming properties of the custard mix. To decrease foam formation, a long time and low speed mixing technique was used to incorporate the powders into the custard mix. However, the powders might not have been thoroughly incorporated into the mix, thereby producing an uneven color in the baked custards.

Flavor

Sensory panelists perceived differences in the flavor of the baked custards. Results of the ANOVA indicated that two-way interactions (type of milk x type of egg) were not significant ($p>0.05$) for flavor characteristics (Appendix F). Type of milk also did not significantly affect flavor of the custards, indicating that neither reduction of lactose nor reduction of milk fat affected the flavor of the custards (Table 7). Results might be attributed to the specific flavor

Table 7-Means ± standard deviations for sensory characteristics of dessert type baked custard[a]

	Type of Milk[b]			Type of Egg[c]	
Characteristics	WM	NFM	LRM	WE	ES
Appearance					
Brightness of color	9.6±4.6[d]	9.3±4.4[d]	10.1±4.1[e]	11.7±2.9[d]	7.6±2.6[e]
Evenness of color	10.7±4.3[d]	10.8±4.1[d]	11.4±3.8[d]	12.8±2.5[d]	9.2±4.5[e]
Flavor					
Egg flavor	6.3±3.3[d]	6.3±3.6[d]	5.6±3.6[d]	6.5±3.6[d]	5.6±3.3[e]
Aftertaste	6.1±3.7[d]	5.7±3.7[d]	6.0±3.9[d]	6.8±4.0[d]	5.0±3.3[e]
Texture					
Firmness	7.8±4.7[d]	7.1±4.4[d]	7.1±4.9[d]	3.9±3.0[d]	10.8±3.2[e]
Graininess	4.8±4.9	4.8±4.9	4.0±4.4	1.0±1.3	8.0±4.3

[a] n = 45; means based on 15-cm line scale (1 = least intense; 15 = most intense)
[b] WM = whole milk; NFM = nonfat milk; LRM = nonfat, 70% lactose-reduced milk
[c] WE = whole fresh egg; ES = egg substitute
[d,e] Means in a row for a subgroup followed by different letters differ significantly ($p<0.05$)

characteristics that were evaluated. Characteristics included egg flavor and aftertaste, which was defined as "the intensity of egg flavor, milk flavor, and/or sweetness after the custard sample is swallowed." These characteristics were evaluated because sensory panelists identified them during the training sessions as the most important flavor characteristics of baked custard.

Type of egg had a significant effect ($p<0.05$) on the flavor of the custards (Table 7). Egg flavor and aftertaste of custards made with the egg substitute were less intense than those of custards made with fresh, whole egg. These results might be due to fat and cholesterol reduction of the LFLC egg yolk powder used in the egg substitute. One of the functions of fat in food is to act as a flavor carrier (Umano et al., 1990); therefore, a reduced level of fat in the custard might decrease the intensity of egg flavor and aftertaste.

Texture

Sensory panelists perceived differences in the texture of the baked custards. Results of the ANOVA indicate that the two-way interaction (type of milk x type of egg) was not significant ($p>0.05$) for firmness of the custards (Appendix F). Type of milk also did not significantly affect firmness, indicating that neither reduction of lactose nor reduction of milk fat affected custard firmness (Table 7). Type of egg had a significant ($p>0.05$) effect on firmness of the custards. Custards made with the egg substitute were firmer than those made with fresh, whole egg. These results support those obtained for gel strength of the custards (Table 6). Custards made with the egg substitute had greater gel strength than those made with whole egg. There might be several explanations for these results. First, xanthan gum, a thickening agent, was used in the egg substitute. Also, baked custard is a protein gel. Custards made with the egg substitute may have formed a stronger gel because of its higher protein content.

There was a significant ($p<0.05$) two-way interaction for graininess of the baked custards, indicating that the effect of type of milk on graininess depended upon the type of egg in the custard (Figure 4). In general, custards made with the egg substitute had a more grainy texture than those made with fresh, whole egg. However, type of milk had a greater effect on graininess of custards containing the egg substitute than on graininess of custards containing the fresh, whole egg. Custards containing the egg substitute and nonfat, 70% lactose-reduced milk were less grainy than those containing the egg substitute and whole milk or nonfat milk. Little difference was noted in graininess of custards containing the fresh, whole egg.

Acceptability

Characteristics of Young and Elderly Adults

Results shown in Table 8 indicate that the majority of elderly adults (83.3%) who participated in consumer testing of acceptability of baked custards were female. The number of young female adults (53.5%) was similar to the number of young male adults (46.5%). Most young adults were 18-29 years (89.6%) of age, and most elderly adults were 60-79 years (87.5%) of age. Young adults were 64.6% White, not of Hispanic origin; 22.9% African-American; 2.1% Hispanic/Latino/Spanish; and 8.3% Asian or Pacific Islander. All elderly adults were White, not of Hispanic origin.

Adults were asked how often they experienced symptoms (i.e. abdominal cramps, gas,

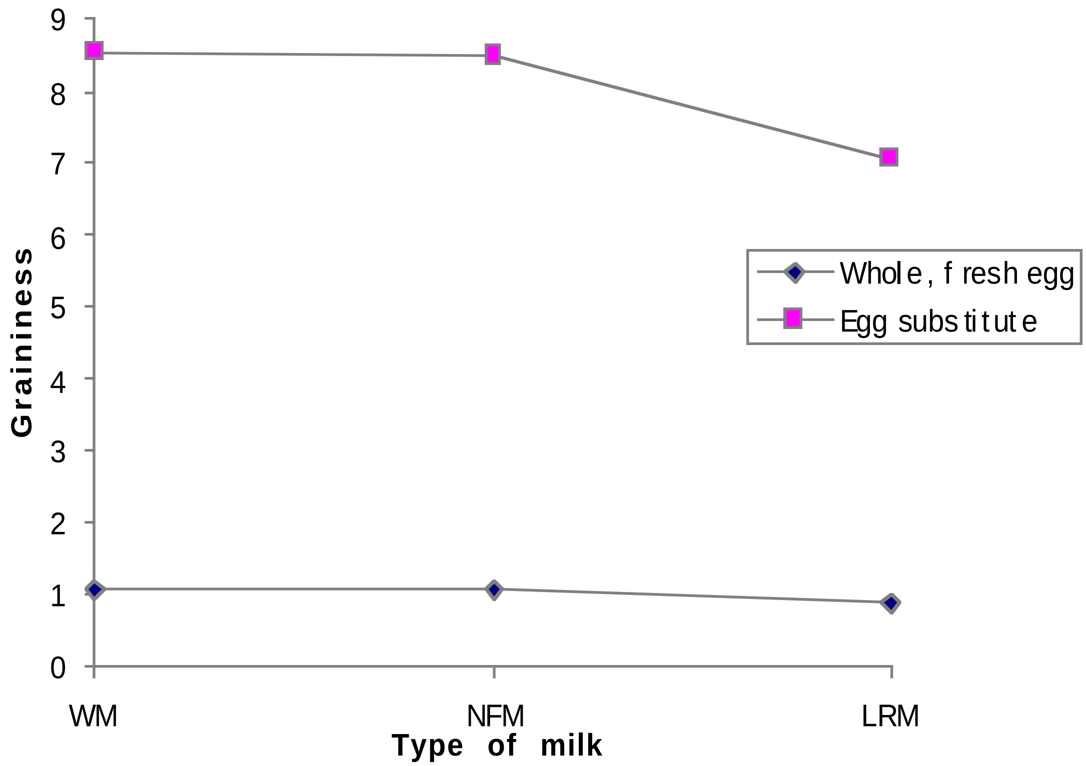

Fig. 4-Interaction between type of milk and type of egg for graininess of dessert type baked custard (n = 45) (WM = whole milk; NFM = nonfat milk; LRM = nonfat, 70% lactose-reduced milk).

Table 8-Characteristics of young and elderly adults participating in consumer testing

Characteristic	Age Group Young (n=48)	 Elderly (n=24)
Gender		
Female	53.5%	83.3%
Male	46.5%	16.7%
Age (years)		
18-19	39.6%	--------
20-29	50.0%	--------
30-39	6.2%	--------
40-49	4.2%	--------
50-59	0%	--------
60-69	--------	66.7%
70-79	--------	25.0%
80-89	--------	8.3%
Ethnicity		
White, not of Hispanic origin	64.6%	100%
African-American	22.9%	0
Hispanic/Latino/Spanish	2.1%	0
American Indian/Alaskan native	0	0
Asian or Pacific Islander	8.3%	0
Don't know/Not sure	0	0
Don't care to answer	2.1%	0
Symptoms of lactose intolerance		
Don't care to answer	0	0
Never	77.1%	54.2%
Sometimes	22.9%	37.5%
Frequently	0	8.3%
Consumption of custard		
Never	60.9%	12.5%
Several times a year	34.7%	83.3%
Several times a month	2.2%	0
Several times a week	2.2%	4.2%

and/or diarrhea) of lactose intolerance after drinking milk or eating dairy foods. Although the majority of elderly and young adults reported that they "never" experience symptoms, 22.9% of the young adults and 45.8% of the elderly reported they experience symptoms either "frequently" or "sometimes" (Table 8). Results support those reported by Kocian (1988) and Gupta et al. (1988) who noted that lactose intolerance is a common disorder in elderly adults.

Adults also were asked how often they consume baked custard. The majority (60.9%) of young adults never consumed custard, but only 12.5% of elderly adults never consumed custard. Most (83.3%) elderly adults consumed custard several times a year (Table 8). Results support those reported by Wu et al. (1996) who found that elderly adults consume baked custard more frequently than young adults. This results do not support those reported by Bringe and Cheng (1995). The researchers found that the LFLC egg yolk did not affect acceptance of scrambled eggs, cakes, ice cream, and mayonnaise.

Acceptability of Lactose-Reduced Baked Custard

Result of the ANOVA indicated that the two-way interaction (age group x type of custard) was not significant for ($p>0.05$) hedonic ratings of the lactose-reduced baked custards (Appendix F). Results also indicate that age and type of custard had significant ($p<0.05$) effects on ratings for the custards. The overall mean hedonic score for the custards was 5.6, indicating that the degree to which adults liked the custards was between "neither like or dislike" and "like slightly". The rating from the young adults (4.9 ± 0.2) was significantly lower than that from the elderly adults (7.0 ± 0.3), indicating that elderly adults liked the custards more than the young adults. The degree to which young adults liked custard was close to "neither like or dislike", and the degree to which elderly adults liked the custard was "like moderately". These results also support those reported by Wu et al. (1996) who found that elderly adults liked lactose-reduced baked custard more than young adults. The custard formulation used in that study was the same as the one used in this experiment.

Custard made with fresh, whole egg (6.5 ± 0.2) was rated significantly higher than custard made with the egg substitute (5.4 ± 0.2). The degree to which the adults liked custard made with fresh, whole egg was between "like slightly" and "like moderately", and the degree to which adults liked custard made with the egg substitute was between "neither like or dislike" and "like slightly".

In general results indicate that the egg substitute had an adverse effect on acceptance of the custard. Reasons for this might be obtained by examining the effects of the egg substitute on the sensory characteristics of the custard. Results shown in Table 7 indicate that the egg substitute affected appearance, flavor, and textural characteristics of the custard, but the lactose-reduced milk affected only brightness of color. The effect of the egg substitute on the flavor characteristics is interesting. Custards made with the egg substitute had less intense egg flavor and aftertaste than those made with whole egg. Although aftertaste is often considered an undesirable characteristic for foods, this might not be true for baked custard. During consumer testing, some adults noted that custard made with the egg substitute “tasted bland”. As explained previously, this “bland taste” might be due to the fat and cholesterol reduction of the LFLC egg solids. The effect of the egg substitute on firmness of the custard also is interesting. Custards made with the egg substitute were firmer than those made with the whole egg. This might have contributed to low acceptance of the product. Although, as explained previously, increased firmness might be desirable if the product is to have foodservice applications, it might be undesirable when consumer acceptance is considered.

Although the number of adults who participated in testing was small, some general suggestions can be made. First, the higher hedonic rating from elderly adults suggests that lactose-reduced custard could be provided in foodservice establishments for elderly adults. The lower hedonic rating from young adults might be due to infrequent consumption of custard. According to Wu et al. (1996), flavor enhancement could be a way of increasing the appeal of custard to young adults. The researchers reported that both young and elderly adults were interested in a low-fat, low-cholesterol version of baked custard; however, custards made with the egg substitute in this experiment received low hedonic ratings, indicating that further development is needed.

4. CONCLUSION

In general, results of this experiment indicate that type of egg had a greater effect on the quality of baked custard than the type of milk. These results were expected because baked custard is a protein gel which depends primarily on egg proteins for gel formation (Penfield and Campbell, 1990). Development of a lactose-reduced custard is feasible, however, additional studies should be done, particularly those that examine its potential for use in the foodservice industry.

Studies should focus on the appeal of the product to both young and elderly adults. Wu et al. (1996) reported that young and elderly adults are interested in flavor enhancement of lactose-reduced baked custards. The researchers reported that adults are interested in the addition of flavors, such as banana, lemon, chocolate, praline pecan, creme caramel, and amaretto. Additional insight into acceptance of the product could be obtained through studies of the quality of lactose-reduced baked custards formulated with those flavors.

The lactose-reduced baked custard mix could serve as a base for other types of products, such as custard pies and filled pastries, used in the foodservice industry. Studies that focus on development and acceptance of these products could help define the niche for the mix in the foodservice industry.

Because of the trend in today's market for reduced-fat and reduced-cholesterol foods, additional studies could be done to examine the effects of other types of egg substitutes on the acceptance of baked custard. Results of consumer testing indicate that the egg substitute adversely affected acceptance of the baked custard. A major problem with the egg substitute was the limited solubility of the dried LFLC yolk solids, which made it difficult to incorporate it into the custard mix. This problem might be overcome through the use of a liquid LFLC egg yolk preparation. One possibility is Source Eggs ™ (Source Food Technology, Inc., Burnsville, MN), which has approximately 50% less fat and 90% less cholesterol than native egg yolk.

CHAPTER IV

EXPERIMENT II: QUALITY OF AN ENTREE TYPE LACTOSE-REDUCED BAKED CUSTARD

1. INTRODUCTION

In Experiment II, the quality of an entree type baked custard was evaluated. This was a cheese flavored baked custard prepared without sucrose. A commercially available nonfat, 70% lactose-reduced milk was used to reduce the amount of lactose and an egg substitute was used to reduce the amounts of total fat and cholesterol. The substitute was a combination of dried egg white solids, dried LFLC egg yolk solids (Eggcellent™) and xanthan gum. The effects of different types of milk and egg on the chemical, physical and sensory characteristics of the custard were examined.

2. MATERIAL AND METHODS

Baked Custard Formulations and Preparation

Formulations

Six baked custard formulations (Table 9) were evaluated in the study. Formula variations were the same as those described for the dessert type baked custard in Experiment I. Vanilla extract, sugar and salt were excluded from the standard formula described by Penfield and Campbell (1990). Cheddar cheese flavor powder (Genarom International, New Brunsich, NJ) was added into the formula at the level recommended by the manufacturer. See Appendix G for specifications for the powder.

Preparation

Procedures were similar to those described in Experiment I for the dessert type baked custard. The cheese flavor powder was added to the whole egg or egg substitute, which then was incorparated into the custard mix in the same manner as previously described for the dessert type custard.

Chemical Analyses

Lactose, galactose, protein, total fat and cholesterol concentrations were measured with the same methods described in Experiment I (Chapter III).

Physical Analyses

Color (Hunter "L", "a" and "b" values) and gel strength (g force) were determined with the same methods described in Experiment I (Chapter III).

Table 9-Formulations for entree type baked custard

Ingredient (g)	Formulation					
	WM[a]-WE[b]	NFM[c]-WE[b]	LRM[d]-WE[b]	WM[a]-ES[e]	NFM[c]-ES[e]	LRM[d]-ES[e]
WM	250.0	____	____	286.5	____	____
NFM	____	250.0	____	____	286.5	____
LRM	____	____	250.0	____	____	286.5
WE	50.0	50.0	50.0	____	____	____
LFLC-EYS[f]	____	____	____	4.6	4.6	4.6
EWS[g]	____	____	____	8.9	8.9	8.9
Cheese flavor[h]	3.0	3.0	3.0	3.0	3.0	3.0
Xanthan gum[i]	____	____	____	0.2	0.2	0.2

[a] WM = whole milk (Kroger Co., Cincinnati, OH)
[b] WE = whole egg (Kroger Co., Cincinnati, OH)
[c] NFM = nonfat (skim) milk (Kroger Co., Cincinnati, OH)
[d] LRM = lactose-reduced (70%), nonfat milk (Lactaid Inc., Pleasantville, NJ)
[e] ES = egg substitutes
[f] LFLC-EYS = low fat, low cholesterol egg yolk solids (NutraSweet Co., Deerfield, IL)
[g] EWS = egg white solids (Henningsen Foods Inc., White Plain, NY)
[h] Cheddar cheese flavor (Genarom International, New Brunsich, NJ)
[i] xanthan gum (Germantown USA Co., PA)

Sensory Evaluation: Descriptive Analyses

Panel Training

Panelists were the same 9 students (6 females; 3 males) who served as panelists in Experiment I. For Experiment II, panelists participated in two additional training sessions. Each session was approximately 45 minutes.

In session 1, panelists evaluated two different samples of custards to identify the appearance, flavor and textural characteristics important to the entree-type custard. Samples that were evaluated were formulations used in the study. One was the formulation for custard containing whole milk and fresh whole egg, and the other was the one for custard containing whole milk and the egg substitute (Table 9). The panelists also defined the characteristics identified and discussed the importance of each one. The panel agreed on seven characteristics that were most important, and these characteristics along with the definitions are shown in Table 10.

In session 2, panelists developed scales for the seven characteristics. Reference standards were evaluated for each characteristic. At least two reference standards were used for each characteristic; one to represent each extreme of a characteristic. Panelists developed terms for these extremes, and these terms then were used as word anchors for the sensory scales. Reference standards are shown in Table 10, and word anchors are shown in Appendix F. Procedures for evaluating custard samples also were developed. These procedures are indicated on the Instruction Sheet (Appendix H) which was used in sensory evaluation.

Sensory Testing

Sensory evaluation was conducted in the same manner as described in Experiment I with the following exceptions. For evaluation, 20-g samples of the custards were served at approximately 50 ^{o}C to the panelists. Sample temperature was maintained by the use of a hot water bath. The scorecard and evaluation procedures (Instruction Sheet) used in testing are included in Appendix H.

Experimental Design and Statistical Analyses

Chemical, Physical, and Sensory Analyses

Experimental designs and statistical analyses were the same as those described in Chapter III for the dessert type baked custard.

3. RESULTS AND DISCUSSION

Composition

Lactose and Galactose Concentrations

Results of the ANOVA indicate significant ($p<0.05$) two-way interactions for lactose and galactose concentrations of the entree type custard mixes; therefore, the effect of type of milk on lactose and galactose concentrations depended on the type of egg in the mixes. Interaction means are shown in Appendix I and represent means for the six custard formulations. In general, mixes containing the egg substitute had more lactose than mixes containing fresh, whole egg (Figure 5).

Table 10-Sensory terminology and reference standards for entree type baked custard

Term	Definition	Reference Standard	Serving Size
Appearance (color)			
Brightness	Purity of yellow color	Cheese cake (Jell-O™ Cheese cake mix, Kraft General Foods, White Plains, NY)	20 g
		Vanilla pudding (Jell-O™ Vanilla pudding mix, Kraft General Foods, White Plains, NY)	20 g
Evenness	Distribution of yellow color	Scrambled eggs (Kroger Co., Cincinnati, OH)	20 g
		Vanilla pudding (Jell-O™ Vanilla pudding mix, Kraft General Foods, White Plains, NY)	20 g
Flavor			
Egg flavor	Intensity of flavor from egg perceived while the sample is in the mouth	Non dairy whipped topping (Cool Whip™, Kraft General Foods, White Plains, NY)	20 g
		Scrambled eggs (Kroger Co., Cincinnati, OH)	20 g
Cheese flavor	Intensity of flavor from cheese perceived while the sample is in the mouth	Sharp cheddar cheese (Kraft Foods, Inc., Glenview, IL)	1" cube
		Vanilla pudding (Jell-O™ Vanilla pudding mix, Kraft General Foods, White Plains, NY)	20 g
Aftertaste	Intensity of any flavor perceived after the sample is swallowed (it maybe cheese flavor, egg flavor, milk flavor or a combination of these)	Whole milk (Kroger Co., Cincinnati, OH)	20 g
		Cheese cake (Jell-O™ Cheese cake mix, Kraft General Foods, White Plains, NY)	20 g
Texture			
Firmness	Force required to break down the custard between the tongue and palate	Vanilla pudding (Jell-O™ Vanilla pudding mix, Kraft General Foods, White Plains, NY)	20 g
		Scrambled eggs (Kroger Co., Cincinnati, OH)	20 g
Graininess	Amount of particles perceived on the surface of the tongue	Vanilla pudding (Jell-O™ Vanilla pudding mix, Kraft General Foods, White Plains, NY)	20 g
		Cream of wheat (Nabisco Inc., East Hanover, NJ)	20 g

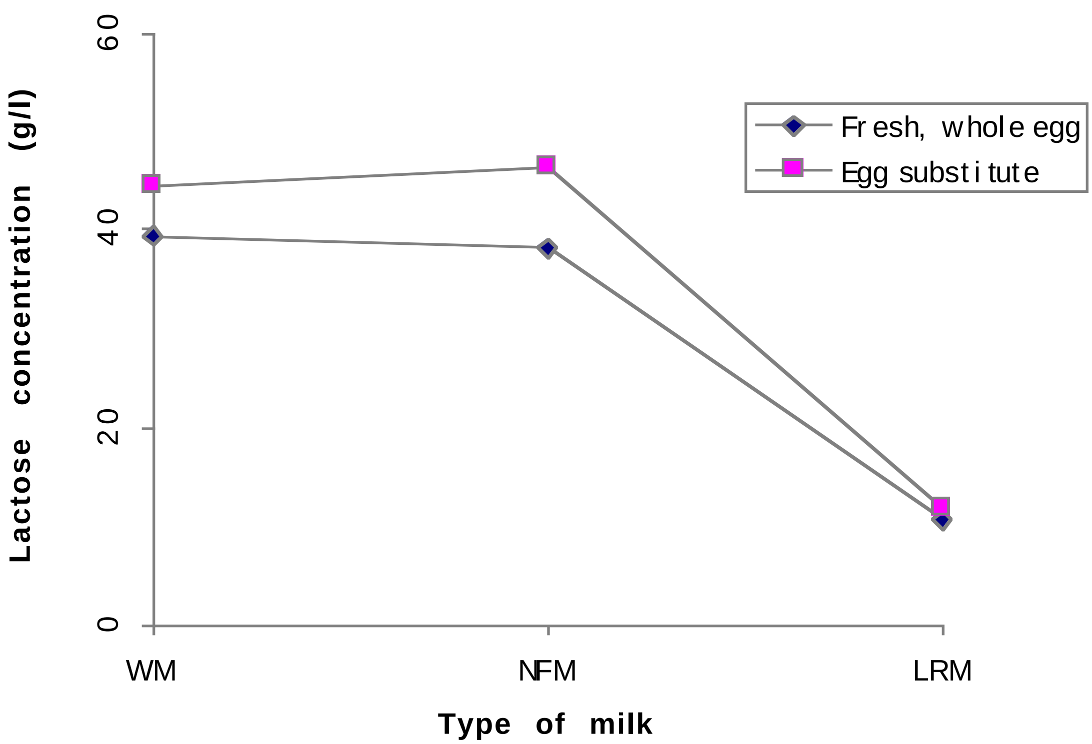

Fig. 5-Interactions between type of milk and type of egg for lactose concentrations of entree type custard mixes (n = 3) (WM = whole milk; NFM = nonfat milk; LRM = nonfat, 70% lactose-reduced milk)

These results can be attributed to a larger proportion of milk in the formulation for custards (Table 9) containing the egg substitute. Milk was used to hydrate the dried egg white and LFLC egg yolk solids. However, mixes containing the nonfat, 70% lactose-reduced milk had much less lactose than mixes containing either whole milk or nonfat milk, regardless of the type of egg in the mix. For mixes containing the lactose-reduced milk, lactose concentrations were similar for mixes containing fresh, whole egg or the egg substitute.

Similar trends were noted in the galactose concentrations of the custard mixes (Figure 6). Galactose concentrations were low for mixes containing either whole milk or nonfat milk regardless of the egg substitute. However, mixes containing the egg substitutes and the lactose-reduced milk had higher galactose concentrations than mixes containing fresh, whole egg and the lactose-reduced milk. Again, these results can be attributed to a larger proportion of milk in mixes containing the egg substitute.

Protein Concentration

Results for protein concentration of the entree type custard were similar to those for the dessert type custard. The two-way interaction (type of milk x type of egg) was not significant ($p>0.05$) for protein concentration. See Appendix I for the interaction means. Type of milk also did not significantly affect protein concentration of the mixes; however, type of egg significantly ($p<0.05$) affected protein concentration (Table 11). Mixes made with the egg substitute had a 30.49% higher protein concentration than those made with the fresh, whole egg. As discussed in Chapter III, this increase in protein might be attributed to several factors. First, the amount of dried egg white solids and dried LFLC egg yolk solids used in the substitute was not based on the amount of protein in native egg white and egg yolk. Also, there was 36.5 g more milk (about 5% protein) in the formula containing the egg substitute. This milk was use to hydrate the ingredients used in the egg substitute.

Total Fat Concentration

The two-way interaction (type of milk x type of egg) was not significant ($p>0.05$) for total fat concentration (Appendix I); however, type of milk and type of egg significantly ($p<0.05$) affected the total fat concentration (Table 11). Results indicate reduction of milk fat affected the total fat concentration. Custard mixes made with whole milk had a higher total fat concentration than mixes made with either nonfat milk or nonfat, 70% lactose-reduced milk. There was no significant difference in total fat for the latter two types of mixes. Mixes made with the egg substitute had a 52.88% lower total fat concentration than those made with fresh, whole egg. This reduction is due to the reduced fat content of the LFLC egg yolk powder, which contains 74% less fat than native egg yolk (Bringe and Cheng, 1995).

Cholesterol Concentration

The two-way interaction (type of milk x type of egg) was not significant ($p>0.05$) for cholesterol concentration (Appendix I); however, type of milk and type of egg had significant

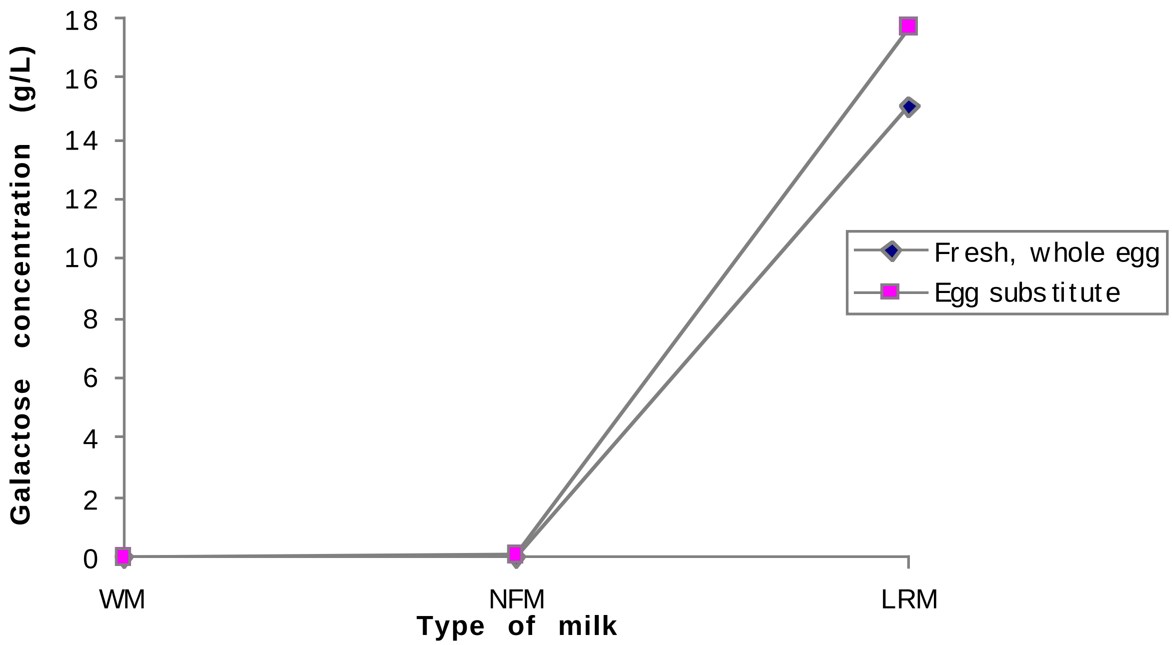

Fig. 6-Interaction between type of milk and type of egg for galactose concentrations of entree type custard mixes (n = 3) (WM = whole milk; NFM = nonfat milk; LRM = nonfat, 70% lactose-reduced milk)

Table 11-Means ± standard deviations for nutrient composition of entree type baked custard mixes

	Type of Milk [a]			Type of Egg [b]	
Nutrient	WM	NFM	LRM	WE	ES
Lactose (g/L)	42.10 ± 3.30	42.34 ± 4.78	11.30 ± 1.79	29.45 ± 14.30	34.38 ± 16.82
Galactose (g/L)	0.03 ± 0.04	0.07 ± 0.07	16.38 ± 1.57	5.03 ± 7.50	5.96 ± 8.84
Protein (g/100 g)	5.88 ± 0.88[c]	5.94 ± 0.91[c]	5.98 ± 0.89[c]	5.15 ± 0.28[c]	6.72 ± 0.21[d]
Total Fat (g/100 g)	3.43 ± 0.82[c]	1.42 ± 0.94[d]	1.28 ± 0.80[d]	2.78 ± 1.10[c]	1.31 ± 1.06[d]
Cholesterol (mg/100 g)	94.37 ± 39.67[c]	50.06 ± 44.51[d]	39.62 ± 31.45[d]	95.29 ± 29.46[c]	27.42 ± 25.46[d]

[a] WM = whole milk; NFM = nonfat milk; LRM = nonfat 70% lactose-reduced milk
[b] WE = whole fresh egg; ES = egg substitute
[c, d] N = 6 for type of milk; n = 9 for type of egg; means in a row within a subgroup followed by different letters differ significantly at $p<0.05$

(p<0.05) effects on cholesterol concentration. Results indicate that reduction of milk fat affected the cholesterol concentration but reduction of lactose did not. Custard mixes made with whole milk had higher cholesterol concentration than those made with either nonfat milk or nonfat, 70% lactose-reduced milk (Table 11). These results were expected because nonfat milk does not contain cholesterol. Type of egg had a significant (p<0.05) effect on cholesterol concentration of the mixes. Mixes made with the egg substitute had a 71.22% lower cholesterol concentration than mixes made with fresh, whole egg. This reduction is due to cholesterol reduction of the LFLC egg yolk powder, which contains 90% less cholesterol than native egg yolk (Bringe and Cheng, 1995). As discussed in Chapter III, results of the analyses of total fat and cholesterol indicate that either nonfat milk or the egg substitute can be used to reduce the amount of total fat and cholesterol in baked custard.

Physical Properties

Color

As discussed in Chapter III, Hunter "L", "a", and "b" values were evaluated for the top and bottom surfaces of the entree type baked custards because the researchers suspected that there might be an increased amount of browning in custards made with the lactose-reduced milk. For the top surface of the custards, the two-way interaction was significant (p<0.05) for Hunter "L" values (Figure 7 and Appendix I). The top surface of custards made with the egg substitue was darker than the top surface of custards made with fresh, whole. However, for custards containing the egg substitute, the top surface of custards made with whole milk tended to be lighter than those of custards made with either nonfat milk or nonfat, 70% lactose-reduced milk.

Hunter "a" values were negative for top surfaces of all types of custards, and Hunter "b" values were positive (Table 12). The two-way interaction was significant (p<0.05) for Hunter "a" values (Figure 8). Lower negative "a" values were obtained for custards made with fresh, whole egg than for custards made with the egg substitute. For custards made with fresh, whole egg, "a" values were lowest for custards made with the lactose-reduced milk. For custards made with the egg substitute, "a" values were lowest for custards made with whole milk. Type of egg affected Hunter "b" values for top surfaces of the custards. Custards made with the egg substitute had lower "b" values than custards made with fresh, whole egg, indicating that custards made with the egg substitute were darker than those made with fresh, whole egg.

For bottom surfaces of the custards, results (Table 12) indicate that type of milk and type of egg had significant effects (p<0.05) on Hunter "L" values. Custards made with whole milk were lighter than those made with either nonfat or nonfat, 70% lactose-reduced milk. Custards made with the egg substitue were darker than those made with fresh, whole egg. The effect of type of milk on "a" values for bottom surfaces of the custards depended on the type of egg (Figure 9). Lower negative "a" values were obtained for custards made with fresh, whole egg than for custards made with the egg substitute. For custards made with fresh, whole egg, "a" values were lowest for custards made with the lactose-reduced milk. For custards made with the

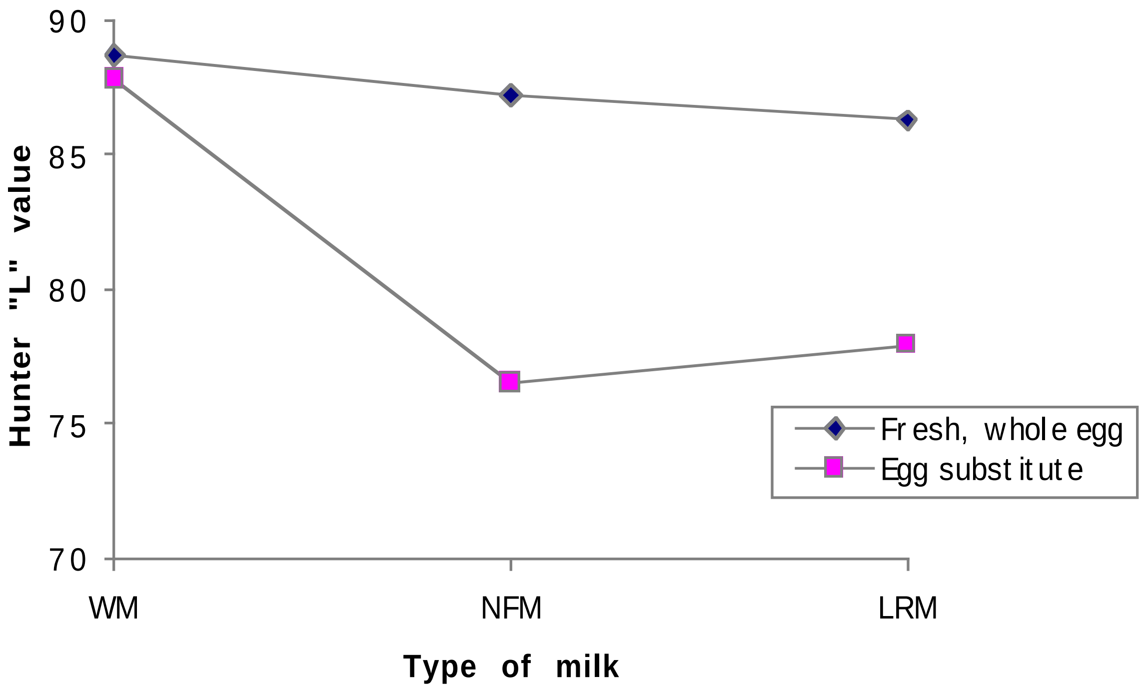

Fig. 7-Interaction between type of milk and type of egg for Hunter "L" values for top surface of entree type baked custards (n=3) (WM = whole milk; NFM = nonfat milk; LRM = nonfat, 70% lactose-reduced milk)

Table 12-Means ± standard deviations for physical properties of entree type baked custards

	Type of Milk [a]			Type of Egg [b]	
Property	WM	NFM	LRM	WE	ES
Top surface					
Hunter "L"	88.22 ± 2.29	81.90 ± 6.02	82.09 ± 5.07	87.39 ± 2.02	80.75 ± 5.70
Hunter "a"	-6.47 ± 0.87	-8.52 ± 1.47	-7.16 ± 2.35	-6.23 ± 1.34	-8.54 ± 1.45
Hunter "b"	33.32 ± 5.37 [c]	29.30 ± 7.55 [c]	32.55 ± 8.78 [c]	37.56 ± 4.10 [c]	25.89 ± 3.92 [d]
Bottom surface					
Hunter "L"	91.70 ± 2.23 [c]	85.09 ± 3.80 [d]	85.43 ± 4.02 [d]	90.08 ± 3.33 [c]	84.73 ± 3.97 [d]
Hunter "a"	-6.49 ± 0.35	-7.94 ± 0.25	-7.51 ± 0.81	-7.00 ± 0.71	-7.63 ± 0.80
Hunter "b"	21.91 ± 1.83	18.94 ± 7.58	23.81 ± 4.77	24.97 ± 3.41	18.13 ± 4.83
Gel strength (g force)	28.67 ± 13.28	22.00 ± 8.65	23.00 ± 10.00	15.11 ± 1.69	34.00 ± 5.94

[a] WM = whole milk; NFM = nonfat milk; LRM = nonfat 70% lactose-reduced milk
[b] WE = whole fresh egg; ES = egg substitute
[c, d] N = 6 for type of milk; n = 9 for type of egg; means in a row within a subgroup followed by different letters differ significantly at $p<0.05$

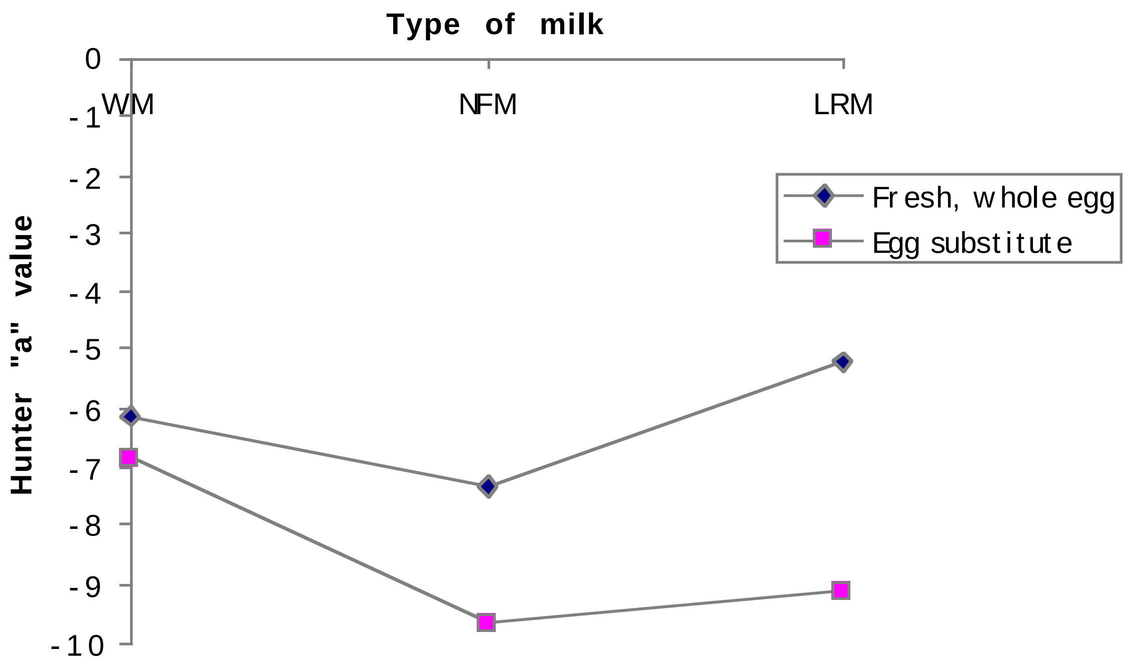

Fig. 8-Interaction between type of milk and type of egg for Hunter "a" values for top surface of entree type baked custards (n =3) (WM = whole milk; NFM = nonfat milk; LRM = nonfat, 70% lactose-reduced milk)

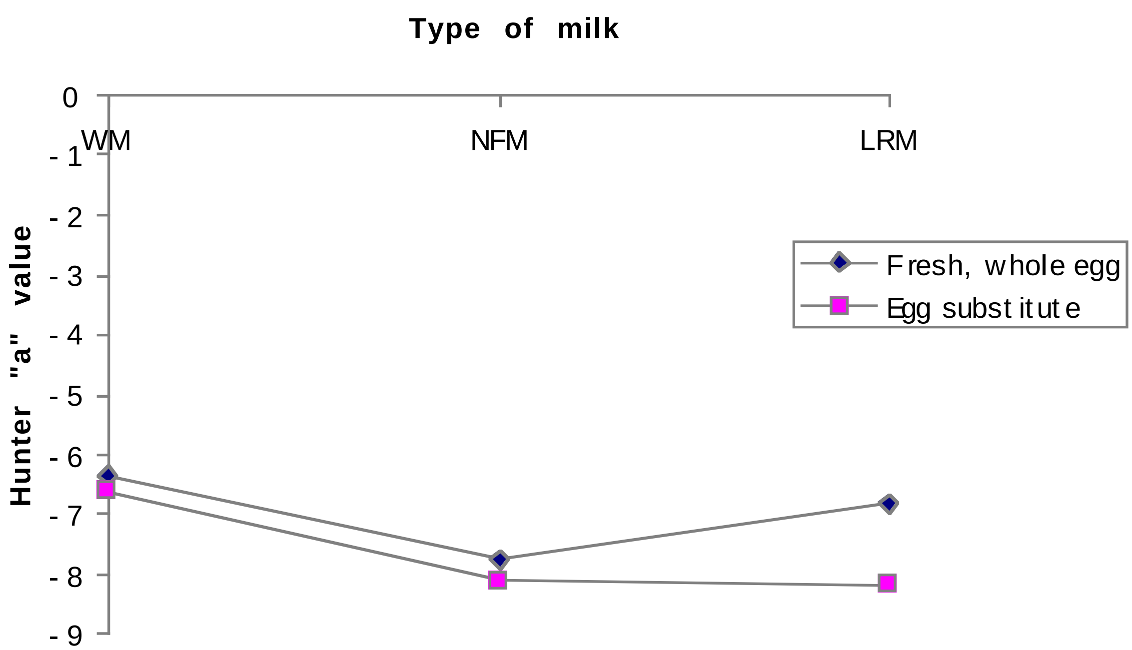

Fig. 9-Interaction between type of milk and type of egg for Hunter "a" values for bottom surface of entree type baked custards (n =3) (WM = whole milk; NFM = nonfat milk; LRM = nonfat, 70% lactose-reduced milk)

egg substitute, "a" values were lowest for custards made with whole milk. The effect of type of milk on "b" values for bottom surfaces of the custards also depended on the type of egg (Figure 10). Type of milk had a greater effect on "b" values for custards made with the egg substitue. The "b" values were lowest for custards made with the nonfat milk.

In general, results for Hunter "L", "a", and "b" values of the entree type baked custards were similar to those for the dessert type baked custard (Experiment I). Although differences were noted in Hunter "L", "a", and "b" values for the top and bottom surfaces of the entree type custards, these difference might not be due to an increased amount of browning in the custards made with the lactose-reduced milk. Differences might be attributed to effects of the egg substitute on color of the custards. As explained in Chapter III, effects of the egg subtitute might be due to differences in the type and/or amount of carotenoid pigments present in the dried LFLC egg yolk solids and the yolks of the fresh, whole eggs. The supercritical CO_2 extraction process used to reduce the amount of fat and cholesterol in the egg yolk solids might have extracted or degraded the pigments in the yolk.

Gel Strength

The two-way interaction was significant for gel strength of the custards. In general, however, gel strength of custards containing the egg substitute was greater for those containing fresh, whole egg (Figure 11). Similar results were obtained for gel strength of the dessert type custard in Experiment I. As dicussed in Chapter III, the stronger gel strength might be due to the use of xanthan gum, a thickening agent, in the egg substitute. It also might be due to the higher protein content of custards made with the egg substitute. Again, greater gel strength might be a desirable attribute if the custard mix is to have foodservice applications, because it would help prevent syneresis.

Sensory Characteristics

Appearance

Sensory panelists perceived differences in the appearance of the baked custards. These differences were similar to those for the dessert type baked custard (Experiment I) with the following exception. Type of milk did not affect the appearance of the entree type custard (Table 13). However, dessert type custard made with the nonfat, 70% lactose-reduced milk was brighter in color than the dessert type custard made with either whole milk or nonfat milk (Table 7).

Flavor

Sensory panelists perceived differences in flavor of the baked custards. Results of the ANOVA indicated that two-way interactions (type of milk x type of egg) were not significant ($p>0.05$) for flavor characteristics (Appendix I); however, type of milk and type of egg significantly ($p<0.05$) affected the characteristics (Table 13). Reduction of milk fat affected the egg flavor, but reduction of lactose did not. This difference between the two types of custards might be attributed to the use of the cheese powder in the entree type custards. The cheese powder was yellow in color (Appendix G). Custards made with fresh, whole egg had

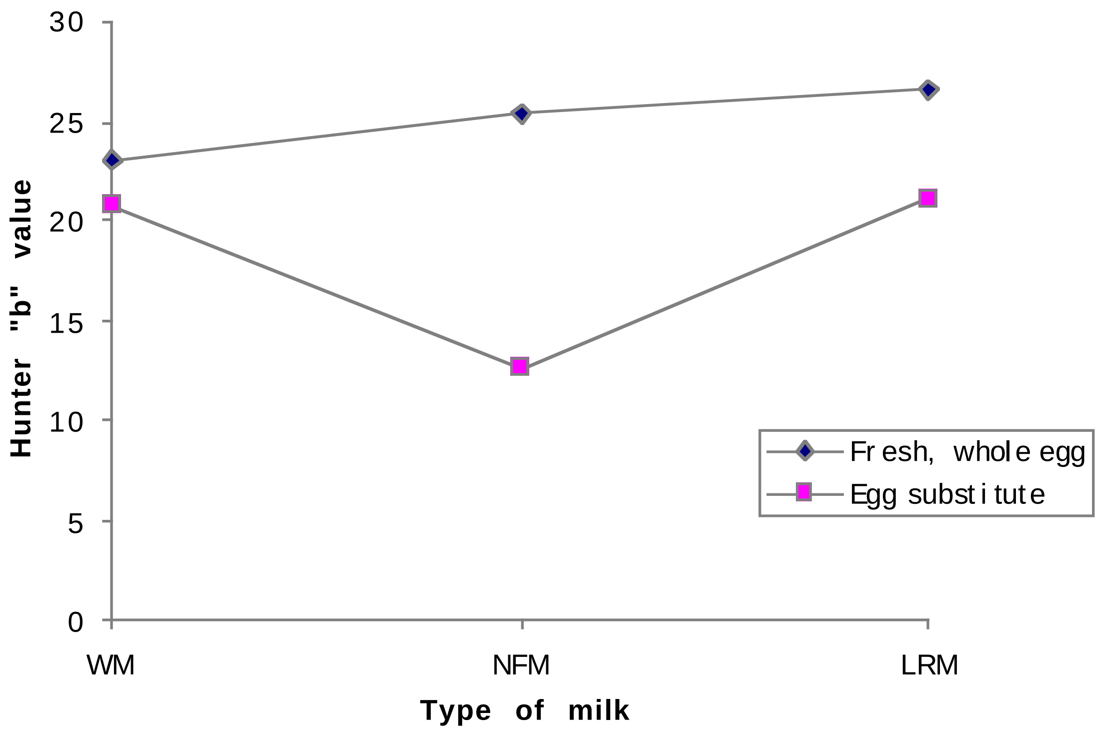

Fig. 10-Interaction between type of milk and type of egg for Hunter "b" values for bottom surface of entree type baked custards (n =3) (WM = whole milk; NFM = nonfat milk; LRM = nonfat, 70% lactose-reduced milk)

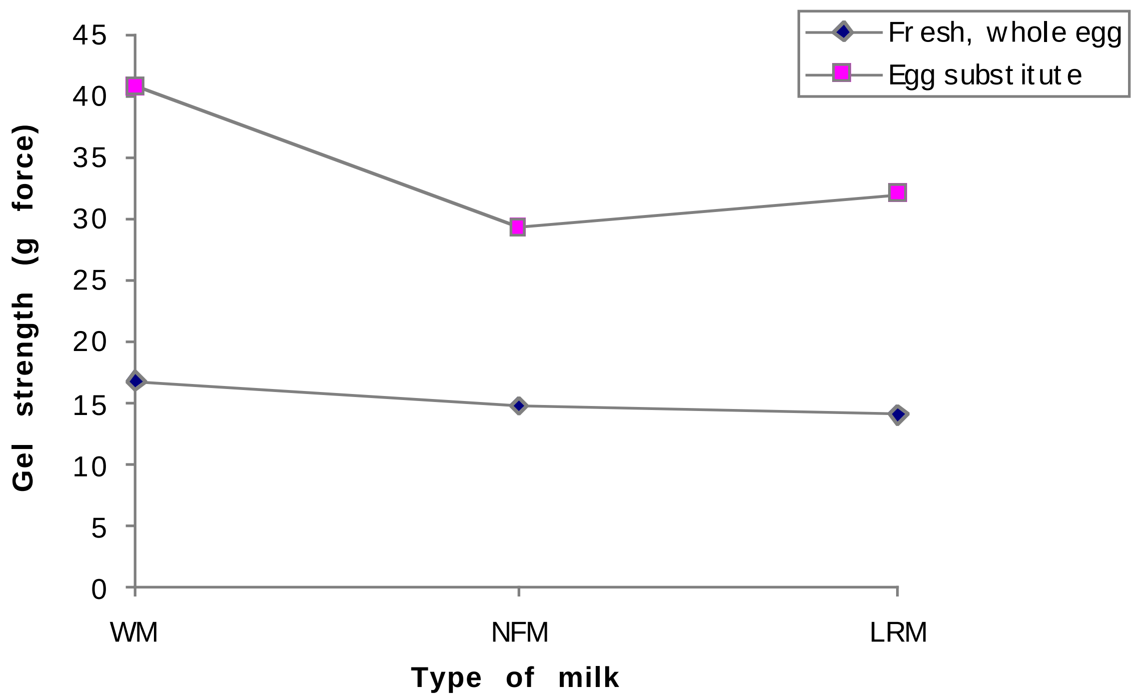

Fig. 11-Interaction between type of milk and type of egg for gel strength of entree type baked custards (n = 3) (WM = whole milk; NFM = nonfat milk; LRM = nonfat, 70% lactose-reduced milk)

Table 13-Means ± standard deviations for sensory characteristics of entree type baked custard[a]

Characteristics	Type of Milk[b] WM	NFM	LRM	Type of Egg[c] WE	ES
Appearance					
Brightness of color	9.7±4.8[d]	10.2±4.5[d]	10.1±4.2[d]	11.8±3.0[d]	8.2±5.0[e]
Evenness of color	11.1±3.9[d]	10.7±4.1[d]	10.9±4.0[d]	12.0±3.3[d]	9.8±4.4[e]
Flavor					
Cheese flavor	6.0±3.7[d]	5.6±3.8[d]	5.5±3.7[d]	7.6±3.6[d]	3.8±2.8[e]
Egg flavor	5.9±3.8[d]	4.9±3.2[e]	4.9±3.1[e]	5.7±3.4[d]	4.8±3.3[e]
Aftertaste	5.8±3.7[d]	5.4±3.8[d]	5.5±3.8[d]	6.6±4.2[d]	4.6±3.0[e]
Texture					
Firmness	5.7±4.5[d]	5.5±4.5[d]	5.5±4.5[d]	2.1±1.9[d]	9.0±3.4[e]
Graininess	3.9±4.2[d]	3.4±4.1[d]	3.4±4.0[d]	1.2±1.7[d]	6.1±4.4[e]

[a] n = 45; means based on 15-cm line scale (1 = least intense; 15 = most intense)
[b] WM = whole milk; NFM = nonfat milk; LRM = nonfat, 70% lactose-reduced milk
[c] WE = whole fresh egg; ES = egg substitute
[d,e] Means in a row for a subgroup followed by different letters differ significantly ($p<0.05$)

significantly more egg flavor than custards made with either nonfat milk or nonfat, 70% lactose-reduced milk. Egg flavor in custards made with nonfat milk was similar to that of custard made with nonfat, 70% lactose-reduced milk. Type of milk did not affect either cheese flavor or aftertaste of the custards.

Type of egg had a significant effect ($p<0.05$) on cheese flavor, egg flavor and aftertaste of the custards (Table 13). Cheese flavor, egg flavor and aftertaste of custards made with the egg substitute were less intense than those of custards made with fresh, whole egg. These results are similar to those obtained for the dessert type custard. As discussed in Chapter III, results might be due to fat and cholesterol reduction of the LFLC egg yolk solids used in the substitute. Because fat functions as a flavor carrier in food (Umano et al., 1990), a reduced level of fat might decrease the intensity of cheese flavor, egg flavor and aftertaste.

Texture

Sensory panelists perceived differences in the texture of the baked custards. The two-way interactions (type of milk x type of egg) were not significant ($p>0.05$) for the textural characteristics (Appendix I). Type of milk also did not affect the texture of the custards, indicating that neither reduction of lactose nor reduction of milk fat affected texture (Table 13). These results are similar to those for the dessert type custard in Experiment I.

Type of egg had a significant ($p<0.05$) effect on firmness and graininess of the custards. Custards made with the egg substitute were firmer than those made with the fresh, whole egg. As discussed in Chapter III, there might be several explanations for these results. First, xanthan gum, a thickening agent, was used in the egg substitute. Also, baked custard is a protein gel. Custards made with the egg substitute may have formed a stronger gel because of the higher protein content.

The texture of custards made with the egg substitute was more grainy than the texture of custards made with fresh, whole egg. Graininess was defined as "the amount of particles perceived on the surface of the tongue". Sensory panelists perceived more particles from custards made with the egg substitute than from custards made with fresh, whole egg.

4. CONCLUSION

Results of this experiment were similar to those in Experiment I (Chapter III). Type of egg had a greater effect on the quality of baked custard than type of milk. These results were expected because baked custard is a protein gel which depends primarily on egg protein for gel formation (Penfield and Campbell, 1990). Consumer testing was not done to evaluate acceptance of the entree type custard as it was for the dessert type custard (Chapter III), because the entree type custard was considered a base for other products and not a finished product in itself. Sensory panelists in descriptive analysis, however, indicated that the flavor of the custards was unappealing.

Based on results of this experiment, development of a lactose-reduced entree type custard is feasible because results indicate that lactose reduction had little effect on quality of the custard.

However, additional studies should be done to examine its potential for use in the foodservice industry.

The lactose-reduced baked custard mix could serve as a base for other types of products, such as a quiche or omelet, that are used in the foodservice industry. Insight into acceptance of the custard could be obtained through studies of the quality of lactose-reduced baked custards formulated with flavors, such as ham, bacon, and herbs. Also, the effect of other egg substitute on the quality of the custard should be examined. One possible substitute was discussed in Chapter III. Studies that focus on those areas could help define the niche for the mix in the foodservice industry.

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APPENDIXES

APPENDIX A
SPECIFICATIONS FOR DRIED EGG WHITE SOLIDS

Egg White Solids - Type p-39 (HENNINGSEN™)

Description:

This product is prepared by desugaring liquid egg white, followed by spray drying and pasteurization at 140° F for 10 days.

Chemical and Physical Standards:

Protein	80.0%, Minimum
Moisture	8.0%, Maximum
Reducing Sugar	0.1%, Maximum
pH	9.5 ± 0.5
Granulation	100% through # 80 U.S.S.S. screen
	90% through #100 U.S.S.S. screen

Microbiological Standards:

Standard Plate Count	10,000 / gm, Maximum
Coloform	10 / gm, Maximum
Yeast and Mold	10 / gm, Maximum
Salmonella	Negative

Henningsen Product Code No. 475

Henning Foods, Inc., 14334 Industrial Road, Omaha, NE 68144-3398

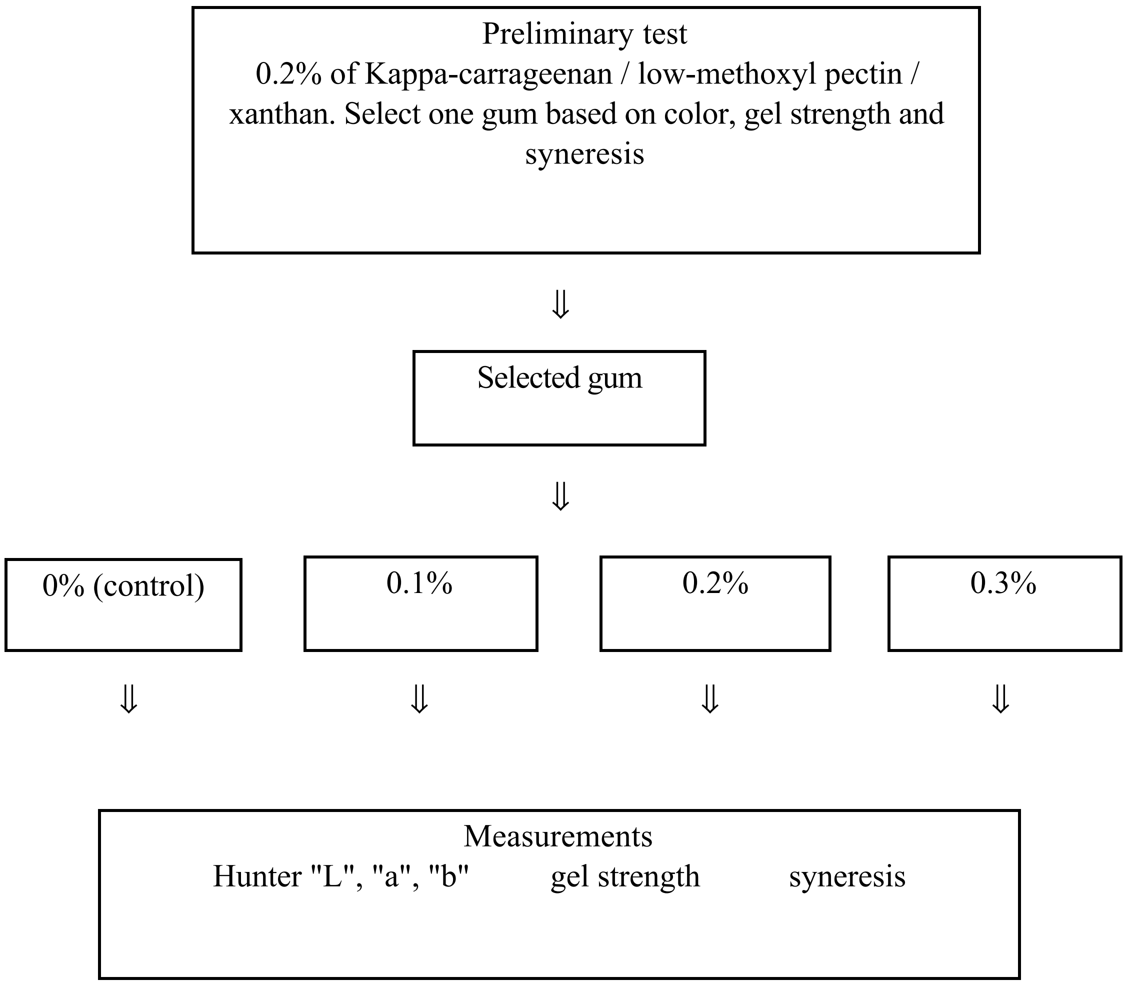
APPENDIX B
EFFECTS OF GUMS ON THE QUALITY OF LACTOSE-REDUCED BAKED CUSTARD MADE WITH LOW-FAT, LOW-CHOLESTEROL EGG YOLK SOLIDS
Experiment Conducted by
Veronica Wu
for
HNF 5234: Carbohydrates and Plant Pigments in Foods
October 1995

Objectives

To examine the effects of gums on color, gel strength, and syneresis of lactose-reduced baked custard made with low-fat, low-cholesterol egg yolk solids (LFLC).

Methodology

Research design:



Materials: Nonfat, 70% lactose-reduced milk (Lactaid^{TM}, H.P. Hood, Inc., Boston, MA), LFLC egg yolk solids (Eggcellent^{TM}, The Nutrasweet Co., Deerfield, IL) and egg white solids (Henningsen P-39, Henningsen Foods, Inc., White Plain, NY) were used to make the custard. Kappa-carrageenan, low-methoxyl pectin or xanthan gums was added to the custard.
Formulation of baked custard: Mixed 4.6 g LFLC egg yolk solids, 8.9 g dried egg white and 2 g corn oil. Added 35.5 g milk to hydrate the mixture for 15 min. Added sugar (25 g) and salt (0.37 g) to the egg mixture. Heated 250 g milk to 60^0 C, added it to egg mixture, and stirred at low speed

for 5 min. Added 1.2 g of vanilla to the custard mix. Put custard into glass cups and placed cups into water bath. Baked at 177^0 C for 40 min (Penfield and Campbell, 1990). For preparation of custards containing the gums, the oil was omitted from the formulation.

Measurements: 1) Color: Hunter "L", "a", "b" values were measured on the top and bottom surfaces of the custards with a Minolta Chromameter CR-200 (Minolta Camera Co., Ltd., Osaka, Japan). Three readings on both top and bottom surfaces were obtained. Two custard samples for each treatment were measured. 2) Gel strength: Stevens L.F.R.A. Analyzer (Model TA-1000, Texture Technologies Corp., Scaradale, NY) was used. TA-2 cone, speed of 2 mm/Sec., and a distance of 5 mm were used in the analysis. Three readings on two custard samples from each treatment were obtained. 3) Syneresis: Custards were inverted on a fine wire screen supported on a funnel. The custard was drained for 1 hr. The volume of liquid was collected in a graduated cylinder and measured. Two samples for each treatment were measured.

Statistical analysis: One way ANOVA with a 0.05 level of significance was used.

Results and Discussion

In the preliminary test, custards made with pectin had lower gel strength and more syneresis than the control custard made with corn oil. Custards made with Kappa-carrageenan had gel strength similar to the control custard and the custard with xanthan gum, but syneresis was less. However, from the appearance, custards made with carrageenan had a layer of LFLC egg yolk solids on the bottom. Among these three gums, xanthan gum seemed to have performed better. Custards made with xanthan had gel strength similar to the control and less syneresis than the control. Xanthan gum homogenized the custard better than the other gums. Therefore, xanthan gum was selected for further testing. Custard was formulated with 0% (control), 0.1%, 0.2%, and 0.3% xanthan gum. Corn oil was added only to the control.

For the Hunter "L", "a", and "b" values, top surface "L" values of the 0.2% treatment was significantly lower than "L" values for the 0.1% and 0.3% treatments. There was no significant difference among the 0%, 0.1% and 0.3% treatments. Top surface "a" values of the control was significantly higher than the other treatments, and there were no significant differences among the other treatments. Top surface "b" values of the 0.1% treatment was significantly lower than the other treatments, and there were no significant differences among the other treatments. Bottom surface "L" values of the 0.1% treatment was significantly higher than the 0.2% and 0.3% treatments, but there was no significant difference among 0%, 0.2% and 0.3% treatments. There was no significant difference between treatments for bottom surface "a" values. Bottom surface "b" values of the control was significantly higher than the other treatments. There was no significant difference among the other treatments (Table 14).

The color of xanthan gum modified custards was less red on the top and less yellow on the bottom than the control, as indicated by the top surface "a" values and bottom surface "b" values, respectively. This might be due to less LFLC egg yolk solids (yellow) concentrating on the top surface and bottom of custards containing xanthan gum.

Gel strength of the control (32.42 g force) custard was significantly lower than that of the 0.1% treatment (35.75 g force). The 0.1% treatment was significantly lower than the 0.2% (40.00

Table 14-Means ± standard deviations for color, gel strength, and syneresis of baked custards evaluated in preliminary testing [a]

	Level of Xanthan Gum			
Characteristic	0% (control)	0.1%	0.2%	0.3%
Top surface				
Hunter "L"	81.27 ± 0.96[ab]	81.90 ± 1.28[a]	80.78 ± 0.57[b]	81.61 ± 0.41[a]
Hunter "a"	-9.02 ± 0.96[a]	10.25 ± 0.79[b]	-10.55 ± 0.79[b]	-10.12 ± 1.22[b]
Hunter "b"	33.70 ± 1.17[a]	30.15 ± 2.65[b]	34.75 ± 3.25 [a]	33.02 ± 1.91[a]
Bottom surface				
Hunter "L"	85.40 ± 1.0[ab]	85.89 ± 1.28[a]	84.61 ± 1.14[b]	84.48 ± 1.15[b]
Hunter "a"	-7.54 ± 0.48[a]	-7.60 ± 0.50[a]	-7.52 ± 0.35[a]	-7.83 ± 0.28[a]
Hunter "b"	15.38 ± 2.79[a]	12.86 ± 2.20[b]	11.52 ± 1.69[b]	11.94 ± 0.82[b]
Gel strength (g force)	32.42 ± 2.39[a]	35.75 ± 1.91[b]	40.00 ± 2.17[c]	38.92 ± 3.31[c]
Syneresis (mL)	2.40 ± 0.63[a]	1.75 ± 0.57[b]	1.65 ± 0.47[b]	1.80 ± 0.42[b]

[a] Means in a row followed by different letters differ significantly at $p<0.05$.

APPENDIX C
CONSENT FORMS USED IN DESCRIPTIVE ANALYSIS AND CONSUMER TESTING

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
INFORMED CONSENT FORM FOR PARTICIPATION IN SENSORY EVALUATION

Project Title: Flavor Enhancement of a Lactose-reduced Dairy Custard

Principal Investigators: Susan E. Duncan, Ph.D. and Denise Brochetti, Ph.D.

I. PURPOSE OF THE PROJECT

Researchers in the Department of Food Science and Technology and the Department of Human Nutrition and Foods are conducting a sensory testing program to evaluate the quality of lactose-reduced dairy custard formulations that are low in fat and cholesterol. All ingredients used in the formulations have been approved for use in foods by the Food and Drug Administration. You are asked to participate in the testing program. Your participation is voluntary.

II. PROCEDURES

As a participant, you will be trained to evaluate the sensory characteristics of dairy custards. Training will involve a minimum of 3 sessions over a period of 2 weeks. Each session will be approximately 30-40 minutes. After training, testing sessions in which you will evaluate dairy custards will be held over a period of 1 month in the Sensory Laboratory, Food Science and Technology Building. Each session will be approximately 5-10 minutes, and you will evaluate 4-6 samples. You will be required to taste all samples, but if you find a sample objectionable, you may choose to spit it out.

III. BENEFITS/RISKS OF THE PROJECT

Your participation in the program will provide information on the quality of lactose-reduced dairy custards. You may receive a summary of results of the sensory tests when the project is completed.

Certain individuals are sensitive to some foods such as milk, eggs, wheat gluten, strawberries, chocolate, artificial sweeteners, etc. If you are aware of any food or drug allergies, please list them in the following space.
____ There may be some risk involved if you have an unknown food allergy.

IV. EXTENT OF ANONYMITY AND CONFIDENTIALITY

Results of your performance in the program will be kept strictly confidential. All participants will be referred to by code for analysis and for any reports or publications of results.

V. COMPENSATION

It is critical to the project that you participate in each session. For your participation, you will receive compensation in the form of snacks and/or food coupons for each session completed.

VI. FREEDOM TO WITHDRAW

Although it is important to the project for you to complete each session, conditions may arise that prevent your completion of all session. You may withdraw from the project without penalty, and you will be compensated for your participation up to the time of withdrawal.

VII. APPROVAL OF RESEARCH

This research project has been approved by the Institutional Review Board for projects involving human subjects at Virginia Polytechnic Institute and State University and by the human subjects review of the Department of Human Nutrition and Foods.

VIII. SUBJECT'S PERMISSION

I have read through the Informed Consent Form and have been given the opportunity to ask questions regarding the sensory testing program. I agree to participate in the program, as described in the Informed Consent Form.

_______________________________________ _______________

Signature Date

Should I have any questions regarding the program or its conduct, I should contact:

Investigator	Phone
Denise Brochetti, Ph.D. Department of Human Nutrition and Foods	(540) 231-9048
Susan E. Duncan, Ph.D. Department of Food Science and Technology	(540) 231-8675
Ernest R. Stout Chair, IRB, Research Division	(540) 231-9359

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
INFORMED CONSENT FORM FOR PARTICIPATION IN SENSORY EVALUATION

Project Title: Lactose-reduced Dairy Products

Principal Investigators: Susan E. Duncan, Ph.D. and Denise Brochetti, Ph.D.

I. PURPOSE OF THE PROJECT

Researchers at Virginia Polytechnic Institute and State University are conducting a sensory testing program to evaluate the quality of lactose-reduced dairy products. All ingredients used in the dairy products have been approved for use in food by the Food and Drug Administration. You are invited to participate in the project. Your participation is voluntary.

II. PROCEDURES

As a participant, you are asked to taste and evaluate samples of custard. The test will take approximately 5 minutes to complete. Although you are required to taste all of the samples, if you find a sample objectionable, you may choose to spit it out.

III. BENEFITS/RISKS OF THE PROJECT

Your participation in the project will provide information on the quality of lactose reduced dairy products. You may receive a summary of results of the sensory tests when the project is completed.

Certain individuals are sensitive to some foods such as milk, eggs, wheat gluten, strawberries, chocolate, artificial sweeteners, etc. If you are aware of any food or drug allergies, please list them in the following space.

____

____

There may be some risk involved if you have an unknown food allergy.

IV. EXTENT OF ANONYMITY AND CONFIDENTIALITY

Results of your performance in the project will be kept strictly confidential. Information that you provide will have your name removed and only a code number will be used during data analysis and any written reports of the project.

V. COMPENSATION

For your participation, you will receive nutrition education brochures and/or snacks.

VI. FREEDOM TO WITHDRAW

Although it is important to the project for you to complete the test, you may withdraw without penalty. You will be compensated for your participation.

VII. APPROVAL OF RESEARCH

This project has been approved by the Institutional Review Board for projects involving human subjects at Virginia Polytechnic Institute and State University and by the human subjects review of the Department of Human Nutrition and Foods.

VIII. SUBJECT'S PERMISSION

I have read through the Informed Consent Form and have been given the opportunity to ask questions regarding the sensory testing program. I agree to participate in the program, as described in the Informed Consent Form.

____ _______________

Signature Date

Should I have any questions regarding the project or its conduct, I should contact:

Susan E. Duncan, Ph.D. Department of Food Science and Technology	(540) 231-8675
Denise Brochetti, Ph.D. Department of Human Nutrition and Foods	(540) 231-9048
Ernest R. Stout Chair, IRB, Research Division	(540) 231-9359

APPENDIX D
INSTRUCTION SHEET AND SCORECARD USED IN DESCRIPTIVE ANALYSIS OF THE DESSERT TYPE BAKED CUSTARDS

Instructions for Sensory Testing of Dessert Type Baked Custards

Read the definition first, recall the reference samples, evaluate the samples by placing a vertical mark across the line. Samples should be swallowed. Rinse your mouth with water between samples.

Reference samples:

Brightness of color: Dull---------------------->Bright
(cheese cake) (vanilla pudding)

Evenness of color: Blotchy------------------->Even
(scrambled eggs) (vanilla pudding)

Egg flavor: None------------------------>Strong
(non dairy whipped topping) (scrambled eggs)

Aftertaste: None---------------------->Strong
(milk) (cheese cake)

Firmness: Soft----------------------->Firm
(vanilla pudding) (scrambled eggs)

Graininess: Smooth---------------------->Grainy
(vanilla pudding) (cream of wheat)

Score Card for Dessert Type Baked Custard

Judge #_______ Sample #___________ Date________

- Brightness of color - the purity of the yellow color

Dull Bright

- Eveness of color - the distribution of the yellow color

Blotchy Even

- Egg flavor - the intensity of flavor from egg perceived while the sample is in the mouth

None Strong

- Aftertaste - the intensity of any flavor perceived after the sample is swallowed (it may be egg flavor, milk flavor, sweetness, vanilla flavor or a combination)

None Strong

- Firmness - the force required to break down the custard between the tongue and palate

Soft Firm

- Graininess - amount of particles perceived on the surface of the tongue

Smooth Grainy

APPENDIX E
SCORECARDS USED IN CONSUMER TESTING OF THE DESSERT TYPE BAKED CUSTARDS

Score Card for Elderly Adults

Judge#_____ Date______

Taste the samples of baked custard and check the term that best describes how much you like or dislike them

	Sample_____	Sample______
1. Like extremely	____________	_____________
2. Like very much	____________	_____________
3. Like moderately	____________	_____________
4. Like slightly	____________	_____________
5. Neither like or dislike	____________	_____________
6. Dislike slightly	____________	_____________
7. Dislike moderately	____________	_____________
8. Dislike very much	____________	_____________
9. Dislike extremely	____________	_____________

Please check the appropriate response:

1. What is your age?
____ 60-69 years
____ 70-79
____ 80-89
____ 90+

2. What is your gender?
____ Female
____ Male

3. Do you experience uncomfortable symptoms (abdominal cramps, gas, and/or diarrhea) after drinking milk or eating dairy products?
____ Frequently
____ Sometimes
____ Never
____ Don't care to answer

4. How often do you consume custard?
____ Never
____ Several times in a year
____ Several times in a month
____ Several times in a week

5. What is your race or ethnic background
____ White, not of Hispanic origin
____ African-American, not of Hispanic origin
____ Hispanic/Latino/Spanish
____ American Indian/Alaskan Native
____ Asian or Pacific Islander
____ Don't know/Not sure
____ Don't care to answer

Score Card for Young Adults

Judge#_____ Date______

Taste the samples of baked custard and check the term that best describes how much you like or dislike them

	Sample_____	Sample______
1. Like extremely	____________	_____________
2. Like very much	____________	_____________
3. Like moderately	____________	_____________
4. Like slightly	____________	_____________
5. Neither like or dislike	____________	_____________
6. Dislike slightly	____________	_____________
7. Dislike moderately	____________	_____________
8. Dislike very much	____________	_____________
9. Dislike extremely	____________	_____________

Please check the appropriate response:

1. What is your age?
____ 18-19 years
____ 20-29
____ 30-39
____ 40-49
____ 50-59

2. What is your gender?
____ Female
____ Male

3. Do you experience uncomfortable symptoms (abdominal cramps, gas, and/or diarrhea) after drinking milk or eating dairy products?
____ Frequently
____ Sometimes
____ Never
____ Don't care to answer

4. How often do you consume custard?
____ Never
____ Several times in a year
____ Several times in a month
____ Several times in a week

5. What is your race or ethnic background
____ White, not of Hispanic origin
____ African-American, not of Hispanic origin
____ Hispanic/Latino/Spanish
____ American Indian/Alaskan Native
____ Asian or Pacific Islander
____ Don't know/Not sure
____ Don't care to answer

APPENDIX F
TABLES OF INTERACTION MEANS FOR THE DESSERT TYPE BAKED CUSTARDS (EXPERIMENT I)

Table 15- Interaction means[a] ± standard deviations for nutrient composition of dessert type baked custard mixes

	Formulation					
Nutrient	WM[b] -WE[c]	NFM[d]-WE	LRM[e]-WE	WM-ES[f]	NFM-ES	LRM-ES
Lactose(g/l)	31.33 ± 3.02	32.14 ± 0.53	10.16 ± 2.40	34.34 ± 4.72	34.08 ± 7.49	9.37 ± 1.21
Galactose (g/l)	0.12 ± 0.17	0.16 ± 0.14	12.67 ± 1.47	0.10 ± 0.14	0.18 ± 0.15	13.62 ± 2.17
Protein (g/100 g)	4.56 ± 0.13	4.84 ± 0.03	4.69 ± 0.12	6.04 ± 0.11	6.20 ± 0.16	6.17 ± 0.29
Total fat (g/100 g)	4.16 ± 0.18	2.14 ± 0.05	1.77 ± 0.05	2.23 ± 0.44	0.40 ± 0.05	0.39 ± 0.07
Cholesterol (mg/100 g)	111.29 ± 36.05	83.12 ± 26.42	70.04 ± 17.09	40.65 ± 5.69	7.63 ± 2.01	6.71 ± 0.66

[a] n = 3
[b] WM = whole milk (Kroger Co., Cincinnati, OH)
[c] WE = whole egg (Kroger Co., Cincinnati, OH)
[d] NFM = nonfat milk (Kroger Co., Cincinnati, OH)
[e] LRM = lactose-reduced (70%), nonfat milk (Lactaid Inc., Pleasantville, NJ)
[f] ES = egg substitute

Table 16-Interaction means[a] ± standard deviations for physical properties of dessert type baked custards

Property	Formulation					
	WM[a]-WE[b]	NFM[c]-WE	LRM[d]-WE	WM-ES[e]	NFM-ES	LRM-ES
Top surface						
Hunter "L"	90.71 ± 0.36	86.26 ± 0.99	84.60 ± 1.46	86.36 ± 0.50	74.27 ± 0.94	75.72 ± 0.69
Hunter "a"	-7.66 ± 0.38	-8.81 ± 0.26	-8.58 ± 0.41	-7.03 ± 1.44	-10.13 ± 0.69	-8.08 ± 0.54
Hunter "b"	33.31 ± 2.20	32.17 ± 2.39	33.05 ± 1.61	29.41 ± 5.58	16.73 ± 3.52	21.10 ± 8.04
Bottom surface						
Hunter "L"	91.82 ± 0.14	87.41 ± 0.68	87.45 ±0.78	88.33 ± 0.50	77.30 ± 0.55	79.20 ± 1.00
Hunter "a"	-6.65 ± 0.28	-7.73 ± 0.36	-6.92 ± 0.41	-6.48 ± 0.60	-8.58 ± 0.37	-7.71 ± 0.14
Hunter "b"	22.70 ± 1.47	23.59 ± 2.84	23.47 ± 1.69	16.50 ± 2.20	7.71 ± 1.78	11.00 ± 1.05
Gel strength (g force)	16.33 ± 2.52	14.67 ± 3.06	15.67 ± 0.58	38.67 ± 2.89	31.33 ± 6.81	31.67 ± 4.93

[a] n = 3
[b] WM = whole milk (Kroger Co., Cincinnati, OH)
[c] WE = whole egg (Kroger Co., Cincinnati, OH)
[d] NFM = nonfat milk (Kroger Co., Cincinnati, OH)
[e] LRM = lactose-reduced (70%), nonfat milk (Lactaid Inc., Pleasantville, NJ)
[f] ES = egg substitute

Table 17- Interaction means[a] ± standard deviations for sensory characteristics of dessert type baked custard

	Formulation					
Characteristic	WM[b] -WE[c]	NFM[d]-WE	LRM[e]-WE	WM-ES[f]	NFM-ES	LRM-ES
Appearance						
Brightness of color	11.41 ± 3.22	11.65 ± 2.85	12.09 ± 2.74	7.76 ± 5.12	6.88 ± 4.42	8.14 ± 4.37
Evenness of color	12.81 ± 2.70	12.59 ± 2.41	12.87 ± 2.50	8.52 ± 4.47	8.99 ± 4.60	10.01 ± 4.27
Flavor						
Egg flavor	6.77 ± 3.32	6.87 ± 3.84	5.80 ± 3.72	5.76 ± 3.27	5.71 ± 3.25	5.42 ± 3.57
Aftertaste	7.15 ± 3.97	6.35 ± 3.98	6.89 ± 4.20	4.98 ± 3.09	5.00 ± 3.39	5.07 ± 3.41
Texture						
Firmness	4.00 ± 2.57	3.89 ± 2.63	3.70 ± 3.61	11.52 ± 2.96	10.28 ± 3.27	10.54 ± 3.33
Graininess	1.07 ± 1.58	1.05 ± 1.25	0.90 ± 1.00	8.55 ± 4.07	8.49 ± 4.32	7.07 ± 4.34

[a] n = 45
[b] WM = whole milk (Kroger Co., Cincinnati, OH)
[c] WE = whole egg (Kroger Co., Cincinnati, OH)
[d] NFM = nonfat milk (Kroger Co., Cincinnati, OH)
[e] LRM = lactose-reduced (70%), nonfat milk (Lactaid Inc., Pleasantville, NJ)
[f] ES = egg substitute

Table 18-Interaction means[a] ± standard deviations for hedonic ratings of the dessert type baked custards

	Formulation	
Age Group	LRM[b] - WE[c]	LRM-ES[d]
Elderly adults[e]	7.63 ± 0.92	6.29 ± 1.94
Young adults[f]	5.35 ± 1.92	4.50 ± 1.80

[a] Means based on hedonic scale of 1 = dislike extremely and 9 = like extremely
[b] LRM = lactose-reduced (70%), nonfat milk (Lactaid Inc., Pleasantville, NJ)
[c] WE = whole egg (Kroger Co., Cincinnati, OH)
[d] ES = egg substitute
[e] n = 24 elderly
[f] n = 48 young adults

APPENDIX G
SPECIFICATIONS FOR DRIED CHEDDAR CHEESE FLAVOR POWDER

Cheddar Cheese Flavor Powder (GENAROM™)

Description:

A fine yellowish powder with a typical mid-aged cheddar character. Ingredients include cheese powder (cheddar cheese, romona cheese), cream, salt, $NaP0_4$, lactaid acid, enzyme modified cheese, modified corn starch, yeast extract, and enzyme modified butter fat.

Chemical Standards:

Protein:	23.5%
Fat:	27.8%
Cholesterol:	184.9mg/100g
Carbohydrates:	9.9%

Microbiological Standards:

Standard Plate Count	less than 10,000 / gm, Maximum
Yeast and Mold	less than 1000
MPN E. coli	less than 3/gm
Salmonella	Negative

Genarom Product Code: 4000.1004

Genarom International, 561 Jersey Avenue, New Brunswick, NJ 08901

APPENDIX H
INSTRUCTION SHEET AND SCORECARD USED IN DESCRIPTIVE ANALYSIS OF THE ENTREE TYPE BAKED CUSTARDS

Instructions for Sensory Testing of Entree Type Baked Custards

Read the definition first, recall the reference samples, evaluate the samples by placing a vertical mark across the line. Samples should be swallowed. Rinse your mouth with water between samples.

Reference samples:

Brightness of color: Dull---------------------->Bright
(cheese cake) (vanilla pudding)

Evenness of color: Blotchy------------------->Even
(scrambled eggs) (vanilla pudding)

Cheese flavor: None--------------------->Strong
(milk) (sharp cheddar cheese)

Egg flavor: None------------------------>Strong
(non dairy whipped topping) (scrambled eggs)

Aftertaste: None---------------------->Strong
(milk) (cheese cake)

Firmness: Soft----------------------->Firm
(vanilla pudding) (scrambled eggs)

Graininess: Smooth---------------------->Grainy
(vanilla pudding) (cream of wheat)

Score Card for Entree Type Baked Custard

Judge #_______ Sample #___________ Date________

- Brightness of color - the purity of the yellow color

Dull ———————————————— Bright

- Eveness of color - the distribution of the yellow color

Blotchy ———————————————— Even

- Cheese flavor - the intensity of flavor from cheese perceived while the sample is in the mouth

None ———————————————— Strong

- Egg flavor - the intensity of flavor from egg perceived while the sample is in the mouth

None ———————————————— Strong

- Aftertaste - the intensity of any flavor perceived after the sample is swallowed (it maybe cheese flavor, egg flavor, milk flavor, sourness, saltness, or a combination)

None ———————————————— Strong

- Firmness - the force required to break down the custard between the tongue and palate

Soft ———————————————— Firm

- Graininess - amount of particles perceived on the surface of the tongue

Smooth ———————————————— Grainy

APPENDIX I
TABLES OF INTERACTION MEANS FOR THE ENTREE TYPE BAKED CUSTARDS (EXPERIMENT II)

Table 19- Interaction means[a] ± standard deviations for nutrient composition of entree type baked custard mixes

	Formulation					
Nutrient	WM[a]-WE[b]	NFM[c]-WE	LRM[d]-WE	WM-ES[e]	NFM-ES	LRM-ES
Lactose (g/l)	39.47 ± 1.75	38.30 ± 2.67	10.58 ± 2.22	44.74 ± 1.84	46.38 ± 1.06	12.03 ± 1.21
Galactose (g/l)	0.03 ± 0.04	0.04 ± 0.05	15.03 ± 0.50	0.04 ± 0.05	0.10 ± 0.09	17.74 ± 0.65
Protein (g/100 g)	5.09 ± 0.28	5.14 ± 0.20	5.22 ± 0.44	6.66 ± 0.16	6.75 ± 0.29	6.74 ± 0.23
Total fat (g/100 g)	4.14 ± 0.36	2.23 ± 0.43	1.95 ± 0.47	2.71 ± 0.05	0.60 ± 0.13	0.61 ± 0.12
Cholesterol (mg/100 g)	128.20 ± 20.07	89.51 ± 16.81	68.16 ± 2.88	60.55 ± 9.93	10.61 ± 1.54	11.09 ± 4.65

[a] n = 3
[b] WM = whole milk (Kroger Co., Cincinnati, OH)
[c] WE = whole egg (Kroger Co., Cincinnati, OH)
[d] NFM = nonfat milk (Kroger Co., Cincinnati, OH)
[e] LRM = lactose-reduced (70%), nonfat milk (Lactaid Inc., Pleasantville, NJ)
[f] ES = egg substitute

Table 20-Interaction means[a] ± standard deviations for physical properties of entree type baked custards

	Formulation					
Property	WM[a]-WE[b]	NFM[c]-WE	LRM[d]-WE	WM-ES[e]	NFM-ES	LRM-ES
Top surface						
Hunter "L"	88.68 ± 3.32	87.24 ± 0.27	86.24 ± 0.85	87.76 ± 1.20	76.56 ± 2.25	77.93 ± 3.42
Hunter "a"	-6.13 ± 0.69	-7.34 ± 1.09	-5.21 ± 1.44	-6.81 ± 1.03	-9.70 ± 0.26	-9.12 ± 0.52
Hunter "b"	37.18 ± 4.58	35.62 ± 3.31	39.87 ± 4.62	29.47 ± 2.57	22.98 ± 3.38	25.23 ± 3.27
Bottom surface						
Hunter "L"	93.70 ± 0.21	88.27 ± 0.66	88.27 ± 3.80	89.70 ± 0.57	81.90 ± 2.29	82.58 ± 1.28
Hunter "a"	-6.38 ± 0.31	-7.78 ± 0.25	-6.85 ± 0.56	-6.61 ± 0.42	-8.10 ± 0.12	-8.17 ± 0.16
Hunter "b"	23.01 ± 0.35	25.34 ± 4.07	26.57 ± 4.47	20.80 ± 2.13	12.55 ± 2.10	21.05 ± 3.75
Gel strength (g force)	16.67 ± 1.53	14.67 ± 0.58	14.00 ± 1.73	40.67 ± 2.52	29.33 ± 5.03	32.00 ± 2.00

[a] n = 3
[b] WM = whole milk (Kroger Co., Cincinnati, OH)
[c] WE = whole egg (Kroger Co., Cincinnati, OH)
[d] NFM = nonfat milk (Kroger Co., Cincinnati, OH)
[e] LRM = lactose-reduced (70%), nonfat milk (Lactaid Inc., Pleasantville, NJ)
[f] ES = egg substitute

Table 21- Interaction means[a] ± standard deviations for sensory characteristics of entree type baked custard

	Formulation					
Characteristic	WM[b] -WE[c]	NFM[d]-WE	LRM[e]-WE	WM-ES[f]	NFM-ES	LRM-ES
Appearance						
Brightness of color	11.54 ± 3.30	11.98 ± 2.90	11.89 ± 2.88	7.89 ± 5.45	8.40 ± 5.09	8.26 ± 4.58
Evenness of color	12.16 ± 3.30	12.02 ± 3.20	11.74 ± 3.40	9.95 ± 4.20	9.36 ± 4.57	10.11 ± 4.39
Flavor						
Cheese flavor	7.80 ± 3.42	7.61 ± 3.64	7.28 ± 3.87	4.15 ± 3.08	3.54 ± 2.80	3.73 ± 2.51
Egg flavor	6.52 ± 3.91	5.35 ± 3.19	5.14 ± 3.01	5.18 ± 3.56	4.42 ± 3.10	4.66 ± 3.12
Aftertaste	6.69 ± 4.09	6.45 ± 4.32	6.59 ± 4.19	4.93 ± 3.06	4.32 ± 2.86	4.46 ± 3.17
Texture						
Firmness	2.25 ± 1.87	2.00 ± 2.02	2.01 ± 1.74	9.31 ± 3.36	9.09 ± 3.28	8.59 ± 3.47
Graininess	1.07 ± 1.20	1.14 ± 1.63	1.35 ± 2.09	6.86 ± 4.18	5.78 ± 4.59	5.53 ± 4.41

[a] n = 45
[b] WM = whole milk (Kroger Co., Cincinnati, OH)
[c] WE = whole egg (Kroger Co., Cincinnati, OH)
[d] NFM = nonfat milk (Kroger Co., Cincinnati, OH)
[e] LRM = lactose-reduced (70%), nonfat milk (Lactaid Inc., Pleasantville, NJ)
[f] ES = egg substitute

VITA

Veronica Tong Wu was born in Beijing, People's Republic of China, on October 18, 1969. She attended Beijing No. 3 San Li He Elementary School and Beijing No. 4 Middle School. She graduated from Beijing No. 8 High School in 1988. After graduation, she began undergraduate studies at Jinan University, Guangzhou, in the Department of Biology. In June 1992, she received a Bachelor of Science degree in Biological Engineering. In July 1992, Veronica started a career as an Assistant Engineer in Shen Bao Cola Limited Co., Shenzhen, People's Republic of China.

In January 1994, Veronica came to the United States and started graduate studies at Murray State University, Murray, KY, in the Department of Agriculture. In the fall of 1994, she transferred to Virginia Tech, Blacksburg, VA, where she earned a Master of Science degree in Human Nutrition and Foods in 1996. Veronica is a member of the Institute of Food Technologists.