THE ACCEPTABILITY OF SNACK CHIPS FORTIFIED WITH CALCIUM CARBONATE

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We hereby recommend that the Thesis prepared under our supervision by Elizabeth Adele Harvey entitled The Acceptability of Snack Chips Fortified with Calcium Carbonate.

be accepted as fulfilling this part of the requirements for the Degree of Master of Science.

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CHAPTER I

INTRODUCTION

A major concern in many parts of the world is a growing population compounded by an inadequate food supply. In developing countries this increase in population, leading to increased food demands, can contribute to protein-calorie malnutrition. The limited supply of protein, what ever the cause, has lead to a search of new protein sources in foods.

The people of the world have looked to agriculture for making greater advancements in technology and thus new sources of high-quality protein foods. A current approach to meeting world needs is the development of suitable combinations of vegetable proteins.

Research has turned, in recent years, to the use and processing of oilseeds as a possible protein supplement. Glandless cottonseeds, peanuts, soybeans and some others have been investigated for their potential as high protein food supplements.

Along with the protein quality of a food source is the consideration of production costs. The process must be reasonably inexpensive. The processing of oilseeds is inexpensive and the supply is plentiful. After oil extraction from such oilseeds as soybean, peanut, and glandless cottonseed, the resulting meal is approximately 50 percent protein and relatively inexpensive to produce (Russo, 1969).

Along with the concern for meeting protein needs in any population is that of other nutrients, such as calcium. Calcium is necessary for bone and teeth formation during growth as well as in other areas of metabolism. The need for adequate calcium is not confined to the very young but is important to all age groups.

Calcium is not evenly distributed in foods. If milk, the richest source, is not included in the diet, it may be difficult to provide adequate calcium. Calcium fortification in foods and nutrition education may be a possible solution for providing adequate calcium to many areas of the population.

Careful consideration must be given to establish a rationale for fortifying foods. Of importance is how the food will be used -- as a beverage, a meal replacement, or a snack (Gage, 1971). Also important is to consider the amount of the food to be consumed, and who will consume the food. Gage reports that snack food fortification is a feasible solution to the potential problem of consuming large quantities of snack food.

PURPOSE OF THE STUDY

The general purpose of this study was to compare the acceptability of snack chips made from cottonseed flour and from peanut flour to that of a commercial snack chip. The snack chips were prepared and fortified with calcium carbonate. The specific purposes were as follows:

1. To compare the preference and acceptability of snack chips prepared with cottonseed flour to that of a commercial snack chip.
2. To compare the preference and acceptability of snack chips prepared with peanut flour to that of a commercial snack chip.
3. To investigate the acceptability of different levels of calcium carbonate in the snack chips made from cottonseed flour or from peanut flour. The levels of calcium carbonate used were 1.00 percent and 1.25 percent of the total weight of the flour mixture.

CHAPTER II

REVIEW OF LITERATURE

As world population increases with somewhat limited protein supplies, the search for high protein foods has become foremost. Many investigations into new protein sources to supplement man's diet were made (Altschul, 1967; Bressani, 1965; Harden and Yang, 1975). There began to be an emphasis on substituting some plant proteins for animal protien in the diets thus increasing the quality of the food source (Altschul, 1967).

Animal proteins are more desirable than vegetable proteins in terms of being complete. However, when considering the cost of land, feed, time, and energy of producing animals for food, the use of more economical sources of protein is needed. Cotton as a crop has economical importance; the protein is edible and can be produced less expensively than other oilseeds (World Protein Resources, 1966). It was reported by the National Cotton Council of America (1974) that proteins from cottonseed can be produced at about five cents per pound.

Cereal grains contribute a large part of protein to man's diet in most parts of the world. These products are acceptable to most as food and the economical processing makes them an inexpensive food source. However, the imbalance of amino acids makes it difficult to support sufficient growth (Harper and Smith, 1968). This leads to the possibility of amino acid fortification to improve protein quality. This may be beneficial only to some since it is an expensive step when the purpose is to find an economical means of a protein supply. Amino acid fortification is useful on a small scale but not quite feasible on a worldwide basis (Cater, 1972).

Much research has been done on the effects of the nutritive value of cottonseed proteins. Graham et al. (1969) reported the use of cottonseed protein in young children with protein - calorie malnutrition. The use of the supplement resulted in their rehabilitation. Alford, Kim, and Olney (1977) investigated cottonseed protein and nitrogen balance in young women. After the experiment, the analysis indicated that cottonseed protein adequately maintained nitrogen balance in the young adult women.

Many studies investigated the use of cottonseed flour as a supplement to other flour, such as wheat (Lawhon, et al., 1972; Lorenze and Maga, 1972; Mathews, Sharpe, and Clark, 1970). Rooney et al. (1972) found that by adding 20 percent cottonseed flour to the wheat flour for bread, they were able to increase the protein content of the bread by 35 percent. In addition to increasing the protein content, Womack, Marshall, and Summers (1954) significantly improved the protein quality of bread when cottonseed flour was added. Harden and Yang (1975) used 18.8 percent cottonseed flour in wheat flour and were able to show substantial improvement in the nutritional value of a bread.

Nutritional value of corn tortillas was substantially improved when supplemented with cottonseed flour (McPherson and Ou, 1976). This was shown by rat-growth studies and amino acid analysis. The rats in this study showed greatest weight gain from tortillas supplemented with 20 to 25 percent cottonseed flour. It was noted by McPherson and Ou that the shelf life was improved in the supplemented tortillas due to lower fat acidity values. In an earlier study Green et al. (1975) improved the protein quality with the addition of oilseed flours.

With the use of cottonseed flour in foods to improve protein quality, it was necessary to determine the acceptability of the product. Johnson (1973) studied the acceptability by children of several products using liquid cyclone process (LCP) cottonseed protein concentrate.

The products included breads, cakes, cookies, candy and others. Johnson concluded that acceptable products made with LCP concentrate could be produced if used in foods where the properties of gluten and starch are not utilized.

Smith (1977) studied the acceptability of several products using a cottonseed flour mixture. Among all groups of elderly subjects in the study, the cookies and muffins were found to be very acceptable. Furthermore, it was demonstrated that continued use of the mix containing cottonseed flour increased the acceptability of the biscuits in one group of subjects.

A major concern in cottonseed production is removal of the non-nutritive, toxic gossypol pigment while conserving high protein quality. Ridlehuber and Gardner (1974) have reported LCP removes the gossypol form cottonseed. It is efficient in providing a high quality protein as well. Mitchell (1974) fed LCP cottonseed as the only source of protein to rats. The protein efficiency ratio (PER) was sufficient to maintain growth. PER is the weight gain per weight of protein eaten.

A few investigators have chromatographically analyzed cottonseed flour for amino acid composition. All used the same technical procedure but slightly varied results could be the result of using different instruments (Moore and

Stein, 1954). The protein content of cottonseed flour ranges from 47 to 70 percent (Martinkus, 1976). Determining the amino acid composition is the most important factor in assessing the nutritive value of any protein source (Smith, 1971). Lysine is the first limiting amino acid followed by threonine and methionine (Frampton and Kuck, 1973).

The supplemental value of cottonseed protein has been reviewed. In addition to supplementing the diet and use in a cereal grain flour mix, other oilseeds are being used in combinations with vegetable proteins. Peanut flour is an oilseed derivative currently being used in different products to improve protein levels.

An early study by Jones and Devine (1944) reported that cottonseed, peanut, and soybean flours were adequate to improve the nutritional value of a wheat flour. These three oilseed flours did improve growth of rats; however, peanut flour to a lesser extent than soybean or cottonseed flour. In their work, DeMaeyer and Vanderborght (1958) used peanut flour to supplement the diets of children having kwashiorkor. This showed positive results.

A report by Young and Waller (1973) showed great variability in limiting essential amino acids of 16 peanut varieties. Peanut flour is equally limited in lysine, methionine, and threonine (Howe, Grilfillan, and Milner, 1965). That report showed when oilseed flours -- sesame, peanut, and cottonseed -- were supplemented with lysine, threonine and methionine, or any one of these, the protein quality was increased significantly. This supplementation further showed that the protein quality of these oilseed flours was near or equal to that of casein which is a high quality animal protein.

Peanut flour is high in many essential minerals in addition to its high protein quality (Russo, 1969). Peanuts were reported by Galvao, Lopez, and Williams (1976) to be a fairly good source of calcium, magnesium, potassium, and phosphorous. Other nutrients found to be nutritionally significant in peanuts were copper, zinc, and iron.

The nutritional status of the U.S. population ages 1 through 74 years was assessed by the first Health and Nutrition Examination Survey, 1971-1972 (HANES). The dietary intakes and biochemical tests were obtained from a representative sample of noninstitutionalized U.S. population. The dietary intakes presented in this survey were: calories and selected nutrients including protein, calcium, vitamins A and C, and iron. For most age, race, and income groups, the mean intakes for calcium and vitamins A and C approached or exceeded adequate levels. Some people had less intake. Negro females ages 18-44 at both income levels had daily mean calcium intakes below 100 percent of the 600 mg standard.

When establishing which foods should be fortified, a number of factors must be considered. Gage (1971) considered the purpose of the food and the quantity of the food which would be consumed. Gage also considered the nutrients to be added and the population group who would benefit from fortification.

In the American diet the use of snack foods has continued to increase (Huenemann et al., 1968; Sims and Morris, 1974). The increased snacking and the growing trend of "away from home" meals do not always lend themselves to good nutrition (Clausi, 1973). If eating trends appear to be such, fortification could be achieved by guidelines of foods to be modified and to what extent.

The attempts to fortify those foods which are being eaten in increasing quantities, especially snack foods, is a feasible solution to replacing the lack of selected nutrients (Clausi, 1973). It may be quite possible to introduce snack foods which are acceptable and which meet the physiological needs of snack food consumers (Sims and Morris, 1974).

The fortification of selected food items with calcium was reported by Ramasastri (1974). Curry powder was used to add vitamins and calcium to the rice based diets of a group in South India. The addition of calcium carbonate to the curry powder did not change its acceptability. Further data showed that while acceptability was not changed, the lower levels of $CaCO_3$ were preferable.

Carlson et al. (1947) investigated a graham-type soy cracker fortified with calcium and vitamins. The result was a palatable product, and rat growth studies showed it was beneficial. Dicalcium phosphate was used at the level of 2.7 g per pound of product. Analysis showed there was 0.25 percent calcium in the tested crackers.

Cohn et al. (1968) showed that by using 2.5 g per day of calcium in divided doses calcium balance was improved in seven osteoporotic patients. The high calcium diet was considered beneficial. The form of calcium used was neocalglucon and was always given with some form of food.

In a study of the effects of single large doses of calcium carbonate on serum calcium levels, six young adults showed a mean peak rise in the fasting state (Epstein, 1973). The same dose of four grams when taken along with breakfast caused a much higher mean peak level in the same group. This suggested that the response of oral calcium doses may be better when taken with food. Similar results were obtained with six elderly subjects in the same study.

Ivanovich, Fellows, and Rich (1967) were concerned about reliable data in relationship to the absorption of calcium carbonate. The absorption of this calcium salt, which is used in treating peptic ulcers, was measured in normal subjects and in patients being treated with calcium carbonate. The results indicated that calcium carbonate absorption was as effective in increasing serum calcium levels as that of calcium gluconate.

Factors affecting calcium absorption were studied by Brine and Johnstson (1955). The report was that protein and vitamin D improve calcium uptake. Phytates and oxylates interfere with and can reduce calcium absorbed from the diet; although oxylates to a somewhat lesser extent. In addition, immobilization and a low caloric content of the diet can also cause a decrease in total calcium absorbed from the diet of an adult.

Calcium carbonate is recognized by the United States Food and Drug Administration as an additive Generally Recognized as Safe (GRAS). Calcium carbonate can be used when handled as a food ingredient and when the amount used does not exceed the amount required for the intended effect (Federal Register, 1976). Calcium carbonate is a powder which is tasteless and odorless (Winter, 1972). It occurs naturally in limestone, coral, and marble. Calcium carbonate is used as an alkali to reduce wine acidity when used up to 2.5 percent. When used up to 0.25 percent it has a neutralizing effect in ice cream and confections, and is used in baking powder up to 50 percent as a neutralizer. More uses include as a white food dye and to promote creaming in fudge.

CHAPTER III

PROCEDURE

The present study was conducted to investigate the acceptability of snack chips fortified with calcium carbonate. The investigator also wanted to observe the acceptability of those snack chips compared to a commercial snack chip.

The glandless cottonseed flour and the peanut flour used in this investigation was milled and processed by the Oilseed Products Division, Food Protein Research and Development Center of Texas A & M University. The glandless cottonseed flour was sent to Texas Woman's University in February, 1978. It was produced from McNair glandless cottonseed grown in New Mexico. Coarse kernels conditioned to 180° F and containing 8 to 9 percent moisture were flaked with flaking rolls to 0.010 inch thickness and extracted with commercial hexane in a crown solvent extractor. Extracted flakes were desolventized at 180° F by indirect steam heat. Defatted flakes were then further processed with an Alpine pin mill.

The peanut flour used in this study was produced from southern Spanish peanuts of unknown origin. The nuts were heated to about 160 $^{\circ}$ F, screw pressed into cakes, then solvent extracted with commercial hexane. The defatted cake was desolventized at 180° F by indirect steam heat then ground using an Alpine contra-plex gringing mill.

The Formula for the Snack Chips

The cottonseed chips recipe which was used was developed at the Texas Woman's University food research laboratory. The flour mixture for the cottonseed chips consisted of 33 percent cottonseed flour, 33 percent all purpose flour and 33 percent whole wheat flour by volume. See Table 1 for percent flour by weight for cottonseed chip and peanut chip formulas.

The formula for the peanut chips was modified by the investigator using the same basic proportions of peanut flour, all purpsoe flour, and whole wheat flour. These proportions were found to yield a satisfactory product for the peanut chips.

The Addition of Calcium Carbonate

Three levels of calcium carbonate were used in each of the cottonseed chips and the peanut chips. The

TABLE 1

FORMULAS FOR COTTONSEED CHIPS AND PEANUT CHIPS

Ingredients	Peanut Chips weight in grams	Cottonseed Chips weight in grams
Cottonseed flour	. . .	39.00*
Peanut flour	38.40*	. . .
All purpose flour	27.20*	29.00*
Whole wheat flour	34.40*	32.00*
Salt	2.00	2.00
Vegetable oil	2.80	2.80
Levels of $CaCO_3$	1.25	1.25
	1.00	1.00
Water	48.00 ml	48.00 ml

* percent by weight of flour mixture

calcium carbonate used was of the highest food grade quality. One percent calcium carbonate was added to one portion of the dry flour mixtures; 1.25 percent was added to a second portion of the dry flour mixtures. The remaining dry flour mixtures did not have calcium carbonate added.

Preparation of the Snack Chips

All ingredients were first assembled at the work table. All untensils were gathered before starting the mixture. A metric balance was used for weighing all ingredients. All dry flour ingredients -- all purpose flour, whole wheat flour and cottonseed flour -- were mixed together in a stainless steel bowl. The salt was then added and all the ingredients were sifted together. The steps were the same for the peanut chips -- peanut flour, whole wheat, and all purpose flour were sifted along with the salt. At this point the calcium carbonate was added to the dry mixtures and again sifted twice to insure even distribution of the calcium carbonate in the dry ingredients. The water and oil were stirred into the dry ingredients until all the liquid was absorbed. The dough was kneaded about two minutes or until it held its shape.

The stiff dough was allowed to rest for approximately 10 minutes. The dough was divided and shaped into 12 balls; each ball was rolled paper thin on a lightly floured surface. The cottonseed mixture was rolled using cottonseed flour; the peanut mixture using peanut flour.

After rolling the balls of dough each were placed between waxed paper and stacked to be held for frying. The peanut chips did require some sepcial handling at this point due to the sticky nature of the dough. The rolled out dough balls were placed in racks -- microwave bacon racks were used -- to prevent sticking to other dough in the batch. This was satisfactory for minimizing this problem.

The cottonseed chips and the peanut chips were prepared by frying in the same manner. An electric skillet was used to fry the snack chips in pure corn oil. A centigrade thermometer was used during the frying to insure that the oil was kept at 190° C. The rolled out dough was placed in the hot oil and fried on one side for approximately 10 to 12 seconds until the edges began to turn golden brown. Each chip was turned using tongs and fried on the other side for approximately 10 seconds until crisp. Each chip was fried separately. After removing the chips from the hot oil, they were placed on two thicknesses of paper towel to adsorb excess oil and more paper towel was used to blot excess oil on the top.

Each batch of snack chips was properly labeled; as cottonseed or peanut, date, and level of calcium carbonate. All were stored at room temperature in metal containers until use the following day.

Selection of the Taste Panel

All taste panel members were selected from young women enrolled at Texas Woman's University, College of Nutrition, Textiles, and Human Development. Each individual completed an initial preliminary taste test. This was done by choosing the one sample of three that differed from the other two by taste (see Appendix A). Of the 10 persons, 15 were selected for the taste panel. One panel member did not complete the tasting sessions; the final taste panel consisted of 14 members.

The Score Sheet

The score sheet used a nine point hedonic scale with difinitional terms corresponding to the numbers in the scale (see Appendix B). The characteristics which were evaluated by the nine point hedonic scale (9 -- excellent-no improvement to 1 -- unacceptable) were external appearance, texture, and palatability. Overall acceptability was rated on a 3-point scale (3 -- best to 1 -- poorest). This was not a forced ranking of the samples, because two or more samples could be rated the same.

The Testing Environment

The tasting area was located in a separate area from the research laboratory to minimize distractions from the preparation area. This room was quiet and noises from other areas were minimized. Adequate light was provided by flourescent ceiling lights for the testing environment. Individual, protable tasting booths were placed on tables to provide an unhurried setting for each panel member. The booths gave room for the plate with samples, water, score sheet, and a pencil.

The Testing Procedure

Cottonseed chips with three levels of calcium carbonate were evaluated along with a commercial Frito brand chip. Frito brand chips were selected as the commercial product for evaluation because of comparable characteristics of the cottonseed chips and the Frito brand chips. The levels of calcium carbonate used were 0 percent, 1.00 percent, and 1.25 percent of the total weight of the dry flour mixture. These four samples were evaluated by the panel members on the five characteristics on the score sheet.

Peanut chips, also with three levels of calcium carbonate, were evaluated along with a commercial Pronto brand snack chip. The Pronto brand chip was selected for evaluation with the peanut chips because of similar characteristics. The levels of calcium carbonate used were the same as used in the cottonseed chips, by weight of the flour mixture. This group was evaluated on the same characteristics.

The panel members were given instructions for the test procedure (see Appendix C). These instructions were for the panel member to keep and listed dates, times, and place for the testing. Also included were instructions for not smoking, drinking coffee, or eating for 30 minutes before each tasting session.

The length of the testing period lasted six days. Each product was tested each day and there were two tasting sessions daily. The cottonseed group was presented first session and the peanut group was presented second session.

Each panel member was presented with the four numbered samples on a plate, a score sheet appropriately numbered for each sample, and a pencil. Water was provided to drink after each sample before tasting the next.

Researchers have suggested presenting samples to the judges at the temperature normally eaten (Kramer and Twigg, 1970; Larmond, 1973; Amerine, Pangborn and Roessler, 1965). Most snack foods are eaten at room temperature, and thus the snack chips in this study were presented to each panel member at room temperature. Refrigeration of the products was not used as this would change the temperature of the chips.

There have been some varied opinions about the number of samples to be presented to a panelist at one given time (Amerine, Pangborn, and Roessler, 1965; Kramer and Twigg, 1970). Recommendations have been that not more than two samples be presented to an untrained panelist at one time because of the fatigue factor. Larger numbers of samples have been presented to save time. Bland tasting products have been presented in larger quantities than more highly seasoned ones when taste panel members have had some training. Samples containing highly seasoned ingredients need to be presented in smaller groups.

The panelists in this study tested four samples at each session, either the cottonseed chip group or the peanut chip group. All samples were randomly assigned, coded and presented to the panelist in a different order each time (see Table 2). Each panelist was permitted to begin with any of the four samples presented.

Analysis of Data

The overall means of the peanut group and the cottonseed group were computed. Single and two-factor analysis of variance with repeated measures was used to determine if any significant ($p < 0.05$) differences existed within either the cottonseed chip group or the peanut chip group.

TABLE 2

RANDOM ORDER OF PRESENTATION FOR COTTONSEED CHIP GROUP AND PEANUT CHIP GROUP

Day	Order of Presentation Cottonseed Chips				Day	Order of Presentation Peanut Chips			
	1	2	3	4		1	2	3	4
1	C^1	1.25%	0%	1.00%	1	1.00%	0%	1.25%	C^2
2	C^1	1.25%	1.00%	0%	2	1.25%	C^2	0%	1.00%
3	1.25%	C^1	1.00%	0%	3	1.00%	C^2	1.25%	0%
4	0%	1.25%	C^1	1.00%	4	C^2	1.00%	0%	1.25%
5	1.00%	C^1	0%	1.25%	5	0%	1.00%	C^2	1.25%
6	C^1	1.00%	0%	1.25%	6	C^2	1.25%	0%	1.00%

C^1 = Commercial Frito brand chip

C^2 = Commercial Pronto brand chip

CHAPTER IV

RESULTS AND DISCUSSION

The study was undertaken to investigate the acceptability of snack chips fortified with calcium carbonate. The cottonseed chips with three levels of calcium carbonate were judged for acceptability along with a commercial Frito brand chip. In a second group, peanut chips with three levels of calcium carbonate were judged for acceptability along with a commercial Pronto brand chip. Another purpose was to investigate the acceptability of different levels of calcium carbonate in the cottonseed chips and the peanut chips. The snack chips were judged by a taste panel of fourteen members. The means and standard deviations for cottonseed chips and peanut chips appear in Table 3.

The Cottonseed Chip Group

The scores for external appearance, texture, and palatability were statistically analyzed for significant differences (see Table 4). Figure 1 shows a bar garph of the hedonic values for these characteristics.

The cottonseed chips were evaluated for external appearance of the surface. A desirable characteristic was that it would appear slightly blistered. The mean

TABLE 3

MEAN SCORES AND STANDARD DEVIATIONS FOR COTTONSEED CHIP GROUP AND PEANUT CHIP GROUP AND PEANUT CHIP GROUP AS EVALUATED BY TASTE MEMBERS

Characteristic	Commercial Frito Brand		Cottonseed Chips					
			0% $CaCO_3$		1.00% $CaCO_3$		1.25% $CaCO_3$	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
External Appearance								
Surface	8.12	0.85	6.93	1.25	7.20	1.18	6.86	1.29
Color	8.11	0.95	6.55	1.23	6.71	1.17	6.23	1.28
Texture	7.67	0.97	7.73	0.94	7.79	0.79	7.45	1.23
Palatability	8.00	0.95	6.79	1.25	6.67	1.21	6.61	1.57
Overall Acceptability	2.55	0.42	2.07	0.35	2.12	0.35	1.87	0.35

TABLE 3 Continued

Characteristic	Commercial Pronto Brand		Peanut Chips 0% $CaCO_3$		Peanut Chips 1.00% $CaCO_3$		Peanut Chips 1.25% $CaCO_3$	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
External Appearance								
Surface	8.19	0.76	7.10	1.35	7.11	1.28	7.14	1.26
Color	8.17	0.93	7.01	1.33	7.14	1.19	7.19	1.19
Texture	8.32	0.61	7.44	1.23	7.04	1.49	7.25	1.38
Palatability	8.00	0.98	6.88	1.20	6.67	1.48	7.00	1.33
Overall Acceptability	2.70	0.42	2.02	0.35	1.95	0.35	2.23	0.26

TABLE 4

ANALYSIS OF VARIENCE OF DIFFERENCES BETWEEN MEAN TASTE PANEL SCORES FOR THE COTTONSEED CHIP GROUP

Characteristic	Degrees of Freedom	F	P
External Appearance			
Surface			
Judges	13	19.41	<0.05%
Formulas	3	23.02	<0.05*
Newman-Keuls'			
0.44* C^1 ($\bar{X}$=8.12)>CS 1.25% $CaCO_3$ ($\bar{X}$=6.86)			
0.40* C^1 ($\bar{X}$=8.12)>CS 0% $CaCO_3$ ($\bar{X}$=6.93)			
0.34* C^1 ($\bar{X}$=8.12)>CS 1.00% $CaCO_3$ ($\bar{X}$=7.20)			
Color			
Judges	13	18.78	<0.05*
Formulas	3	44.47	<0.05*
Newman-Keuls'			
0.45* C^1 ($\bar{X}$=8.11)>CS 1.25% $CaCO_3$ ($\bar{X}$=6.86)			
0.41* C^1 ($\bar{X}$=8.11)>CS 0% $CaCO_3$ ($\bar{X}$=6.55)			
0.35* C^1 ($\bar{X}$=8.11)>CS 1.00% $CaCO_3$ ($\bar{X}$=6.71)			
0.41* CS 1.00% $CaCO_3$ ($\bar{X}$=6.71)>CS 1.25% $CaCO_3$ ($\bar{X}$=6.23)			
Texture			
Judges	13	15.71	<0.05*
Formulas	3	1.42	0.24
Palatability			
Judges	13	33.56	<0.05*
Formulas	3	36.49	<0.05*
Newman-Keuls'			
0.40* C^1 ($\bar{X}$=8.00)>CS 1.25% $CaCO_3$ ($\bar{X}$=6.61)			
0.36* C^1 ($\bar{X}$=8.00)>CS 1.00% $CaCO_3$ ($\bar{X}$=6.67)			
0.30* C^1 ($\bar{X}$=8.00)>CS 0% $CaCO_3$ ($\bar{X}$=6.79)			

TABLE 4 Continued

Characteristic	Degrees of Freedom	F	P
Overall Acceptability			
Judges	13	3.48	<0.05*
Formulas	3	19.40	<0.05*
Newman-Keuls'			
0.24* C[1] ($\bar{X}$=2.55)>CS 1.25% $CaCO_3$ ($\bar{X}$=1.87)			
0.21* C[1] ($\bar{X}$=2.55)>CS 0% $CaCO_3$ ($\bar{X}$=2.07)			
0.18* C[1] ($\bar{X}$=2.55)>CS 1.00% $CaCO_3$ (X=2.12)			
0.21* CS 1.00% $CaCO_3$ ($\bar{X}$=2.12)>CS 1.25% $CaCO_3$ ($\bar{X}$=1.87)			
0.18* CS 0% $CaCO_3$ ($\bar{X}$=2.07)>CS 1.25% $CaCO_3$ ($\bar{X}$=1.87)			

* Significant (P <0.05)

C[1] = Commercial Frito brand chip
CS = Cottonseed chip

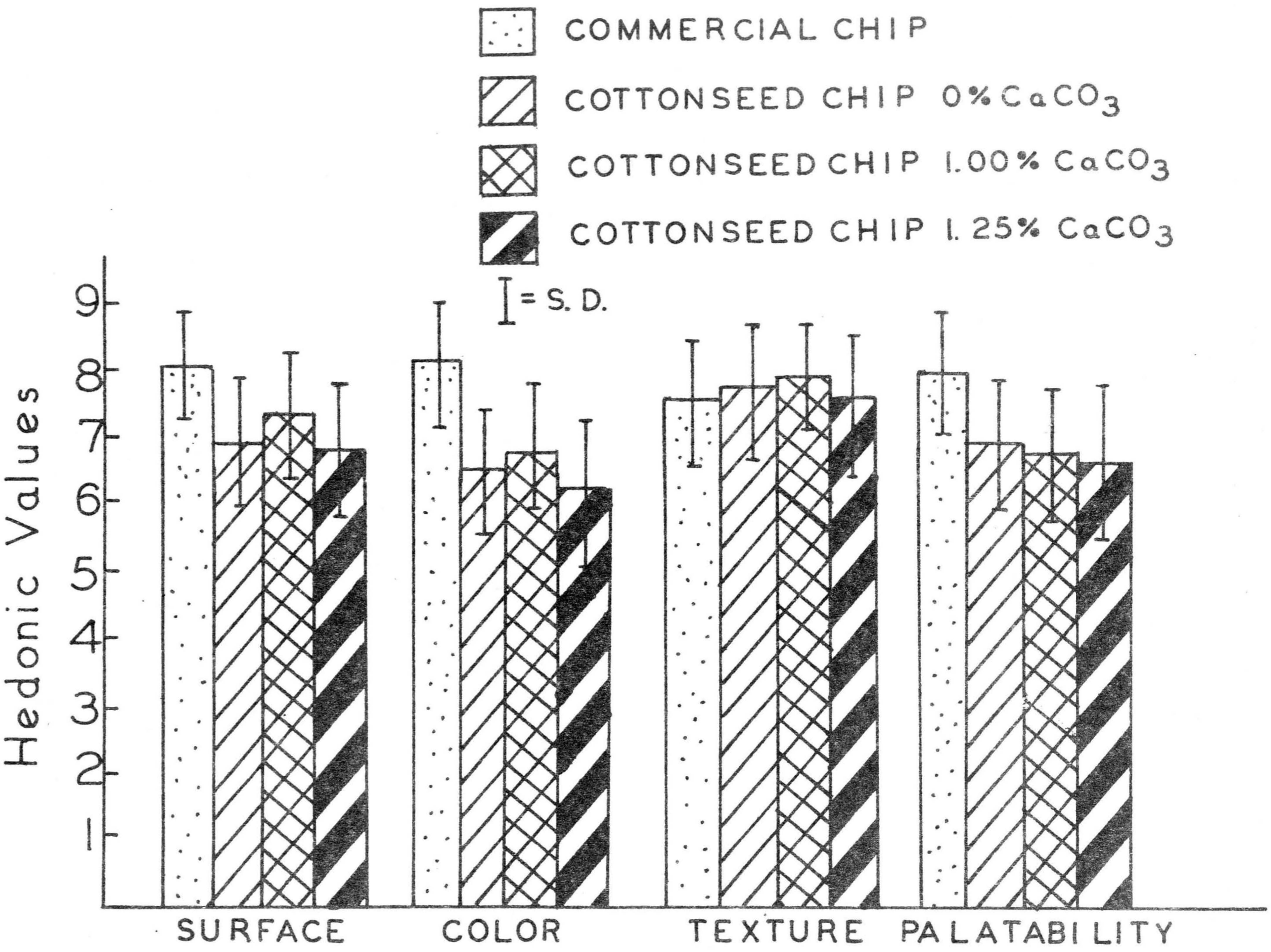

Fig. 1. Mean Score Values for Four Characteristics As Evaluated By Taste Panel Members for the Cottonseed Chip Group.

of the commercial chip was significantly higher than that of the cottonseed chips for surface. However, within the three cottonseed chips the overall means were lower than for the commercial chip, although there was no significant difference between the means. A written comment on the score sheet by one panelist indicated that the cottonseed chip had holes. The evaluation of external appearance was affected by the holes in the chip.

The next characteristic evaluated in the cottonseed chip group was color. A golden color was desirable; too light or too dark was undesirable. The color of the commercial chip had a mean significantly higher than the cottonseed chips. Within the cottonseed chips the overall means were lower but did not differ significantly between the levels of calcium carbonate. One panelist commented on the score sheet on one day that the color was too dark. Another panelist commented on another day that there appeared to be varying degrees of browning on the same chip. This affected the means and could have contributed to the lower scores by more than one panelist.

Texture was an important characteristic of the samples. A desirable texture included crispness and firmness when broken. When the means were analyzed there were no significant differences in the means between any of the samples. All samples had ratings of "good" to "very good." One remark made by two panelists was that the commercial chip seemed to be tough. This would affect the scores for texture of the commercial chip since the overall mean for texture was slightly lower than the means for two of the cottonseed chips.

Palatability was reflected by the acceptable taste of the product. Palatability of the chips was evaluated by pleasing flavor. An undesirable characteristic was an aftertaste or a strong flavor. The overall mean of the commercial chip was significantly better than that of the cottonseed chips for palatability. There was no significant difference between the means of any of the cottonseed chips for palatability, although all had an "acceptable" flavor. It was mentioned by one panelist that the cottonseed chips on one occasion had a nutty flavor. Bressani, Elias, and Braham (1966) reported that there has been a nutty flavor in foods containing cottonseed flour. The commercial chip was said to be too salty by a few panelists, although the commercial chip had an overall rating of "very good."

Overall acceptability reflected the panelist's opinion of each chip regardless of the other scores assigned to the sample. The overall acceptability ratings

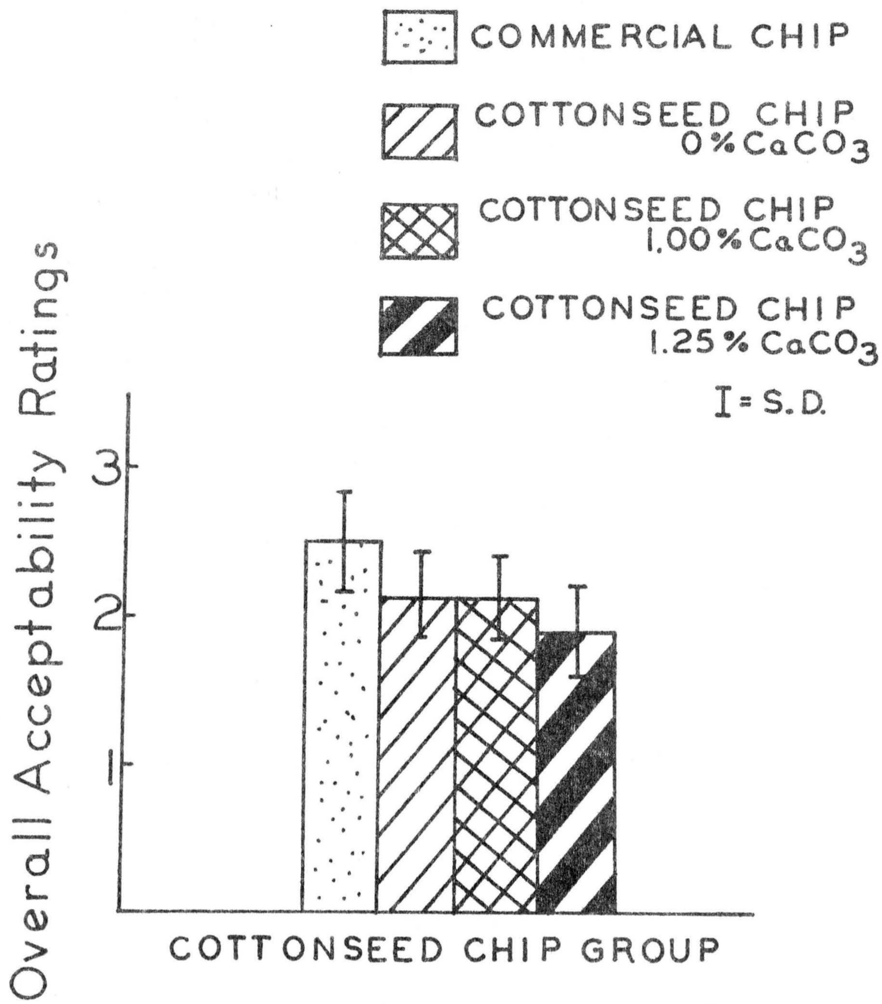

Fig. 2. Mean Score Values for Overall Acceptability As Evaluated By Taste Panel Members for the Cottonseed Chip Group.

were 1, 2, or 3, with 3 being the best. The samples were rated the same or differently according to the opinion of the panelist. The results showed there were significant differences between the means of all samples except two. The commercial chip was rated highest. There was no significant difference in overall acceptability between the cottonseed chips with 1.00 percent calcium carbonate and the chips without calcium carbonate with the former being slightly more acceptable. Figure 2 shows that all samples ranged in acceptability from 1.87 to 2.54.

The Peanut Chip Group

Peanut chips with three levels of calcium carbonate were evaluated along with a commercial Pronto brand chip. As in the cottonseed chip group, external appearance, texture, palatability and overall acceptability were rated. The mean scores are shown in Figure 3. Analysis of variance was used to determine differences between taste panel evaluations (Table 5).

External appearance of the surface of the peanut chips was evaluated by the same desirable quality as in the previous group. The overall mean of the commercial chip scored significantly higher than the means of the peanut chips for surface appearance. When the means of

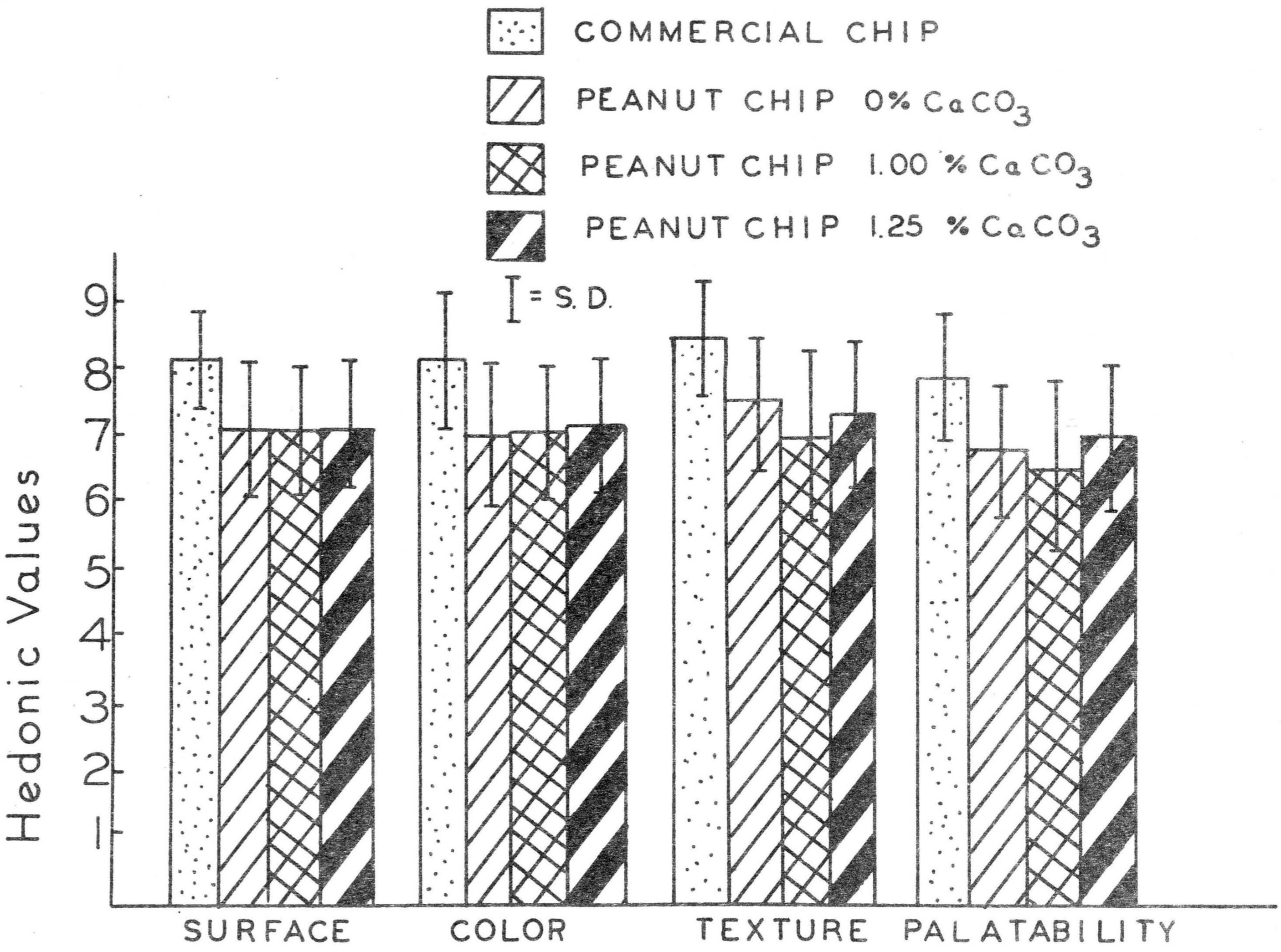

Fig. 3. Mean Score Values for Four Characteristics As Evaluated By Taste Panel Members for the Peanut Group.

TABLE 5

ANALYSIS OF VARIANCE OF DIFFERENCES BETWEEN MEAN TASTE PANEL SCORES FOR THE PEANUT CHIP GROUP

Characteristic	Degrees of Freedom	F	P
External Appearance			
Surface			
Judges	13	26.66	<0.05*
Formulas	3	23.38	<0.05*
Newman-Keuls'			
0.40* C^2 ($\bar{X}$=8.12) >PN 0% $CaCO_3$ ($\bar{X}$=7.10			
0.37* C^2 ($\bar{X}$=8.12) >PN 1.00% $CaCO_3$ ($\bar{X}$=7.11)			
0.31* C^2 ($\bar{X}$=8.12) >PN 1.25% $CaCO_3$ ($\bar{X}$=7.14)			
Color			
Judges	13	20.79	<0.05*
Formulas	3	20.55	<0.05*
Newman-Keuls'			
0.43* C^2 ($\bar{X}$=8.17) >PN 0% $CaCO_3$ ($\bar{X}$=7.01)			
0.39* C^2 ($\bar{X}$=8.17) >PN 1.00% $CaCO_3$ ($\bar{X}$=7.14)			
0.32* C^2 ($\bar{X}$=8.17) >PN 1.25% $CaCO_3$ ($\bar{X}$=7.19)			
Texture			
Judges	13	25.48	<0.05*
Formulas	3	23.99	<0.05*
Newman-Keuls'			
0.42* C^2 ($\bar{X}$=8.32) >PN 1.00% $CaCO_3$ ($\bar{X}$=7.04)			
0.38* C^2 ($\bar{X}$=8.32) >PN 1.25% $CaCO_3$ ($\bar{X}$=7.25)			
0.32* C^2 ($\bar{X}$=8.32) >PN 0% $CaCO_3$ ($\bar{X}$=7.44)			
0.38* PN 0% $CaCO_3$ ($\bar{X}$=7.44) >PN 1.00% $CaCO_3$ ($\bar{x}$=7.04)			
Palatability			
Judges	13	25.15	<0.05*
Formulas	3	22.06	<0.05*
Newman-Keuls'			
0.46* C^2 ($\bar{X}$=8.00) >PN 1.00% $CaCO_3$ ($\bar{X}$=6.67)			
0.42* C^2 ($\bar{X}$=8.00) >PN 0% $CaCO_3$ ($\bar{X}$=6.88)			
0.35* C^2 ($\bar{X}$=8.00) >PN 1.25% $CaCO_3$ ($\bar{X}$=7.00)			

TABLE 5 Continued

Characteristic	Degrees of Freedom	F	P
Overall Acceptability			
Judges	13	2.66	<0.05*
Formulas	3	24.89	<0.05%
Newman-Keuls'			
0.25* C^2 ($\bar{X}$=2.70)>PN 1.00% $CaCO_3$ ($\bar{X}$=1.95)			
0.22* C^2 ($\bar{X}$=2.70)>PN 0% $CaCO_3$ ($\bar{X}$=2.02)			
0.19* C^2 ($\bar{X}$=2.70)>PN 1.25% $CaCO_3$ ($\bar{X}$=2.23)			
0.22* PN 1.25% $CaCO_3$ ($\bar{X}$=2.27)>PN 1.00% $CaCO_3$ ($\bar{X}$=1.95)			
0.19* PN 1.25% $CaCO_3$ ($\bar{X}$=2.27)>PN 0% $CaCO_3$ ($\bar{X}$=2.02)			

*Significant ($P < 0.05$)

C^2 = Commercial Pronto brand chip
PN = Peanut chip

the peanut chips with varying levels of calcium carbonate were analyzed there were no significant differences. All peanut chips received a rating of "good" for surface appearance with the commercial chip being rated as "very good."

When color was evaluated in the peanut chip group, the analysis showed that the commercial chip scored significantly higher than the peanut chips. The commercial chip had an overall rating of "very good." When the means were analyzed comparing the peanut chips with three levels of calcium carbonate there were no significant differences between the means. All peanut chips received ratings of "good." It was observed by one panelist that the peanut chip on one day of the study was "too light."

For texture the commercial chip was rated significantly higher than any of the peanut chips. The rating for the commercial chip was "very good." The peanut chip without calcium carbonate had a mean significantly higher than that of the peanut chip with 1.00 percent calcium carbonate. There was no significant difference between the means of the other peanut chips for texture. All the peanut chips recieved mean ratings of "good" for texture.

The analysis showed that palatability of the commercial chip was significantly better than the peanut chips. The commercial chip had a mean rating of "very good." The peanut chips received a mean rating of "good" with no significant differences between the means for palatability. Alghouth the palatability was similar for the peanut chips, the chip with 1.25 percent calcium carbonate was slightly more acceptable than the commercial chip. One panelist remarked that the commercial chip was too salty on three different days. Because the peanut chips were not said to be too salty, health benefits might be expected.

The overall acceptability of the peanut chip group was rated in the same manner as that of the cottonseed chip group. Figure 4 gives the overall acceptability values for the peanut chip group. The commercial chips scored significantly higher than the peanut chips at all levels of calcium carbonate. The peanut chip with 1.25 percent calcium carbonate was significantly more acceptable when compared to the two lower levels of calcium carbonate. However, when the peanut chip with 0 percent calcium carbonate was compared to the chip with 1.00 percent calcium carbonate there was no significant

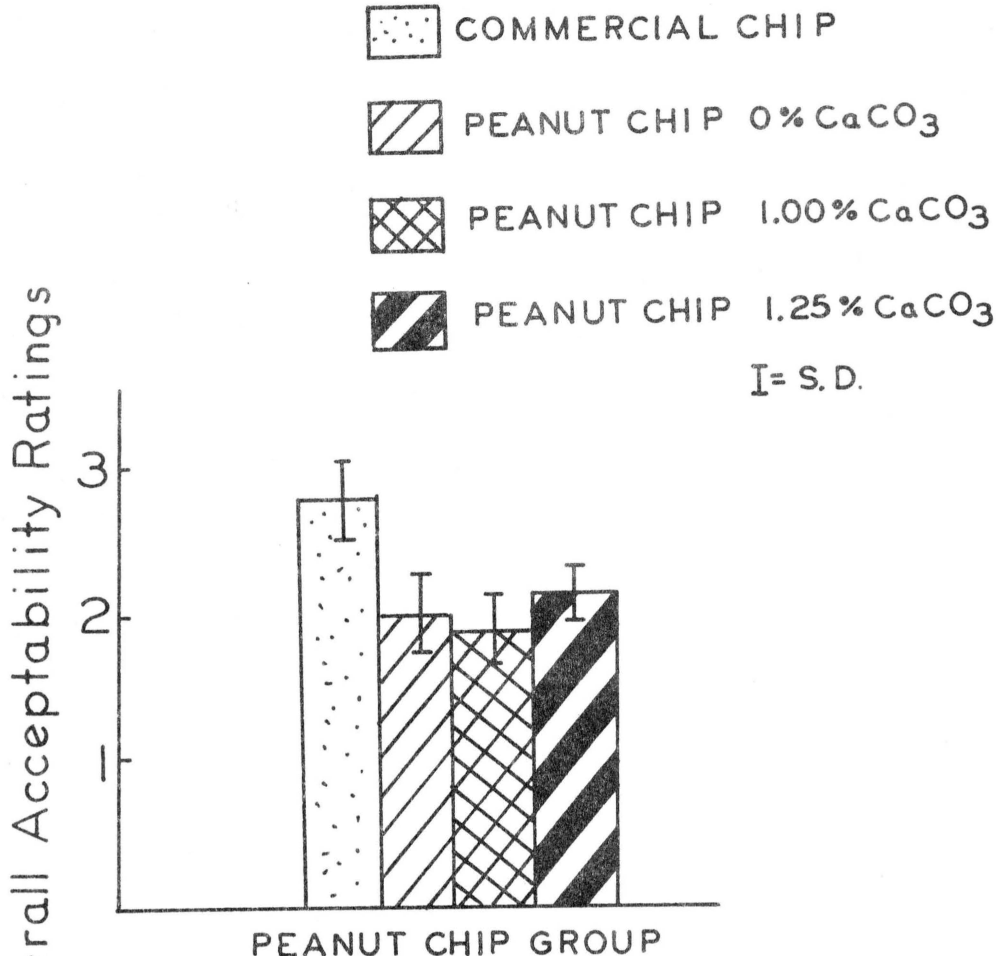

Fig. 4. Mean Score Values for Overall Acceptability As Evaluated By Taste Panel Members for the Peanut Chip Group.

difference for overall acceptability with the former being slightly more acceptable.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of this study was to compare the acceptability of snack chips made from cottonseed flour and from peanut flour to that of commercial chips. The preference for and acceptability of cottonseed chips fortified with 1.00 percent and 1.25 percent calcium carbonate were compared to the acceptability of a Frito brand chip. The commercial chip was judged significantly higher than the cottonseed chips for external appearance (surface and color), and for palatability. There was no significant difference between the means for texture of the commercial chips or the cottonseed chips. There were significant differences in overall acceptability between the means for all products except between the means of the 0 percent calcium carbonate level and the 1.00 percent calcium carbonate level which did not differ significantly. Although the commercial chip was often rated significantly better, the cottonseed chips constantly received "good" ratings overall and were found to be very acceptable.

In another group, peanut chips with 0 percent, 1.00 percent, and 1.25 percent calcium carbonate were evaluated for acceptability along with a commercial Pronto brand chip. The commercial snack chip was shown to be significant in preference to all the peanut chips for external appearance (surface and color), for texture and for palatability. Within the peanut chips there were no significant differences between the levels of calcium carbonate for surface appearance, color, or palatability. For the characteristic of texture, the peanut chip without calcium carbonate was rated significantly higher than the peanut chip with 1.0 percent calcium carbonate. For overall acceptability, the commercial chip was significantly more acceptable than the peanut chips. Within the levels of calcium carbonate all levels differed significantly except between the chip without calcium carbonate and 1.00 percent calcium carbonate which was slightly less preferable. For overall acceptability the chip with 1.25 percent calcium carbonate was significantly more acceptable than the chips with no calcium carbonate, or with 1.00 percent calcium carbonate. All the chips in this group were judged to be very acceptable with ratings of "good."

APPENDIX A

Name ______________________________

Preliminary Taste Test

Of the three samples in each group, one is different. Select the one that differs by taste. Circle your choice.

Group A.	1.	2.	3.
Group B.	1.	2.	3.

APPENDIX B

Panel Member ______________________ Date ________________

SCORE CARD FOR SNACK CHIPS

Characteristics				
External Appearance: Surface Slightly blistered				
Color: Rich golden color Not too dark or too light				
Texture: Crisp, firm when broken Not soggy or not tough				
Palatability: Flavor Pleasing, No aftertaste No strong flavor				
Overall acceptability: Rate 1, 2, or 3. with 3 being the best.				

Rate by number scale as follows:

9. Excellent -- No improvement
8. Very good
7. Good
6. Slightly acceptable
5. Acceptable
4. Slightly unacceptable
3. Poor
2. Very Poor
1. Unacceptable

APPENDIX C

INSTRUCTIONS FOR JUDGES

DATES: Wed., June 14 - Wed. June 21. (except Sat. and Sun.)

TIME: 10:00 a.m. - 2:00 p.m.

PLACE: Old Main Building, Room 309.

There will be two tasting sessions daily.

Do not smoke, drink coffee, or eat for 30 minutes prior to the tasting sessions.

Do not discuss the results with other panelists during or after the tasting sessions.

Taste one sample at a time. Water will be provided. You may drink water to remove the taste of a given sample before tasting the next sample.

Score the samples to reflect differences:

The scores range from one to nine, with nine being "Excellent -- No Improvement" and one being "Unacceptable".

If the samples are different, score them differently; if the samples are the same, socre them the same.

The scores for overall acceptability should reflect, regardless of other scores assigned to a sample, your opinion of the acceptability of a sample of snack chips. If you feel two or more samples are equally acceptable, socre them the same. If you feel they are different, score them differently.

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