CATTLEHIDE COLLAGEN IN CAKES

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INTRODUCTION

The problem of feeding the world's rapidly expanding population is of great concern. "World population now increases by 2% *per annum* which means a doubling in only 35 years. Therefore . . . increased production and utilization of proteins for human consumption are critical world needs" (Richardson, 1975, p. 152). Protein foods receive great emphasis because they are so important in the growth and maintenance of healthy tissue, and because they are the most expensive component of the diet. Unfortunately, they are also in short supply in world areas in which they are most needed. The search for untapped sources of protein has led to work with unconventional proteins such as fish protein concentrate, single cell protein, and oilseed proteins such as soybean and cottonseed, among others. Richardson (1975, p. 177) indicates that "a much more intensive research effort will be necessary in the future in order to supplement traditional foods with novel proteins and develop entirely new food systems involving novel proteins".

Another member of this group of novel proteins is hide collagen. The slaughtering of beef creates a tremendous volume of cattlehides. Historically, these hides have been processed and cut into two layers. The outer layer has been used for leather and the inner layer for suede leather, gelatin and glue. The make-up of the inner layer is largely collagen, a "protein [that] has unusual chemical and physical properties including a unique fibrous structure not found in other natural proteins" (Whitmore, Booth, Naghski, and Swift, 1975, p. 101). "Food use of collagen from cattlehide is a concept given impetus from the fact that the two billion pounds now going into leather, gelatin and glue are threatened by commercial production of substitutes" (Whitmore, Jones, Windus, and Naghski, 1970, p. 382).

Hide collagen has been used for some time in the manufacture of sausage casings. Satterlee, Zachariah and Levin (1973) have successfully used collagen as a replacement for nonfat dry milk solids in sausage emulsions. Other suggested uses have been as a binder, moisturizer, filler and also as a nutrient enhancer. The lack of information on the benefits and acceptability of collagen in baked products appears to warrant a study in this area.

Purpose and Objectives

The purpose of this study was to incorporate collagen into a food system, cake, to increase nutritional value, while maintaining acceptable texture, moisture, mouthfeel, and flavor characteristics, and overall acceptability to a trained attribute panel. The objectives of the study were as follows:

1. To assess the effects of collagen on:
   a) nutritional value,
   b) sensory attributes of texture, moisture, mouthfeel, flavor, and overall acceptability, and
   c) objective measurements of moisture, specific volume and tenderness by shear force (kg/g) of cakes.
2. To determine the highest level of collagen in cake which will

be accepted by a trained attribute panel.

3. To make recommendations for further research in this area.

Hypotheses

The following hypotheses were postulated for the study:

H_1: There will be no significant difference in texture, moisture, mouthfeel, flavor, or overall acceptability of control cakes made with standard ingredients and those incorporating 10, 15 or 20 percent collagen.

H_2: There will be no significant difference in specific volume, moisture content, and shear force (kg/g) values of control cakes made with standard ingredients and those incorporating 10, 15 or 20 percent collagen.

H_3: There will be no significant difference in nutritive value of control cakes made with standard ingredients and those incorporating 10, 15 or 20 percent collagen.

Assumptions and Limitations

Assumptions made for the study were as follow:

1. The trained attribute panel will evaluate cakes as instructed.
2. All cakes will be prepared in the food research laboratory under controlled environmental conditions.

The limitations of the study were acknowledged.

1. The collagen used in the study was obtained from Eastern Regional Research Center (ERRC), U.S. Department of Agriculture, Philadelphia, Pennsylvania.
2. Only shortened cakes will be used in this research.

Definition of Terms

The following terms were important to this research:

Baked products--baked flour mixtures such as yeast breads, yeast rolls, biscuits, muffins, cakes, and cookies.

Biological value--

> . . . a measure of the relationship of protein retention to protein absorption on the assumption that more will be retained when the essential amino acids are present in sufficient quantity to meet the needs for growth (Guthrie, 1975, p. 74).

Collagen--"protein that forms the chief constituent of connective tissue, cartilage, tendon, bone, and skin" (Guthrie, 1975, p. 492).

Complete protein--"protein that contain(s) all essential amino acids in proportions capable of promoting growth when [it is] the sole source of protein in the diet" (Guthrie, 1975, p. 57).

Essential amino acid--"an amino acid that must be supplied in the diet to provide the body's need for it" (Robinson, 1977, p. 698).

Fish protein concentrate (FPC)--"any low-cost, stable, wholesome product of high nutritive quality, hygienically prepared from fish, in which the protein and other nutrient materials are more concentrated than they were in the fresh fish" (Stillings and Knobl, 1971, p. 412).

Flavor--"the blend of taste and smell sensations evoked by a substance in the mouth" (Webster's, 1975, p. 437).

Incomplete protein--protein which lacks one or more essential amino acids and thus is unable to provide all the amino acids for synthesis of body proteins (Guthrie, 1975).

Limiting amino acid--the essential amino acid present in a protein in the smallest amount.

Oilseed protein concentrate--product obtained by leaching out of defatted meal soluble materials either with aqueous alcohol, or under acidic conditions where the protein is insoluble. (Cater, Cravens, Horan, Lewis, Mattil, and Williams, 1978).

Oilseed protein isolate--product obtained by treating the defatted meal with an alkaline solution to dissolve the protein and then coagulating it into a curd by shifting the pH to the isoelectric point. (Cater et al., 1978).

Protein efficiency ratio (PER)--". . . the ratio between the weight gain of a growing animal (new tissue formed) and the amount of protein consumed" (Whitney and Hamilton, 1977, p. 533).

Single cell protein (SCP)--"microbial cells from algae, bacteria, fungi, and yeasts [produced] for use as a source of protein" (Lipinsky and Litchfield, 1974, p. 16).

Texture--a composite property related to viscosity, elasticity, and other physical properties of foods which is experienced by the sensation of the mouth skin after ingestion, and by sensations of the finger when touched. (Amerine, Pangborn and Roessler, 1965).

Textured vegetable protein--product made of isolated plant protein spun into fibers and combined with other ingredients to create various food products.

Unconventional protein source--protein source other than the major ones which are cereals, legumes, livestock products, and fish.

CHAPTER II

REVIEW OF LITERATURE

This chapter is a presentation of pertinent literature read by the author to gain a background understanding of the problem of protein malnutrition and to become exposed to research that had been done to develop food systems for alleviating this problem. Literature has also been reviewed in the specific area of collagen.

Protein

A Dutch chemist named Mulder first introduced the term protein, meaning "to take first place" in 1838 (Guthrie, 1975, p. 52). He used it to describe "a nitrogen-containing constituent of food that he believed to be of prime importance in the functioning of the body and without which life is impossible" (Guthrie, 1975, p. 52). Although not considered more important than other nutrients, it is true that proteins are present in every living cell and are vital for tissue synthesis and regulation of body processes. Without protein, the body cannot grow, and continued deprivation causes depletion of established body tissue.

"The shortage of protein is second in importance only to the shortage of calories in the world's food supply" (Robinson, 1977, p. 41). In developing countries, protein-calorie malnutrition is the major health problem. The disturbing results include stunted physical growth and development, possibly retarded mental development, and even death for millions of infants and young children. Other groups plagued by protein deficiency diseases are pregnant and nursing mothers, persons with infectious and parasitic diseases, and persons recovering from an illness.

In 1970, the World Health Organization/Food and Agriculture Organization Joint Expert Committee on Nutrition met to discuss the different aspects of protein-calorie malnutrition. The point was brought out that in developing countries, the percentage of severe protein-calorie malnutrition in children below five years of age range from 0 to 7.6. At the same time, levels of moderate protein-calorie malnutrition may be between 4 percent and 43 percent. The committee's conclusion has been stated as follows:

> It is clear from the above information that it is difficult to provide at the present time even a rough estimate of the total number of malnourished children in the world, although it is obvious to everyone concerned that malnutrition in its different forms is widely prevalent in most developing countries (Aylward and Jul, 1975, p. 24).

One reason for the high rate of protein-calorie malnutrition in many countries has been the shortage of protein of high biological value. A protein of high biological value, also called a complete protein is one which contains "all essential amino acids in proportions capable of promoting growth when they are the sole source of protein in the diet. . ." (Guthrie, 1975, p. 57). Only animal proteins contain all the essential amino acids which are threonine, valine, leucine, isoleucine, phenylalanine, tryptophan, methionine, and lysine. Countries which have diets with most of the protein from sources other than animal are most likely to have an incidence of protein-calorie malnutrition. In India, for example, 59 percent of the protein supply come from grain, 27 percent from legumes, oilseeds, and nuts, and only 12 percent from animal protein. The United States diet, in contrast, is made up of 16 percent protein from grain, 5 percent from legumes, oilseeds, and nuts, and 70 percent from animal protein (Abbott, 1966).

Greater utilization of protein may be achieved by eating a combination of foods with protein of low biological value, or incomplete proteins. Most cereals are deficient in lysine and threonine, while most legumes are low in methionine. Therefore, when foods from both of these groups are eaten together, the amino acid deficiencies in one are compensated for by the other. In some countries, such as those in Central America, this dietary pattern has been followed for hundreds of years, by eating corn and beans together. Not all countries have the foods available, however, which combine well for maximum protein utilization. In fact, "in the face of increasing population growth, the continuing need for more energy foods leads to the planting of higher-yielding cereals and roots and tubers, and militates against growing the lower-yielding legumes" (Forman and Hornstein, 1976, p. 242). Much research has been done to improve the protein content of readily available, inexpensive foods.

Protein Supplementation of Baked Products

Baked products are an excellent media for increasing protein intake. Wheat flour, the principal flour used in baked products, is deficient in the amino acid lysine, hence it is desirable to add sources of protein which supply this amino acid, and raise the level and quality of protein in the product. Some of the major unconventional protein sources which are being experimented with for this purpose are the oilseeds, single cell protein, and fish protein concentrate. One of the lesser known unconventional protein sources being studied by researchers is collagen.

Oilseeds

The major oilseeds are soy, cottonseed, peanut, safflower, sunflower, and coconut. The soybean has played a vital role in human diets in Asia, where it originated, for centuries. For instance, soybean products provide 12 to 13 percent of the dietary protein in Japan. In the United States, however, soybean production began mainly as a new source of edible oil, which had been in short supply during World War I. The defatted meal left after processing began to be used in animal feeds, and is now the major source of protein used in feeding poultry and livestock. Only about 1.5 percent of the defatted meal goes into the human food supply (Circle and Smith, 1975). Soybean used in human diets has advantages in that it has a good amino acid content and nutritive value. Soy flour contains 56 percent protein, concentrates-72 percent, and isolates-96 percent; however, they are deficient in the amino acid methionine. Soybeans also have a definite beany flavor and odor, and although it has been accepted in Asia, this flavor has not been accepted in the United States.

Many researchers have experimented with baked products using soy flour and soy protein concentrate. It has been reported by Finney, Bode, Yamazaki, Swickard, and Anderson (1950) that breads with excellent loaf volume and crumb grain may be made with substitution of 8 percent soy flour for hard winter wheat flour; however, palatability scores show a markedly higher score for flavor of the all-wheat control bread. Protein supplementation of chapati, an unleavened, wheat flour bread which is the staple food in West Pakistan, has been studied by Bass and Caul (1972). A six-member trained flavor profile panel has shown bread supplemented with 10 and 15 percent soy protein concentrate to be unacceptable for aroma, flavor and aftertaste characteristics. The 5 percent level, however, was acceptable. Sproul (1975) has reported on a study of muffins, butterscotch bars and applesauce cake enriched with the oilseed flours soy, cottonseed and peanut. The soy flour products were the most acceptable of the enriched products for flavor, texture and overall acceptability, however, they were preferred less than the control.

Cottonseed, a byproduct of cotton production, is processed for oil, with the remaining meal going into animal feed and fertilizer. Even less cottonseed meal than soybean meal goes into human food. Only one processor in the United States is currently producing a food-grade cottonseed flour, compared with 12 companies which produce soy products such as flour, concentrates, isolates, and textured products. This flour is used as a food additive because of its moisture binding abilities, which improve shelf life and control spread in cookies, and reduce fat absorption in doughnuts. The major disadvantage of the flour is that it contains the pigment gossypol, which imparts a yellowish brown color, and can therefore be used only in small amounts. In addition, the heat process which is necessary to inactivate gossypol's toxicity, causes it to bind with lysine, thus lowering the availability of this amino acid. Researchers have now developed a glandless cottonseed which does not contain gossypol. Its protein content is 65 to 68 percent, and its PER is equal to that of casein. In addition, it is light cream in color.

Staats and Tolman (1974) have experimented with supplementation of saltine crackers with a glandless cottonseed protein concentrate, a degladed cottonseed protein concentrate, and a storage cottonseed protein isolate. The glandless cottonseed protein concentrate was the most acceptable to a six-member taste panel for exterior appearance, interior appearance, crispness, tenderness, and flavor. The 20 percent level compared favorably with the control, which contained no protein concentrate. Protein levels were more than doubled in the crackers with supplementation. Bacigalupo, Aguilar, Luna de la Fuente, and Riestra (1967) reported on the addition of Protal, a cottonseed protein concentrate, to white wheat flour for breadmaking. Levels of 0, 5, 10, 15, 20, and 25 percent Protal have been studied. Results showed that enrichments of 5 to 10 percent Protal were acceptable in terms of flavor, texture, volume, and color. The color was similar to that of whole wheat bread. Nutritive value was raised significantly from a PER of 0.83 for the control to 0.98 for 5 percent and 1.08 for 10 percent.

Around three-fourths of the peanuts grown in the United States go into human food, mainly peanut butter; however, this is not true worldwide. For example, India, which produces one-third of the world's peanuts, only utilizes 10 percent or less as food. In the United States, production has increased faster than consumption, creating the need for larger markets for peanuts. Surplus peanuts are now used for edible oil and peanut meal for animal feed. Peanut meal contains 50 to 55 percent protein. Peanut proteins are highly compatible with bread dough systems because of their white color and bland flavor; however, because they contain low levels of lysine, threonine, and methionine, they have lower nutritional value than soy and cottonseed proteins.

Khan, Rhee, Rooney, and Cater (1975) have compared the baking properties of peanut protein concentrate with commercial defatted peanut flour, experimental defatted peanut flour, and full fat soy flours. Results indicated that substitutions of greater than 10 percent in a bread formula reduced the volume of the loaf significantly compared to bread with substitutions of the other protein sources. Flavor and crumb color of the bread with peanut protein concentrate have been rated superior to the others by a six-member taste panel.

The cultivation of safflower for its edible oil is centuries old. India and the United States are world leaders in production of safflower. The meal remaining after oil extraction is used in animal feed. Analysis of the amino acid composition of safflower shows that lysine is limiting, and that methionine and isoleucine are at low levels. Safflower has a distinctive bitter flavor and a high fiber content, both of which must be reduced in order to produce an acceptable high protein flour or concentrate. Protein determination of experimental safflower seed products developed shows that flour contains 67 percent protein, defatted meal-64 percent, and concentrate-81 percent. Matthews, Sharpe, and Clark (1970) report the effects of adding safflower seed flour on dough and bread performance, however sensory evaluations have not been reported.

The sunflower has been an important oilseed crop just since the early nineteenth century. The United States has only in recent years begun its commercial production as an oilseed, although it is of great importance in Russia and eastern Europe. Defatted meal remaining after oil extraction is used as an animal feed. It contains 46.8 percent protein. Experimentally, isolates and concentrates for human consumption have been prepared. These contain 90 to 96 percent and 52 to 55 percent protein, respectively. Limiting amino acids are lysine and isoleucine. A dark greenish-brown color is present in the isolate. The sunflower meal, however, has a creamy color, and a pleasing nutty flavor, and thus has potential as a human food.

Fleming and Sosulski (1977) reported on the breadmaking properties of sunflower concentrate added to wheat flour. Loaf volume, specific volume, crumb grain, crumb compressibility, and loaf shape all deteriorated with the addition of 12 percent sunflower concentrate; however, acceptable bread was produced with the concentrate by adding dough conditioners.

Coconut is a product of a palm tree which grows in the tropics. It is sold as it is, as extracted oil, or as desiccated coconut. Although there is potential for coconut to be used as a protein for human use, the traditional method of oil extraction, which is unsanitary, leaves the meal suitable only for animal feed. New methods have been developed experimentally for preparing isolates and flour.

A study was conducted by Chastain, Sheen and Cooper (1975) to formulate an acceptable bread supplemented with coconut flour, which has increased nutritional value. Results showed that a loaf with up to 20 percent coconut flour was acceptable for color, grain, texture, flavor, and general acceptability to a six-member taste panel. The protein content of the bread was increased from 11.39 percent in the all-wheat control to 12.67 percent in the 20 percent level of coconut flour substituted for wheat flour.

Single Cell Proteins

Single cell protein (SCP), which includes bacteria, yeast, molds, and algae, has been undergoing development as a supplement to the world protein source for over a decade. When produced from nonagricultural raw materials, SCP is a completely synthetic source of food with a controlled composition. The various substrates which have been studied for growth of SCP are paraffins and gas-oil, alcohol, cellulose, starch, and sugars. The advantages and disadvantages of each substrate depend mainly upon the availability and cost in various countries. Those countries which need additional protein for animal feed may find SCP to be a possible solution to the problem.

Human use of SCP has focused mainly on yeast, probably because of its familiarity. Yeast, as well as other types of SCP, is 60 to 65 percent protein. It is limiting in methionine, but when supplemented, its biological value is increased to approximately the level of egg. Characteristics of poor flavor and acceptability have limited the use of yeast SCP as a major source of protein. SCP is utilized in the food industry in such applications as emulsifier, flavoring agent and nutrient supplement. Suggested applications for future use of SCP have been as extenders for ground meat and frankfurters, in fabricated foods similar to those now made from soy fibers, and as protein enrichment for baked products (Lipinsky and Litchfield, 1974).

Zabik and Garrison (1975) have studied baker's yeast as a protein supplement in corn meal muffins. A five-member trained taste panel found the 10 percent level of supplementation to be very similar to the control for surface appearance, interior crumb color, texture, tenderness, moistness, and flavor. The 20 and 30 percent levels received lower color and flavor scores than those of the control. All muffins, however, were given scores of 4 or higher on a 7 point descriptive scale, with 7 the optimum score. The protein increased approximately one gram for each 10 percent addition of baker's yeast to the muffins. Zouranjian (1979) studied the effects of three different yeast single cell proteins on all-purpose and whole wheat muffins. Substitutions for the flour at the four, seven and nine percent levels were made for each yeast. An eight-member trained attribute panel ranked the muffins for appearance, mouthfeel, flavor, and overall acceptability. Results showed that one type of yeast, Toruway-49, was acceptable in both all-purpose and whole wheat muffins up to the nine percent level; Torutein-LF was acceptable in both types of muffins up to the seven percent level; and Boost-100 was acceptable up to the seven percent level in all-purpose and nine percent level in whole wheat muffins. Protein levels rose significantly with the addition of the yeasts.

Fish Protein Concentrate

From all available evidence, it can be concluded that fish has been used as human food since before recorded history. Two methods of preserving surplus fish, by making forms of fish protein concentrate (FPC), were developed in the West over 2,000 years ago. The first method was developed by a community of people living on the coast of the Persian Gulf. They prepared fish by drying in the sun and pounding it into a flour for making bread. The other process came from Greece and Rome. A type of fish sauce, called liquamen was manufactured from small fish that would be otherwise useless and unsaleable.

In later years, attempts have been made in various countries to utilize surplus fish through FPC. For example, in 1937, South Africa made an attempt to introduce FPC to certain native population groups who had inadequate protein intakes. The project was discontinued, however, because of a lack of public interest. Other countries, including the United States, have had similar experiences. Some FPC is used in Sweden in bakery products.

FPC processed from deboned fish contains about 90 to 95 percent protein. It is odorless, tasteless, and colorless. Kvitka (1972) conducted a study on the acceptability and quality of whole wheat bread, peanut butter cookies, whole wheat muffins, and date nut bars supplemented with FPC. Results showed that, generally, levels of up to 5 percent supplementation were acceptable for appearance, texture, flavor, and overall acceptability; however, the overall quality became less acceptable as the level of FPC increased. Several studies have been reported by Sidwell, Stillings and Knobl (1970) in which FPC was added to bread, pasta, crackers, cookies, soups, tortillas, and beverages. Foods with 5 percent FPC were found to be very acceptable; but with higher levels of supplementation, variations in organoleptic characteristics were noted. These studies have shown that the quality and quantity of the protein in the product may be markedly improved with FPC supplementation.

Collagen

"Considerable quantities of collagen are available each year in the form of limed cattlehide parts unsuited to the manufacture of leather" (Whitmore et al., 1975, p. 101). This surplus collagen has in the past been used mainly in production of gelatin and glue. The development of substitutes for making these products has created the need for new uses of collagen. Food use has been suggested as a binder, texturizer, and also as a nutrient enhancer. The food industry has been using collagen in the manufacture of sausage casings for some years. Experimental use of collagen as a replacement for nonfat dry milk in binding and extending sausage emulsions has been reported as acceptable by Satterlee, Zachariah and Levin (1973).

Collagen fed to rats as the only protein source does not support life (Happich, Whitmore, Feairheller, Taylor, Swift, Naghski, Booth, and Alsmeyer, 1975). It lacks the amino acid tryptophan and is limiting in the essential amino acids lysine, threonine, and methionine. Table I shows the amino acid composition of collagen and lean beef. Moisture-free collagen is 91.5 percent protein (Happich et al., 1975).

Food-grade collagen comes from hides of inspected beef. Processing is done at the Eastern Regional Research Center (ERRC), U. S. Department of Agriculture, Philadelphia. The procedure followed by the ERRC begins with the purchase of limed flesh splits from tanneries. The splits are cut into 3/8 inch wide strips by a rotary strip cutter. The strips are then cut across by a rotary knife cutter and are less than one inch square. These pieces are then acidified in stainless steel tanks containing a solution of water, propionic acid and benzoic acid. After soaking for about four hours, the desired pH is reached, and the water is drained out.

Comminution of the hide takes place next. The Urschel "Comitrol" and a disc mill are the two types of grinders used to produce five products which vary in size and structure of particles. Variations in grinding procedures yield the different products which are suitable for

TABLE I

COMPOSITION OF COLLAGEN AND LEAN BEEF[1]

Amino Acid	Collagen	Lean Beef
	Essential amino acids	
Isoleucine	1.6	5.0
Leucine	3.0	8.3
Lysine	3.7	8.8
Methionine	0.7	2.6
Cystine	-	1.3
Phenylalanine	2.1	4.9
Tyrosine	0.9	3.9
Threonine	1.9	4.4
Tryptophan	-	1.3
Valine	2.3	5.5
	Nonessential amino acids	
Alanine	8.6	6.0
Arginine	8.6	6.5
Aspartic acid	5.7	9.6
Glutamic acid	10.2	15.7
Glycine	21.5	4.9
Histidine	0.8	3.6
Hydroxylysine	1.3	-
Hydroxyproline	10.8	-
Proline	13.3	4.2
Serine	3.0	3.6

[1]Grams of amino acid residue per 100 grams of total amino acid residues.

Source: Happich et al., Journal of Food Science (1975).

incorporation in various food systems. Product # 1 is obtained by grinding in the "Comitrol" with the 0.06 inch cutting head. Grinding Product # 1 with the microcut head of the "Comitrol" yields Product # 2. Product # 3 comes from processing Product # 1 in the disc mill. The 0.20 inch cutting head of the "Comitrol", and the disc mill are used to produce Product # 4. Product # 5 is ground only by the disc mill. Each of the five products is canned in wet form in # 10 cans and frozen. Some freeze-drying and air-drying of Product # 1 has also been done.

The literature shows that some work has been done to incorporate surplus collagen into food systems such as sausage, both in casings and emulsions. The tremendous volume of hides which is available, however, and the lack of reported studies on supplementation of baked products with collagen has created the need for such a study.

CHAPTER III

RESEARCH PROCEDURES

This study was developed to assess the effects of adding collagen on nutritive value and certain organoleptic and objective properties of carrot cake and applesauce cake. The research design, panel selection and training, instrumentation, and experimental procedures and materials are presented in this chapter.

Research Design

Experimental research in the laboratory was used to test the hypotheses, employing collagen as the independent variable. The randomized, complete block design was used. Randomization was achieved by randomizing the position in which the cakes were placed in the oven, the piece of cake assigned to each judge and the order in which the samples were presented to the judges. Judges evaluated samples of each treatment at each session, including a standard, 10 percent added collagen, 15 percent added collagen, and 20 percent added collagen, based on the weight of the flour.

Selection and Training of Taste Panel Members

Through personal contact, eight potential panelists were asked to participate in preliminary tests to evaluate the nature and acceptability of collagen in cakes. At the time of initial contact they were told the times the panel would meet and the length of the study. Final panelists were chosen on the basis of the results of three taste tests. The first test measured the person's ability to differentiate between the four basic tastes (sweet, sour, salty, and bitter). Above-threshold solutions of sucrose, salt, citric acid, and quinine sulfate were tasted and identified by the panelists. The second test was a triangle test in which panelists were asked to choose the sample which was different when presented two sucrose solution samples and one sample of salt solution. The panelists were next given a triangle test with two cake samples without collagen, and one with 20 percent collagen. All panelists were able to pass these tests.

The eight panelists were instructed on the use of the scorecard. Meanings of terms used on the scorecard were explained. The characteristics of high quality cakes (Appendix A) were listed and given to each panelist, as well as being posted on the wall of each tasting booth. A standard cake product was shown and tasted during the training period. Time for questions and discussion was allowed.

After the initial training period, scoring of cakes was done to give panelists experience with the instrument. While turning in scorecards, panelists were again asked to bring up any questions or problems for clarification.

The panel met at 3:00 p.m. for four days to evaluate each type of cake. Evaluations took place in a well-lighted sensory evaluation room equipped with separate carrels, adjacent to the preparation area. Distilled water was provided for rinsing the mouth between samples.

Instrumentation

The sensory testing system used for the study was scoring as described by Amerine, Pangborn and Roessler (1965). The instrument (Appendix A) was developed specifically for the study based on similar ones used for different food products. Other instruments were used in preliminary experiments, but none met the exact requirements needed for the study. Members of the Food, Nutrition and Institution Administration research faculty evaluated and approved the instrument. Faculty and graduate students used the instrument in preliminary experiments to evaluate cake samples. Validity was established in that the instrument measured the characteristics stated in the objectives; texture, moisture, mouthfeel, flavor, and overall acceptability of cakes.

Product Development

Air-dried collagen was obtained from Eastern Regional Research Center, U.S. Department of Agriculture, Philadelphia, Pennsylvania. The ERRC method of drying the collagen begins with frozen Product #1 (Figure 1), which is thawed in the cans for approximately 24 hours in warm water. A tray dryer manufactured by the National Drying Machinery Company is used at a temperature range of 120-130 degrees F. Thawed collagen is placed in the trays at a depth of one-half inch and dried for approximately 24 hours. Several hours into the drying period, the partially dried collagen is broken into smaller pieces to facilitate drying.

After drying, the collagen pieces are further comminuted using a comminuting machine with 0.1875 inch holes, manufactured by the W.J.

Fitzpatrick Company. Another grinding is done using the 0.06 inch head of the Urschel "Comitrol". This finished product (Figure 2) is then packaged and shipped. Other ingredients for applesauce cake and carrot cake were purchased at a local supermarket.

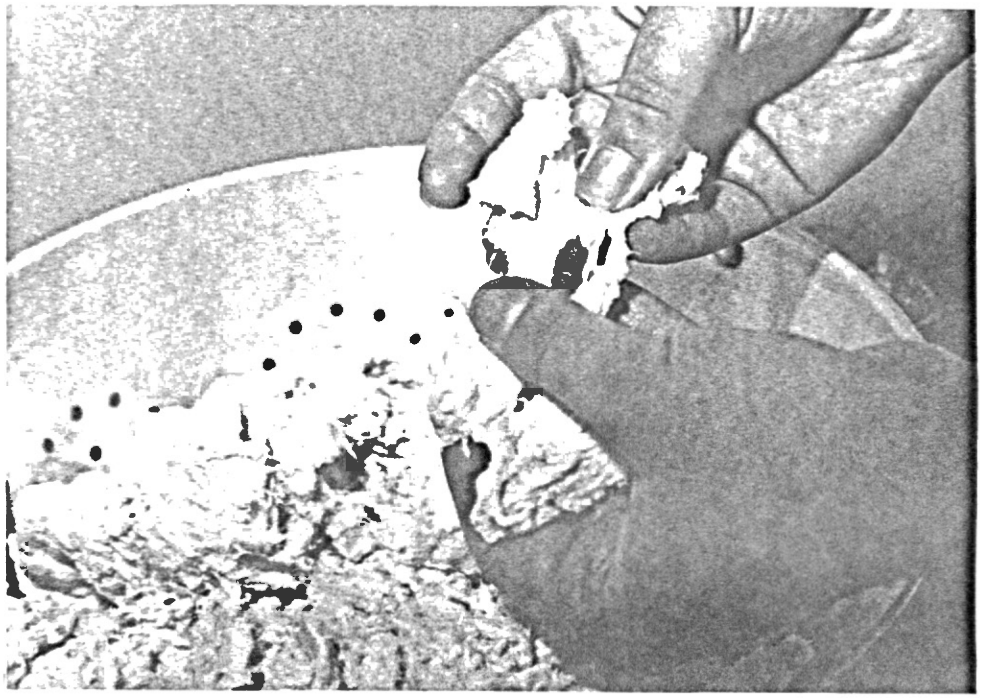


Figure 1. Frozen Collagen

Two types of cakes, white shortened cake and applesauce cake, were supplemented with collagen in preliminary experiments. Observations revealed that white cake was not well-suited for collagen supplementation because of collagen's granular nature. Applesauce cake, which contained nuts and raisins in the formula, was an acceptable product when tasted by four individuals on three occasions. Therefore, another nut cake, carrot cake, was selected to study along with applesauce cake. The carrot cake formula contained oil, and thus produced a moister, more tender product than the applesauce cake formula, which contained solid shortening. Both formulas were studied in order to widen the possible applications of adding collagen to other food systems.

Figure 2. Air-dried Collagen

The formula for applesauce cake was from Betty Crocker's Cookbook (1978, p. 235) (Appendix B). The carrot cake formula (Appendix B) was a home recipe. Both were converted to grams and procedures were developed

(Appendix B). All ingredients were weighed on a Mettler PC4400 electronic top-loading precision balance. Mixing was done with a Kitchen Aid Mixer Model K45. Cakes were baked in a General Electric Model CN50 automatic deck oven, using 8-inch square aluminum cake pans sprayed with non-stick vegetable spray.

On each test day, eight cakes were prepared; two standard, two with 10 percent collagen, two with 15 percent collagen, and two with 20 percent collagen, based on the weight of the flour. One cake from each pair was used for sensory evaluation, the other for objective tests. Based on preliminary study, one gram of liquid was added per gram of collagen.

After removing from the oven, cakes were cooled for 10 minutes on racks before being removed from pans. Completely cooled cakes were cut into 1 1/2 inch square samples, placed on coded white plates and covered with plastic film for sensory evaluation.

Tenderness by shear force (kg/g) was recorded using the Kramer shear cell of the Instron Universal Testing Instrument Model 1122. Four samples of 1 1/2 inch square from each cooled cake were weighed to the nearest 0.01 gram and chilled for 15 minutes before shearing. Samples were sheared one hour after removal from oven. Volume by rapeseed displacement was measured for whole cakes, and specific volume was calculated. Moisture was determined after drying a 2 gram sample for 24 hours at 105 degrees C. Cake appearance was recorded by means of photography to show crumbface and volume.

Analyses of Data

An analysis of variance determined if a significant difference existed between treatments, panelists and replications for both types of cake. A Duncan's multiple range test determined the location of significant differences. The Statistical Analysis System (SAS) (Barr and Goodnight, 1972) was used to analyze the data.

CHAPTER IV

RESULTS AND DISCUSSION

Air-dried collagen was incorporated into two types of cake, applesauce and carrot, and evaluated by a trained attribute panel of eight for texture, moisture, mouthfeel, flavor, and overall acceptability. The purpose was to increase nutritional value of the cakes while maintaining acceptable organoleptic characteristics. Objective tests including tenderness by shear force (kg/g), moisture determination and specific volume were performed. This chapter presents the data analyses to determine if there were differences in cakes with collagen added and those without collagen.

Sensory Evaluation of Applesauce Cake

Results of the analysis of variance for the sensory evaluation of applesauce cake are presented in Table II. A significant difference ($p < 0.05$) due to collagen level was discerned for moisture, mouthfeel, flavor, and overall acceptability; however, no significant difference was found for texture. The effect of day of experiment was significant ($p < 0.05$) for texture and flavor, but not for moisture, mouthfeel and overall acceptability. Panelist and collagen level interaction affected only mouthfeel significantly ($p < 0.05$); and all attributes were affected significantly ($p < 0.05$) by panelist.

Table III shows mean taste panel scores and Duncan's multiple range

TABLE II

ANALYSIS OF VARIANCE FOR SENSORY EVALUATION OF APPLESAUCE CAKE

Attribute	Source	DF	Mean Squares	F Value	Observed Significance Level
Texture					
	Day	3	0.3473	0.2679	0.8487
	Panelist	7	20.1607	15.5528	0.0001
	Collagen Level	3	2.5106	1.5944	0.1969
	Panelist x Collagen Level	21	1.3601	0.8637	0.6354
Moisture					
	Day	3	5.6583	4.4259	0.0145
	Panelist	7	10.6509	8.3311	0.0002
	Collagen Level	3	18.0904	22.1243	0.0001
	Panelist x Collagen Level	21	1.1484	1.4045	0.1456
Mouthfeel					
	Day	3	5.6109	7.8018	0.0014
	Panelist	7	7.1432	9.9324	0.0001
	Collagen Level	3	21.1095	24.8278	0.0001
	Panelist x Collagen Level	21	1.5068	1.7722	0.0385
Flavor					
	Day	3	0.8761	0.5934	0.6297
	Panelist	7	5.4221	3.6726	0.0097
	Collagen Level	3	15.8739	15.4600	0.0001
	Panelist x Collagen Level	21	0.6874	0.6695	0.8485
Overall Acceptability					
	Day	3	3.7622	3.6474	0.0287
	Panelist	7	4.9717	4.8200	0.0026
	Collagen Level	3	28.3822	27.4381	0.0001
	Panelist x Collagen Level	21	1.4431	1.3951	0.1502

TABLE III

MEAN TASTE PANEL SCORES[1] FOR APPLESAUCE CAKE MADE WITH VARIOUS LEVELS OF COLLAGEN ADDED[2]

Collagen Level	Variable				
	Texture	Moisture	Mouthfeel	Flavor	Acceptability
None	4.828^{a}	5.756^{a}	5.838^{a}	5.922^{a}	5.972^{a}
10%	4.781^{a}	4.488^{b}	4.591^{b}	4.841^{b}	4.450^{b}
15%	4.231^{a}	4.263^{b}	4.088^{c}	4.375^{b}	4.019^{b}
20%	4.472^{a}	4.106^{b}	4.150^{bc}	4.494^{b}	3.953^{b}

[1]Seven-point descriptive scale with 7 being the optimum score.

[2]Values within column having no letter in common are significantly different ($p < 0.05$).

test for applesauce cake. The standard was scored higher on all attributes than were the cakes with collagen. Only the variable texture showed no significant difference ($p < 0.05$) between cakes with collagen and those without collagen. For all other attributes, a significant difference ($p < 0.05$) between the standard and the 10, 15 and 20 percent collagen levels was detected. A significant difference ($p < 0.05$) was also perceived between the 10 and 15 percent collagen levels for the characteristic mouthfeel.

Sensory Evaluation of Carrot Cake

The results of the analysis of variance for sensory attributes of carrot cake are recorded in Table IV. For the attributes texture,

TABLE IV

ANALYSIS OF VARIANCE FOR SENSORY EVALUATION OF CARROT CAKE

Attribute	Source	DF	Mean Squares	F Value	Observed Significance Level
Texture					
	Day	3	0.7817	0.4690	0.7105
	Panelist	7	4.8609	2.9163	0.0267
	Collagen Level	3	8.3565	9.3334	0.0001
	Panelist x Collagen Level	21	1.5611	1.7436	0.0429
Moisture					
	Day	3	0.6580	0.8234	0.5020
	Panelist	7	3.0505	3.8172	0.0081
	Collagen Level	3	1.6218	2.4940	0.0656
	Panelist x Collagen Level	21	0.9158	1.4083	0.1438
Mouthfeel					
	Day	3	1.0806	1.1078	0.3688
	Panelist	7	7.4175	7.6038	0.0003
	Collagen Level	3	11.6858	24.0309	0.0001
	Panelist x Collagen Level	21	1.3076	2.6890	0.0012
Flavor					
	Day	3	1.1738	1.1776	0.3423
	Panelist	7	6.1594	6.1787	0.0007
	Collagen Level	3	7.7555	6.8911	0.0006
	Panelist x Collagen Level	21	0.9373	0.8329	0.6724
Overall Acceptability					
	Day	3	0.9340	0.7855	0.5178
	Panelist	7	6.8384	5.7516	0.0011
	Collagen Level	3	9.6460	11.4484	0.0001
	Panelist x Collagen Level	21	1.1099	1.3172	0.1937

mouthfeel, flavor, and overall acceptability, the differences due to collagen levels were significant ($p < 0.05$). Moisture differences due to collagen levels were significant at the 0.1 level. All the organoleptic traits were significantly affected ($p < 0.05$) by panelist. This was expected in that some panelists generally rated all cakes, including the standard, lower for all attributes than did other panelists. The interaction between panelist and collagen levels affected texture due to the fact that panelists were not in agreement as to which cake should be rated highest for each attribute. Day of experiment had no significant effect on any of the attributes.

Mean taste panel scores of carrot cake for each level of collagen for the five sensory attributes are shown in Table V. As with the applesauce cake, the standard was scored highest on all attributes. The results of Duncan's multiple range test indicate that there is a significant difference ($p < 0.05$) between the standard and the 10, 15 and 20 percent levels for texture, mouthfeel, flavor, and overall acceptability. For moisture, there was a significant difference ($p < 0.05$) between the standard and the 10 and 20 percent levels, but not the 15 percent level. Texture, moisture, flavor, and overall acceptability were not significantly different ($p < 0.05$) in the 10, 15 and 20 percent levels; however, for mouthfeel, there was a significant difference ($p < 0.05$) between the 10 and 20 percent levels.

Objective Evaluation of Applesauce Cake

The analysis of variance for tenderness by shear force (kg/g) of applesauce cake is presented in Table VI. These values were significantly affected by collagen level at the 0.0001 level. Table VII shows that these significant differences were between the standard and 10, 15 and 20 percent levels, and between the 10 and 15 percent levels. Figure 3 illustrates the relationship between the increase in collagen level, and the rise in shear force (kg/g) values. No significant differences ($p < 0.05$) between cakes with collagen and those without collagen were found in terms of moisture (Table VIII). Similar results were obtained from the specific volume data for applesauce cake (Table IX). Visible variations in volume and crumbface of the four cakes were minimal (Figure 4). The dark spots in the crumbface are raisins.

TABLE V

MEAN TASTE PANEL SCORES[1] FOR CARROT CAKE MADE WITH VARIOUS LEVELS OF COLLAGEN ADDED[2]

Collagen Level	Variable				
	Texture	Moisture	Mouthfeel	Flavor	Acceptability
None	5.763^{a}	6.272^{a}	6.125^{a}	6.088^{a}	5.969^{a}
10%	4.566^{b}	5.809^{b}	5.369^{b}	5.194^{b}	5.122^{b}
15%	4.888^{b}	5.881^{ab}	5.044^{bc}	5.128^{b}	4.934^{b}
20%	4.925^{b}	5.794^{b}	4.713^{c}	5.019^{b}	4.713^{b}

[1]Seven-point descriptive scale with 7 being the optimum score.

[2]Values within column having no letter in common are significantly different ($p < 0.05$).

TABLE VI

ANALYSIS OF VARIANCE FOR TENDERNESS BY SHEAR FORCE (KG/G)

Source	DF	Mean Squares	F Value	Observed Significance Level
Applesauce Cake				
Day	3	1.4521	6.1814	0.0015
Collagen Level	3	2.4052	10.2388	0.0001
Day x Collagen Level	9	0.2124	0.9041	0.5298
Carrot Cake				
Day	3	0.2490	7.2085	0.0007
Collagen Level	3	0.3900	11.2890	0.0001
Day x Collagen Level	9	0.0503	1.4562	0.1913

TABLE VII

MEAN VALUES FOR OBJECTIVE MEASUREMENTS OF APPLESAUCE CAKE[1]

Collagen Level	Analysis Procedure		
	Tenderness by Shear Force (kg/g)	Moisture (%)	Specific Volume (ml/g)
None	2.7286[a]	51.8330[a]	1.6040[a]
10%	3.2196[b]	52.8940[a]	1.6067[a]
15%	3.3971[bc]	52.3440[a]	1.5900[a]
20%	3.6458[c]	52.3877[a]	1.5797[a]

[1]Values within column having no letter in common are significantly different ($p < 0.05$).

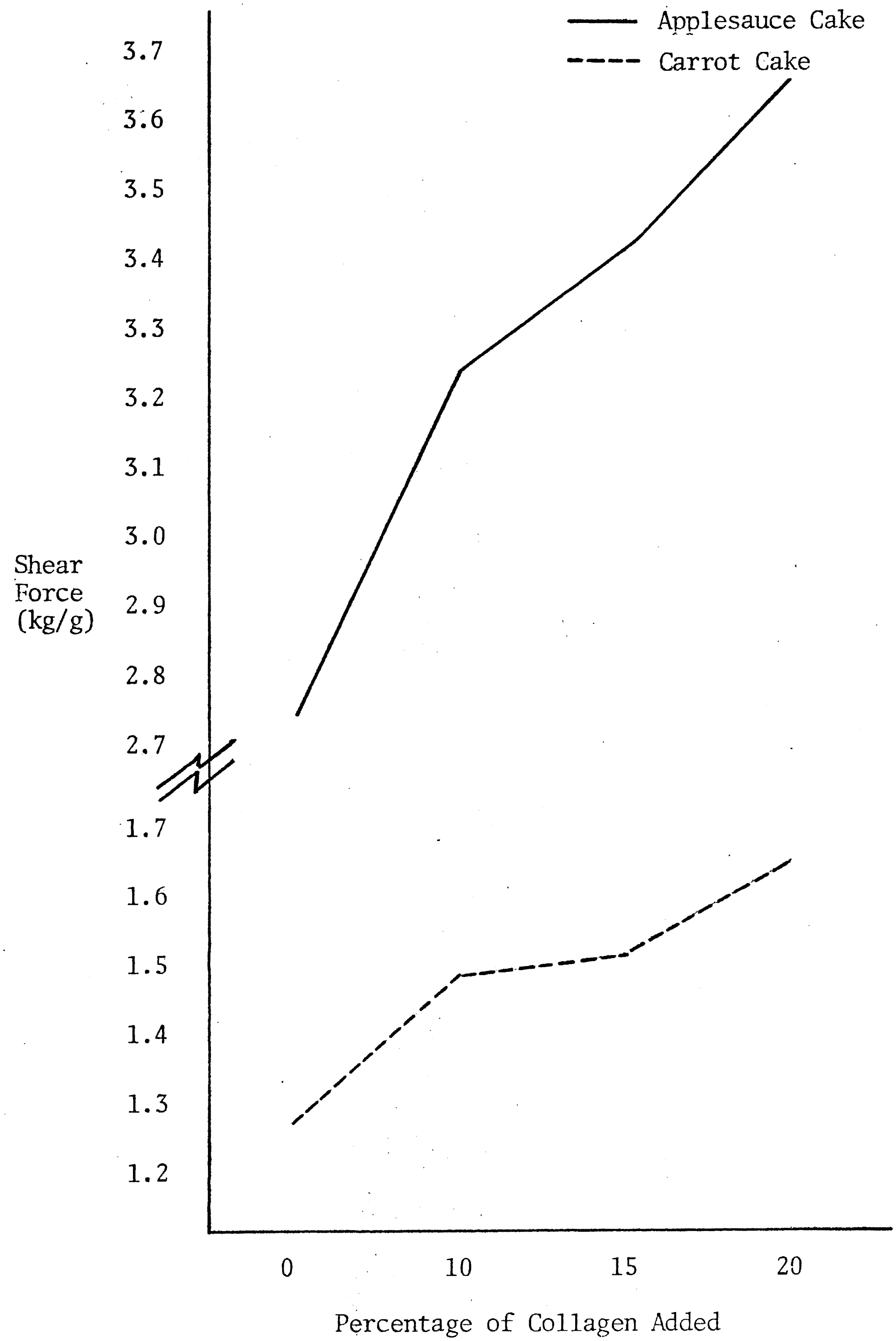


Figure 3. Tenderness by Shear Force (kg/g) for Cakes with Collagen Added

TABLE VIII

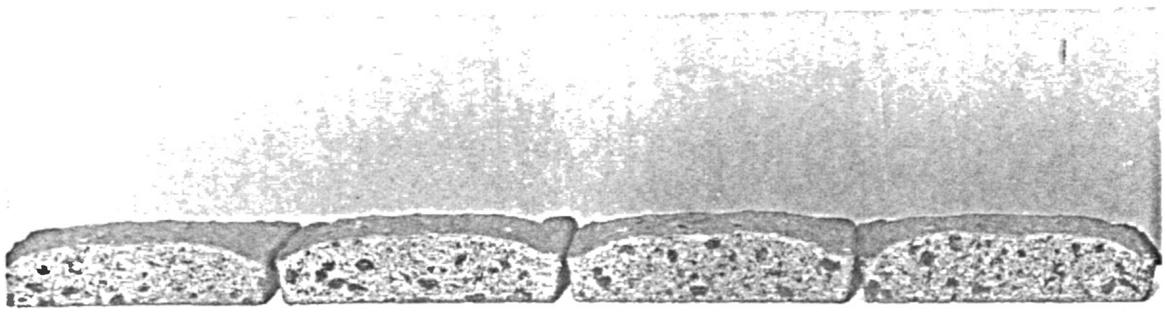
ANALYSIS OF VARIANCE FOR MOISTURE (%)

Source	DF	Mean Squares	F Value	Observed Significance Level
Applesauce Cake				
Day	2	0.4675	0.4425	0.6651
Collagen Level	3	0.5638	0.5337	0.6781
Carrot Cake				
Day	2	17.3736	1.1839	0.3697
Collagen Level	3	33.8495	2.3066	0.1764

TABLE IX

ANALYSIS OF VARIANCE FOR SPECIFIC VOLUME (ML/G)

Source	DF	Mean Squares	F Value	Observed Significance Level
Applesauce Cake				
Day	2	0.0120	6.2610	0.0341
Collagen Level	3	0.0005	0.2496	0.8590
Carrot Cake				
Day	2	0.9088	918.1584	0.0001
Collagen Level	3	0.0039	3.9620	0.0716



0 10 15 20

Percent Collagen Added

Figure 4. Applesauce Cake

Objective Evaluation of Carrot Cake

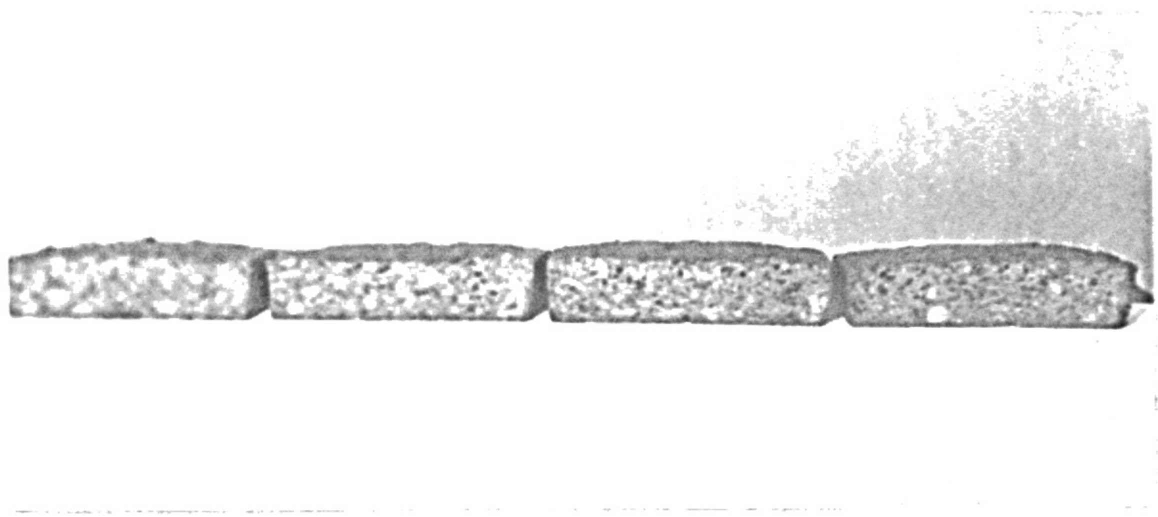
The effect of collagen level on tenderness by shear force (kg/g) of carrot cake is shown in the analysis of variance Table VI. Collagen level did have a significant effect on these values at the 0.0001 level. There was interaction between panelist and collagen. Table X presents the mean values for tenderness by shear force (kg/g) along with the results of Duncan's multiple range test. Significant differences ($p < 0.05$) were found between the standard and 10, 15 and 20 percent levels, and between the 10 and 20 percent levels. Figure 3 is a graphic presentation of the rise in shear force (kg/g) values with the addition of collagen. Carrot cake, which was made with oil, was a much more tender product than the applesauce cake, as shown by the shear force (kg/g) values (Figure 3). Since no significant differences in moisture content were found between any of the cakes (Table X), collagen may be added up to the 20 percent level, with a corresponding increase in liquid, without a significant difference in moisture percentage. Significant differences ($p < 0.05$) in specific volume were found between the standard and 20 percent level, and between the 10 and 15 percent levels (Table X), however, these differences did not seem to be related to collagen levels. A photograph of the four cakes (Figure 5) shows that there were few differences in volume and crumbface. The white spots in the crumbface are pineapple chunks.

TABLE X

MEAN VALUES FOR OBJECTIVE MEASUREMENTS OF CARROT CAKE[1]

Collagen Level	Analysis Procedure		
	Tenderness by Shear Force (kg/g)	Moisture	Specific Volume (ml/g)
None	1.2654[a]	44.4210[a]	1.9620[a]
10%	1.4802[b]	51.1867[a]	1.8957[b]
15%	1.5139[bc]	49.8753[a]	1.9793[a]
20%	1.6413[c]	51.7810[a]	1.9510[ab]

[1]Values within column having no letter in common are significantly different ($p < 0.05$).



0 10 15 20

Percent Collagen Added

Figure 5. Carrot Cake

Summary of Sensory Evaluation

Results of the sensory evaluation of applesauce cake indicate that the panelists were able to detect differences in cakes with collagen and those without collagen for the attributes moisture, mouthfeel, flavor, and overall acceptability. Panelists were not able to discern differences in texture, which was based on appearance. While mean scores for the standard were higher for all attributes than the scores for cakes with collagen, all mean scores were at least 4 on a seven-point scale, with 7 as the optimum score. Based on the fact that 4 was the midpoint of the scale, all scores were considered fair or better.

In carrot cake, panelists could discern differences between the standard and 10, 15 and 20 percent collagen levels for all attributes.

As in the applesauce cake, all mean scores were also at least 4 on a seven-point scale. Additional information provided by the panelists were comments on the presence of small hard pieces left in the mouth after tasting samples containing collagen. Based on these results, hypothesis 1 cannot be accepted, in that significant differences in sensory attributes were found between control cakes and those incorporating collagen.

Summary of Objective Evaluation

The objective tests performed on applesauce cakes included tenderness by shear force (kg/g), moisture determination, and specific volume. Shear force (kg/g) values did show that there was a difference in tenderness of cakes with collagen and those without collagen. Results of moisture determinations and specific volume revealed no significant differences, indicating that the addition of collagen has no effect on these factors. Photography showed few differences.

Carrot cakes became more resistant to force with the addition of collagen, just as applesauce cakes did. The increase in shear force (kg/g) values for carrot cake, however, was much smaller in comparison to applesauce cake. The addition of collagen did not have a significant effect on the moisture content; therefore, up to 20 percent collagen may be added. Specific volume was affected, but an increase cannot be attributed to an increase in collagen level. Visible differences in volume and crumbface as recorded by photography were minor. Based on the results of objective tests, hypothesis 2 cannot be accepted in that there were differences in tenderness by shear force (kg/g) values and specific volume found between cakes with collagen and those without collagen. In terms of moisture content, however, the hypothesis could be accepted.

Nutritional Assessment

The addition of collagen increased the level of protein in applesauce cake (Table XI). At the 10 percent level of added collagen, total protein was increased 56.9 percent over that of the standard cake. The protein content of the cake with 15 percent added collagen was 83.6 percent higher than the standard, while the 20 percent collagen level was 110.2 percent higher than the standard. Specific essential amino acids which were increased with the addition of collagen were isoleucine, leucine, lysine, methionine, phenylalanine, tyrosine, threonine, and valine. Only cystine and tryptophan, the essential amino acids not present in collagen, were not increased with supplementation of collagen.

Table XII presents the protein and amino acid content of carrot cake. As with applesauce cake, total protein was measurably increased with the addition of collagen. Total protein increased 38.8, 57.1 and 74.8 percent over standard carrot cake at the 10, 15 and 20 percent collagen levels. Based on data calculated from tables, hypothesis 3 cannot be accepted, in that there is a difference in nutritive value of control cakes and those incorporating 10, 15 and 20 percent collagen.

TABLE XI

PROTEIN AND AMINO ACID CONTENT OF APPLESAUCE CAKE[1] (GRAMS/SERVING)[2]

Level of Supple-mentation	Protein	Iso-leucine	Leucine	Lysine	Methio-nine	Cystine	Phenyl-alanine	Tyro-sine	Threo-nine	Trypto-phan	Valine
0%	2.242	0.085	0.145	0.058	0.035	0.048	0.102	0.052	0.062	0.026	0.095
10%	3.518	0.102	0.178	0.103	0.043	0.046	0.125	0.062	0.083	0.025	0.121
15%	4.117	0.110	0.193	0.123	0.047	0.046	0.137	0.066	0.093	0.025	0.133
20%	4.712	0.118	0.208	0.144	0.050	0.045	0.148	0.070	0.104	0.024	0.145

[1]Protein and amino acid content of flour, egg and pecans based on Food and Agriculture Organization values (1970). Collagen values based on Happich et al. (1975).

[2]Cake makes 9 servings. Average weight per serving: 77 grams.

TABLE XII

PROTEIN AND AMINO ACID CONTENT[1] OF CARROT CAKE (GRAMS/SERVING)[2]

Level of Supple-mentation	Protein	Iso-leucine	Leucine	Lysine	Methio-nine	Cystine	Phenyl-alanine	Tyro-sine	Threo-nine	Trypto-phan	Valine
0%	2.599	0.095	0.155	0.075	0.041	0.050	0.108	0.059	0.070	0.032	0.110
10%	3.608	0.108	0.179	0.109	0.047	0.048	0.125	0.066	0.087	0.031	0.129
15%	4.083	0.114	0.192	0.130	0.050	0.047	0.133	0.069	0.095	0.030	0.138
20%	4.542	0.119	0.201	0.143	0.053	0.046	0.142	0.072	0.102	0.029	0.147

[1]Protein and amino acid content of flour, egg and pecans based on Food and Agriculture Organization values (1970). Collagen values based on Happich et al. (1975).

[2]Cake makes 9 servings. Average weight per serving: 77 grams.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

This study was undertaken to assess the effects of collagen on: (a) nutritive value, (b) sensory attributes of texture, moisture, mouthfeel, flavor, and overall acceptability, and (c) objective measurements of moisture, specific volume, and tenderness by shear force (kg/g) of cakes. Two types of cake, applesauce and carrot, were supplemented with 10, 15 and 20 percent (based on weight of flour) levels of collagen. Each type of cake was evaluated for four days by a trained attribute panel of eight using the Scorecard for Evaluation of Cakes developed specifically for the study.

The need for development of new sources of protein has been well documented. A review of the literature indicated that although many unconventional protein sources including the oilseeds, single cell protein and fish protein concentrate have been incorporated into baked products, no studies have been reported on supplementation of baked products with collagen. Food use of collagen has been limited mainly to sausage casings and emulsions. The lack of reported studies and the need for finding uses for a protein-rich byproduct warranted this study.

Conclusions

An analysis of variance was performed on sensory and objective data using the Statistical Analysis System (Barr and Goodnight, 1972). Duncan's multiple range test was run to determine significant differences ($p < 0.05$) in cakes. Panel members detected differences in moisture, mouthfeel, flavor, and overall acceptability between applesauce cake with all three levels of collagen and the standard. Texture (appearance) was the only attribute not affected by collagen level. Panelists could perceive a difference between standard carrot cake and those containing 10, 15 and 20 percent levels of collagen for all sensory attributes. Although the standard scored higher than cakes with collagen for both types of cake, all cakes scored at least 4 on a seven-point scale, with 7 the optimum score. Based on these findings, cakes with up to 20 percent added collagen would be considered fair. Hypothesis 1 could not be accepted, however, in that significant differences ($p < 0.05$) were found between sensory attributes of standard cakes and those incorporating 10, 15 or 20 percent collagen.

Shear force (kg/g) values as determined by the Instron Universal Testing Instrument Model 1122 increased with the addition of collagen in both applesauce and carrot cakes. Oven drying of cakes showed no differences in moisture percentage due to the addition of collagen for either type of cake. Volume by rapeseed displacement was used to calculate specific volume. Some differences were found, but could not be attributed to supplementation with collagen. Because of the differences found between cakes with collagen and those without collagen in terms of shear force (kg/g) values, hypothesis 2 could not be accepted.

Protein and amino acid levels were calculated using tables from the Food and Agriculture Organization (1970) and from Happich et al. (1975). Calculations showed that in applesauce cake, total protein per serving was increased 56.9 percent in the 10 percent level of collagen over that of the standard. The 15 and 20 percent levels of collagen were increased 83.6 and 110.2 percent. Total protein per serving of carrot cake increased 38.8, 57.1 and 74.8 percent over the standard, in the 10, 15 and 20 percent levels of collagen, respectively. Levels of all essential amino acids were increased except cystine and tryptophan in both types of cake with the addition of collagen. Hypothesis 3, therefore, could not be accepted in that there are significant differences in nutritive value between standard cakes and those containing 10, 15 or 20 percent collagen.

Recommendations

Further study of cattlehide collagen in baked products is needed. Preliminary experiments showed that air-dried collagen in its granular form could be added to cookies and other cakes. Because collagen does not break down or dissolve in baking, a method of preparing collagen flour needs to be developed. With this product, yeast breads, quick breads, cake mixes, pasta products, snack foods, and other food systems could be supplemented.

Additional objective tests could be recommended such as color measurements, index to volume with planimeter, ink prints, total nitrogen determinations, and rat feeding experiments to determine PER of collagen within a food system. These tests would provide a more comprehensive range of knowledge of the effects of supplementing baked products with air-dried collagen.

The present study showed that protein and amino acid levels of applesauce and carrot cakes were increased with the addition of collagen, and overall acceptability was maintained up to the 20 percent level.

The applications for consumer use of collagen-supplemented baked products could be widespread. School lunch, elderly feeding and international food assistance programs are possible outlets for utilizing this protein source.

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APPENDIXES

APPENDIX A

SENSORY EVALUATION OF CAKES

INSTRUCTIONS TO TASTE PANEL MEMBERS

This study will consist of 8 tasting sessions which will be held at 3:00 p.m. on the following days:

February 19
February 20
February 21
February 22
February 25
February 26
February 27
February 28

Please be present for each session.

Please do not discuss the products with another judge during the sessions.

Water should be drunk before and after each sample.

Smoking, eating or drinking spicy foods or beverages, or use of perfume should be avoided one hour before the taste session.

You will be asked to evaluate four samples at each session. Place a vertical line through the scale for each characteristic at the appropriate point.

Be sure to complete the entire score card.

After tasting, place the waste paper and plate on the top shelf of the cart. Place the score card on the second shelf.

Thank you for participating in this study.

CHARACTERISTICS OF HIGH QUALITY CAKES

INNER TEXTURE:	Uniform distribution of small gas holes. Cell walls should be quite thin.
MOISTURE:	Crumb should be slightly moist.
MOUTHFEEL:	Crumb should feel "velvety" or extremely smooth as it comes into contact with the palate and the back of the mouth.
FLAVOR:	Delicate, sweet, well-blended flavor should predominate.
OVERALL ACCEPTABILITY:	Overall judgement of the above attributes.

SCORECARD FOR EVALUATION OF CAKES

INNER TEXTURE

___ uniform cells — uneven cells

___ uniform cells — uneven cells

___ uniform cells — uneven cells

___ uniform cells — uneven cells

MOUTHFEEL

___ velvety — coarse

___ velvety — coarse

___ velvety — coarse

___ velvety — coarse

MOISTURE

___ moist — dry

___ moist — dry

___ moist — dry

___ moist — dry

FLAVOR

___ well-blended flavor — off-flavor

___ well-blended flavor — off-flavor

___ well-blended flavor — off-flavor

___ well-blended flavor — off-flavor

OVERALL ACCEPTABILITY

___ excellent — poor

___ excellent — poor

___ excellent — poor

___ excellent — poor

COMMENTS:

NAME ____________________

DATE ____________________

APPENDIX B

FORMULAS AND PROCEDURES

FORMULA FOR CARROT CAKE

All-purpose flour	126.0 g
Sugar	195.0 g
Baking soda	3.0 g
Baking powder	3.2 g
Salt	3.0 g
Cinnamon	1.0 g
Nutmeg	1.0 g
Allspice	1.0 g
Oil	157.5 g
Egg	84.0 g
Carrots, grated	109.0 g
Pineapple, crushed, drained	102.0 g
Pineapple juice	26.0 g
Pecans, chopped	30.0 g

1. Assemble ingredients and equipment; preheat oven to 325 degrees F. Weigh all ingredients. Spray pans with non-stick vegetable spray. Sift dry ingredients.
2. Mix oil and sugar 1 minute on speed 1. Add eggs and mix 1 minute on speed 1. Add dry ingredients and mix 1 minute on speed 1. Add carrots, pineapple, pineapple juice, and nuts, and mix 1 minute on speed 1. Scale 775 g into each pan.
3. Bake 44 minutes.

FORMULA FOR APPLESAUCE CAKE

All-purpose flour	157.5 g
Sugar	195.0 g
Baking soda	3.0 g
Salt	4.5 g
Baking powder	0.4 g
Cinnamon	0.9 g
Cloves	0.3 g
Allspice	0.55 g
Applesauce	194.3 g
Water	59.3 g
Shortening	47.0 g
Egg	41.3 g
Raisins	73.0 g
Pecans, chopped	29.5 g

1. Assemble ingredients and equipment; preheat oven to 350 degrees F. Weigh all ingredients. Spray pans with non-stick vegetable spray.
2. Beat all ingredients in large mixer bowl on speed 1, 30 seconds. Scrape bowl. Beat on speed 3 for 3 minutes. Scale 775 g into each pan.
3. Bake 42 minutes.

VITA

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Candidate for the Degree of

Master of Science

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