12-1981

Effects of acidification of canned southern peas (vigna unguiculata) processed by a pasteurization method on some physical and organoleptic characteristics

Cherie L. Turner

To the Graduate Council:

I am submitting herewith a thesis written by Cherie L. Turner entitled "Effects of acidification of canned southern peas (vigna unguiculata) processed by a pasteurization method on some physical and organoleptic characteristics." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Food Science and Technology.

J.L. Collins, Major Professor

We have read this thesis and recommend its acceptance:

H.O. Jaynes, J.R. Mount

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Accepted for the Council:

Vice Chancellor
Graduate Studies and Research

EFFECTS OF ACIDIFICATION OF CANNED SOUTHERN PEAS (*VIGNA UNGUICULATA*) PROCESSED BY A PASTEURIZATION METHOD ON SOME PHYSICAL AND ORGANOLEPTIC CHARACTERISTICS

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Cherie L. Turner

December 1981

ACKNOWLEDGMENTS

The author wishes to express sincere gratitude and appreciation to her major professor Dr. J. L. Collins, for his valuable advice, guidance, encouragement, understanding and assistance throughout the entire graduate program and in the preparation of the thesis. Sincere appreciation and thanks are expressed to Dr. H. O. Jaynes and Dr. J. R. Mount for serving on the graduate committee and offering helpful suggestions and advice.

The author wishes to thank Dr. J. T. Miles, Department Head, for his support.

Special thanks are extended to Ms. Ruth Hill and Mr. Marvis Fryer for their assistance with canning and proximate analysis determinations and for allowing the use of the Oxygen Bomb Calorimeter and the Sand Filtration System for fiber analysis, respectively.

Thanks are extended to Dr. W. B. Sanders for his assistance in developing the statistical program and to Ms. Ola Sanders for her assistance with the sensory evaluation.

Appreciation is extended to Dr. J. M. Stewart of the Plant and Soil Science Department for use of the freeze-dryer and to Dr. W. J. McLaurin for providing the southern peas used in the experiment.

The author is also deeply indebted to Mr. Carl Turner and Ms. Dorothey Turner, Trey Turner, Mr. and Mrs. Jimmy Linn, and Gary Parker for their love, confidence, encouragement and support throughout the gratuate experience. The greatest thanks, appreciation, and love are extended to God who makes all things possible.

ABSTRACT

The major objective of this experiment was to prepare an acidified canned product of peas which could be processed by a pasterization method (boiling water bath) rather than by retorting. The effect of acidification on some chemical components, physical properties, microbiological counts and organoleptic characteristics was measured.

The percentage of vinegar affected the pH of the peas and liquor (0.01 level) and the acidity of liquor at the 0.05 level. Holding the samples in storage affected the acidity of peas and liquor (0.01 level) and the pH of liquor at the 0.05 level.

Firmness of the peas was increased (0.01 level) as the level of vinegar was increased in the acidified aqueous solutions. The amount of sugar in the sauces and the different sauces in which the peas were canned did not affect firmness.

Color of the peas was measured with the Hunter Colorimeter. Level of vinegar and sugar affected color significantly; however, the absolute difference in values was usually small. Mean values for peas canned in acidified solutions were: L = 46.9; "a" = -0.1; and "b" = 12.7. Mean values for rinsed peas which were canned in sauces were: L = 35.2; "a" = 0.3, and "b" = 15.2.

The level of vinegar did not affect the count of any of the microorganisms in samples of peas canned in the acidified solutions. The mesophilic and thermophilic aerobic counts were reduced during storage. On the first day of measurement, the highest estimated mean log count was 0.89 (colonies/g of sample).

For peas canned in the sauce the amount of vinegar or sugar had only a slight affect on the microbiological counts. The estimated mean

log counts were: for mesophilic aerobes and anerobes 1.25 and 0.53, respectively; for thermophilic aerobes and anaerobes, 1.14 and < 0.04, respectively. The spices used to make the sauces contributed to the relatively high counts.

Samples of peas in which sauces were evaluated by a sensory panel for texture, flavor and overall acceptability were scored by use of a hedonic system.

Of all the experimental factors, only the level of vinegar affected texture (0.05 level). As the level of vinegar was increased, the peas became firmer causing the panelists to assign lower scores to the samples. On an 8-point scale (1 = dislike extremely; 8 = like extremely) the firmness scores ranged from 4.8 to 5.2 with a mean score of 4.9. The mean scores for flavor and overall acceptability was 4.7. These scores indicate that the samples were liked slightly. In general, the samples were too tart and too spicy. The peas were too firm.

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I. INTRODUCTION

Southern peas (*Vigna unguiculate*), or cowpeas as they are called outside the United States, are grown widely in many areas of the world. The largest percentage of cowpeas is grown in Africa, where in 1972, 94% of the world's crop was produced (24). Other areas of production are India, South and Central America, and the southern United States, including Tennessee (2, 18, 26, 85). In the southern United States this crop is referred to erroneously as "peas" because botanically the plant is a bean. The term "peas," however, will be used hereafter.

Two-thirds of the production of peas in the United States in 1973 was commercially processed by freezing (79). Peas are also canned commercially. Home grown peas are frozen and canned.

Among certain groups of people in the United States and other parts of the world, peas are a staple food item (41, 43, 45, 75, 76). The major proportion of the world production of peas is allowed to mature to the dry stage before harvesting. Many methods may be used to prepare the peas for eating. While canning is used extensively in the United States to preserve peas, this method of preservation is not used to any extent in developing countries. However, Dovlo et al. (25) contend that the present small-scale food processing industries in Africa using cowpeas show potential for expanding.

Because peas are a low-acid food (pH about 6.6), canned peas must be processed at a temperature of 115^{o} C for an extended period of time to destroy *Clostriduim botulinum*. With the shortage of fuel abroad and high cost of fuel in this country, canning procedures need to be improved by reducing the processing temperature and length of time.

Acidification of certain low-acid foods is commonly practiced to lower the pH. This condition allows for a reduction in the amount of heat needed to preserve the product (23, 39, 47). This procedure seems feasible for reducing the processing temperature and time required for canning peas as a safe product.

The major objective of this experiment was to prepare an acidified canned product of peas which could be processed by a pasteurization method (boiling water bath) rather than by retorting. The effects of acidification on some chemical components, physical properties, microbiological counts and organoleptic characteristics was measured.

II. LITERATURE REVIEW

A. Classification

The term "southern peas," Vigna unguiculata or V. sinesis, applies to a commonly grown legume (bean) crop in the southern United States (2, 18, 25, 26). In this area the crop usually is called "peas" or blackeye peas. Here, the term "peas" will be used. Outside this country this legume is referred to as cowpeas. In the United States the legume consists of three main groups: crowder peas, cream peas, and peas with a pigmented helium (21, 84). The latter group is preferred. Many varieties of V. unguiculata are available for growing (14, 25, 73, 74).

B. Areas of Production of Peas

Peas are grown in many areas of the world including India, Africa, South America, and the southern United States (19,73). Major producing countries in Africa are Nigeria, Volta, Uganda, Niger, Senegal and Tanzania (25). In the southern United States peas are grown in all states to some extent but are grown primarily in Georgia, Mississippi, Oklahoma, South Carolina, Tennessee and Texas. Among certain groups of people this crop constitutes a staple food item (77).

Progress has been made in production of legumes including peas through research conducted by the Grain Legume Inprovement Program of the International Institute of Tropical Agriculture (ITTA) (25). In 1973, ITTA reported the world yield at 1.6 metric tons/ha. In 1979, 42,435 metric tons of peas were harvested in the United States where 9.2 metric tons of peas were frozen by commercial processors (21, 29, 42). In that year, 25,250,000 cases of canned peas (all sizes) were processed (21).

C. Nutritional Value of Peas

The nutritional food value of peas is high, containing on the average 23.5% crude protein, 1% crude fat, 56.5% carbohydrates in the dry matter (14, 19, 20), and several vitamins and minerals of significant amount (1, 49).

The United States Recommended Daily Allowances (RDA's) of nutrients for adolescent males (highest values) (54) and the nutritional values of peas (1, 43, 88, 89) are presented in Table 1.

1. Protein Content

Protein malnutrition and calorie deficiency are dietary problems in many developing countries (61, 62, 75, 76). Due to the limited availability of animal food supplies, more than one-half the world's population utilizes the seeds of legumes to supply its dietary needs (45, 85). The protein of peas is deficient in the sulpho-amino acids, cysteine and methionine (61, 62, 75).

Venkataraman et al. (85) studied the effect of germination on the biological value digestibility coefficients, and net protein utilization of peas. Results indicated that the biological value of ungerminated, uncooked peas was 68% of the theoretical maximum, but this was increased to 79% by cooking. The effect of germination and cooking on the protein efficiency ratio (PER) of legumes, including peas, was evaluated by Jaya et al. (41). Diets containing cooked peas had a higher PER than diets containing raw peas when fed to rats.

TABLE 1

THE U. S. RECOMMENDED DAILY ALLOWANCES FOR NUTRIENTS
AND THE NUTRITIONAL VALUE OF PEAS

Nutrient	U.S.D.A.[a]	Canned Peas[b] 100g (wet weight basis)
Protein	56	12.8
Vitamin A (μg RE)[c]	1,000	15
Vitamin C (mg)	60	8
Vitamin D (μg)[d]	10	-
Vitamin E (μg TE)[e]	10	-
Thiamin (mg)	1.4	0.23
Riboflavin (mg)	1.7	0.13
Niacin (mg NE)[f]	18	1.3
Vitamin B6 (mg)	2.0	0.32
Vitamin B12 (mg)	3.0	-
Folacin (μg)	400	140
Calcium (mg)	1,200	4.6
Iron (mg)	18	3.8
Iodine (μg)	150	6.0
Phosphorus (mg)	1,200	2.9
Magnesium (mg)	400	165
Zinc (mg)	15	28
Energy Kcal	2,800	179

[a]Reference (55).

[b]References (1, 43, 89, 90).

[c]Retinol equivalents. 1 retinol equivalent = 1 μg retinol or 6 μg β-carotene.

[d]Cholecalciferol. 10 mg cholecalciferol = 400 IU of vitamin D.

[e]α - tocopherol equivalents. 1 mg d-α-tocopherol = 1 α- TE.

[f]1 NE (niacin equivalent) is equal to 1 mg of niacin or 60 mg of dietary tryptophan.

2. Carbohydrate Content

Most legumes contain an average 60% carbohydrate component (68). Starch and reducing sugars represent 54% of the available carbohydrates. Oligosaccharides (stachylose, raffinose) are heat stable and as undigested carbohydrates, induce flatulence in the large intestine by microbiological fermentation (45, 69). Akpapunam and Markakis (2) reported that peas contain an average 3.4% stachyose, 1.2% raffinose, and 2.2% sucrose.

Hemicelluloses, one of the cell wall constituents, were investigated (18) using acid hydrolysis. Most of the hemicelluloses, totaling 2.3%, were water-soluble with the remaining hemicelluloses being acid-soluble.

3. Total Lipids

Total lipids extracted from peas averaged 2.0% (49). Neutral lipids, mostly triglycerides, constitute 49%, and glycolipids constitute 11% of the total lipid content.

4. Mineral and Vitamin Content

Peas are rich in the minerals zinc, copper, magnesuim, phosphorus, calcuim, iron, and manganese (50, 89). Peas contain the following vitamins (Table 1): thiamin, riboflavin, niacin, pyridoxine, pantothenic acid, biotin, and folic acid (57, 58).

D. Uses of Peas

On a relative basis consumption of peas is low. Several reasons exist for the limited consumption; the reasons include unfamiliarity with peas by the consumer, unavailability of peas, the presence of the flatulence causing carbohydrates raffinose and stachylose (2, 45, 61, 62), and the requirement for lengthy periods of time to rehydrate and cook the peas (43, 71, 73, 74).

Peas are a versatile vegetable and can be included in many dishes. Dried, frozen and canned peas can be used in soups and stews and may be steamed, fried, boiled, roasted, and baked (19, 48). Dovlo et al. (25) published on the preparation and use of peas in recipes.

E. Experimental Uses of Peas

An acceptable product utilizing peas, pork, and tomato sauce was developed by Ammerman and Seale (5, 6). Fill weight, levels of pork and tomato solids, and color were evaluated for acceptability. Moin-moin, an African dish using peas and tomato sauce, was canned by Ayodeji and Potter (15). Heat penetration, color, flavor (evaluated for acceptability), and proximate analysis were determined.

Legume products including peas with low flavor intensity are used as extenders and additives for meat and bakery products (43). The high protein content makes pea powders attractive extenders for cereal products. Onayemi and Potter (62) prepared a powder from peas with added methionine. They studied storage stability, organoleptic properties, and nutritional composition of the product. The process for drying an aqueous slurry (paste) of the flour consisted of drum-drying at 45 pounds per square inch (psi) (1 psi = 703.1 kg/square meter). This treatment did not affect the methionine and lysine contents.

Okaka and Potter (59, 60) produced a powder from peas that was superior to the previously prepared powder. The new powder did not possess a "beany" flavor as the former powder prossessed. Production of the powder with a less beany flavor was accomplished by soaking the peas in acidified aqueous solutions, dehulling, blanching in 100^{o}C steam, grinding and drum-drying (60). Moin-moin was prepared from the powder and tested for sensory attributes, nutritional composition, and storage stability.

Zamora and Fields (92) allowed peas to undergo natural fermentation for four days at 25^{o}C. The microorganisms isolated from peas included Lactobacillus casei, L. leichmanii, L. plantarum, Pediococcus pentosaceus, and P. acidilactici. Growth of these organisms increased the amount of niacin, thiamin, riboflavin, methionine, and isoleucine. Microbiological and toxicological evaluations of fermented peas indicated the absence of toxic substances (93).

F. Physical Qualities of Peas

1. Firmness

Food texture is evaluated by rheological sensations resulting from mastication (44). Simulation of the sensory process may be achieved by applying certain instrumental techniques. Sefa-Dedeh et al. (73) developed a method to measure the texture of raw and soaked peas. A wedge-type blade mounted on the Instron Testing Machine was used to cut across the cotyledons of the pea.

Soaking the peas prior to cooking produces a softer product than non-soaked cooked peas. Sefa-Dedeh et al. (74) studied the affects of environmental temperature and humidity during storage of dry peas on hardness of the raw and cooked peas. They reported that structural changes occur due to deterioration and hydrolysis of cell wall material in the seed coat.

Firmness of products such as canned peas and baked beans depends on the type, size and maturity of the beans, proportion of syrup, amount of beans and length of time the beans have been stored (8, 87).

Firmness of peas is influenced by chemical reactions involving phytates, divalent cations, pectates and lignins (46). Pectins are hydrated and dissolved when held in boiling water. Softening is retarded by the presence of acids and calcium salts, whereas, alkali accelerates the rate of softening (25). Pectates are unchanged by boiling. However, calcuim and magnesium of the pectates may be replaced by sodium of salt (NaCl) used in cooking, resulting in softening of the peas.

2. Color of Peas

USDA Standards for Grades of frozen peas (1976) require that 10% of the peas possess an "obvious green" color. Commercial harvesting and processing can cause loss of color (38, 79). Discoloration of peas results from brusing and breakage which may occur during mechanical harvest (90). Sistrunk and Bailey (78) studied factors affecting the discoloration of canned peas (Princess Ann cultivar). Use of immature peas and lower blanching temperatures caused more discoloration of liquor after canning. When alkalies were added to canned peas, corresponding increases in discoloration occurred due to pigments leaching from the helium of the pea (71). Heat during processing precipitates the anthocyanin pigments in the outer palisade layer and the inner basal layer of cells in the seed coat of some varieties of peas. Anthocyanin is found only in the inner basal layer of the purple hull variety (78).

The degree of greenness of peas can be influenced by time and temperature of storage prior to canning (78). Rizley and Sistrunk (71) found that peas soaked in pyrophosphate solution and canned were lighter (increased luminosity) than peas which were not soaked prior to canning. The color of canned peas was evaluated by Ammerman and Seale (6). Color was affected by time and temperature of blanching. Flora (32) analyzed the effects of modified canning procedures on the color of crowder peas. Acidified canned peas were lighter and had higher Gardner "b" values (increased yellowness) than untreated canned peas.

G. Preservation of Peas

Peas are processed commercially and at home peas are processed by canning and freezing. Mature dry peas are packaged as dry, frozed and canned (21, 53). Mature, succulent peas are processed by freezing and canning.

Dry peas are prepared for canning by soaking 10 to 12 hours in water with 4 to 6 grains hardness (1 grain per gallon = 17.1 ppm Ca CO_3). The peas are destoned, blanched from four to six minutes in water at 88 to 93^{o}C, and rinsed in cold water (48). Enameled cans are filled with peas and a brine (93^{o}C) is added (5.4 to 7.7 kg NaCl per 379 liter closure water) to complete the fill of the can. Atmospheric closure of the cans is made at 93^{o}C.

H. Potential For Spoilage of Low Acid Foods

Since microorganisms use the human food supply as a source of nutrients for growth, an understanding of the growth habits of microbiological flora as associated with food is important (40). Increasing numbers of bacteria, utilization of nutrients, and production of enzymes may cause off-flavors and toxins which spoil the food. Some microorganisms are pathogenic and when associated with food supplies, constitute a critical public health problem (70). Thus, heat sterilization is a very important process to render food safe.

Heat resistance of microorganisms (cells and spores) is affected by certain factors such as temperature of the growth medium, concentration of spores or cells, composition of the food in which spores are heated, and water activity and pH of the food (16, 24, 40, 82).

I. pH and Food Spoilage

Every microorganism has a minimal, maximal, and optimal pH for growth. In many biological functions, pH is as important a factor as temperature. Cells and spores are more heat stable in a food with a neutral pH (16, 40, 82, 91).

Foods with a pH less than 4.6 generally are not spoiled by bacteria (16, 47, 82, 91). The addition of acid to food increases the effectiveness of heat to destroy bacterial spores. One advantage of this fact is that considerably less heat is required to sterilize high acid foods (pH $<$ 4.6).

Foods are divided into classes according to their pH (16, 24, 28, 39, 40). These classifications are as follows: low acid foods with pH values above 4.6 and acid foods with pH values below 4.6. Food with a pH greater than 4.6 is subject to spoilage by mesophilic and thermophilic spore-forming anaerobic bacteria (24). Therefore, foods in this pH range must be processed under pressure at high temperatures for specified lengths of time to insure destruction of *Clostridium botulinum* (56, 77).

In 1946, the U.S.D.A. published the results of heat penetration and bacteriological studies of canned food (39). In order to destroy the spores of Clostridium botulinum, the causative bacterium for botulism, a heat treatment of 121^{o}C for 2.45 minutes is required, the equivalent of six hours of boiling (65).

J. Process Failure and Low Acid Food Spoilage

Only minute amounts of non-pathogenic bacterial spores should survive commercially- and home-canned low acid foods (16, 39, 48). Three classes of thermophilic spoilage of processed low-acid foods are identified according to the causative organisms. These are as follows: flat-sour producing bacteria, Bacillus stearothermophilus; anaerobic gas and acid producers such as Clostridium thermosaccharolyticum; and sulphide spoilage bacteria, Desulfotomaculum nigrificans, which cause the food to darken due to sulfide formation (48). Insufficient heat treatment of low-acid foods can contribute to spoilage by putrefactive mesophilic anaerobes (spore-formers) such as Clostridum sporogenes and Cl. butyricum. Mesophilic aerobes (spore-formers) such as Bacillus subtillis and B. coagulans are spoilage agents found in unswelled containers, while B. polymyxa and B. marcerans are spoilage agents found in swelled containers (48, 77).

K. Clostridium Botulinum as a Pathogenic Organism

Botulism results from ingestion of a preformed toxin produced by Clostridium botulinum, an anaerobic spore-forming bacillus (47, 70, 91). The potential for Clostridial poisoning is a constant threat to the health of humans because the spores are prevalent in the soil and may contaminate food processing plants. Improper processing of canned vegetables could produce conditions supporting botulism.

Six serological types of toxin-producing Cl. Botulinum have been identified; these are types A, B, C (C_α and C_β), D, E, and F (63, 70, 91). Types A, B, and E are associated with food poisoning in humans. Cl. botulinum toxins are temperature-sensitive proteins, being inactivated by heat for ten minutes at 100^{o}C. (16, 47, 70).

L. Botulism and Home-Canned Food

The increase in reported outbreaks of botulism caused by consumption of home-canned low-acid food reflects an increase in home-canning activity (30, 52, 65). From 1970 to 1977, 104 such outbreaks occurred involving 248 individuals. Two-thirds of these cases were due to home-canned products. Home-canned acid foods were involved in 34 of the 722 reported outbreaks of food-born botulism from 1899 through 1975 (68). Only five deaths due to botulism have been attributed to commercially canned foods since 1940 (56).

M. Acidification of Low Acid Foods

Sterilization of some low-acid products under normal procedures is impractical because the heat produces unmerchantable products (48). Vegetables such as Globe artichokes, pimientos, onions, and peppers under proper control may be acidified to the point where they are considered to be acid foods and are processed in boiling water. Laboratory approved details are essential for blanching, container fill, and brine composition when acidification procedures are used.

A variety of acids are used as food preservatives; the list includes benzoic, propionic, malic, citric, furmaric, phosphoric, lactic, and acetic acids (66). Vinegar used for pickling must contain 6-10% acetic acid according to regulations (36). Low-acid foods preserved in vinegar include beets, cauliflower, corn, figs, fish, green beans, meat, pickles, okra, olives, pears and relishes (10, 16, 24, 28, 48, 52, 72).

Acetic acid is often added to foods as an inhibitory agent. Spoilage of acid foods by yeast was studied by Pitt (66). Acetic acid proved more inhibitory against yeast spoilage than citric, malic, tartaric, benzoic, and sorbic acids (66). Use of acetic acid during processing reportedly had inhibitory affects on Micrococus, Bacillus, Staphlococcus and Enterobactinaceae (37).

N. Thermal Preservation of Low-Acid Canned Foods

Normally, canned foods contain microorganisms that cause spoilage; therefore, heat sterilization is required to insure a safe product. The definition of sterilization is any process producing a germ-free medium. The term "commercially sterile" more accurately describes the conditions normally found in processed food. Commercially sterile canned foods contain viable spores of thermophiles which will not germinate, grow or produce toxin under conditions normally maintained during the storage of foods (16, 40, 82).

Heat resistance of microorganisms is expressed in terms of the thermal death time (TDT). TDT is defined as the time required to kill a stated number of organisms or spores under a specified temperature (16, 24, 65, 82). pH is an important factor which affects the D value; this value is defined as the time in minutes at a constant temperature required to destroy 90% of the spoilage organisms or spores in the food (23, 24, 48). From the plot of the D values, the z value can be obtained. The z value is the temperature required for the curve to transverse one logarithmic cycle of the graph paper. The z value denotes the temperature required for a ten-fold change in time to achieve the same lethal effect. The sterility value (F_o) is the length of time necessary to obtain a 12-D destruction of spores in the food at 121^{o}C. The 12-D concept refers to the minimum heat process necessary to reduce the survival of spores by a factor of 12. Increases in the acidity (lower pH) causes decreases in the D values (40, 56).

O. Safety of Acid Canned Foods

Considerable concern has been expressed that pH of some of the foods long considered to be acid (pH below 4.6) might be high enough to permit growth of *Cl. botulinum* (72). The tomato has been considered an acid product with a pH of 4.6 or less; consequently, minimal sterilization processing has been considered adequate (67, 91). Odlaug and Pflug (56) isolated the spores of *Cl. botulinum* type A from home-canned tomato juice (pH 4.8) in an outbreak of botulism in Idaho in 1974. That same year spores of *Cl. botulinum* type B were isolated in home-canned tomatoes (pH 5.2) in an outbreak in Alabama. Heat resistant *Cl. botulinum* type A spores from the Idaho outbreak had an extrapolated D value (100^{o}C) of 47 minutes in a pH 7.0 buffer and 18 minutes in tomato juice with pH of 4.2 (56).

P. pH of Certain Home-Canned Acid Foods

Mundt et al. (52) compared the pH and titratable acidity values of home-canned tomatoes and juice from different counties of Tennessee. The pH ranged from 3.5 to 4.7. Titratable acidity ranged from 0.2 to 2.2%.

Powers and Godwin (67) determined the pH of tomatoes grown in Georga. The pH ranged between 4.38 and 4.60. In 1978, further studies were conducted on the pH of home-canned tomatoes in Georgia. About 86% of the spoiled jars examined had mold growth, indicating insufficient heat processing.

Some common spoilage agents found in acid foods include aerobic spore-forming bacteria such as Bacillus thermoacidurans which produce "flat sour" spoilage (48). Also found in these foods are anaerobic spore-forming gas producers such as Cl. pasteurianum, non-spore forming lactic acid producers such as Lactobacillus and Leuconostoc, yeasts, and relatively heat resistant molds such as Bepsochlamys fulia (48, 56).

Q. Synergism Among Organisms Contributing to the Spoilage of Acid Foods

Botulinum toxin was found in tomato juice (pH 4.2) where growth of certain species of Cladosporum had raised the pH above 4.6 at the surface. Increases in pH above 4.6 created a favorable environment for growth of Cl. botulinum (56). Odlaug and Pflug (56) demonstrated toxin production of Cl. botulinum in tomato juice where surface growth of Aspergillus spp. had raised pH above 4.6.

Fields et al. (30) isolated Bacillus subtilus, and other organisms from home-canned tomatoes. The pH of the medium was raised above 4.6 enabling the potential growth of Cl. botulinum.

R. Antagonistic Conditions Among Organisms Which Inhibit Clostriduim botulinum

In the presence of Bacillus licheniformis, no toxin was produced from a Cl. botulinum type A species (56). This microorganism produces bactracin, an antibiotic. Streptococcus lactis, Lactobacillus casei, Cl. bifermentans and Cl. perfringes have been shown to destroy performed toxin Cl. botulinum (56, 77).

III. MATERIALS AND METHODS

A. Source of Southern Peas

Southern peas (referred to as peas hereafter) of the Purple Hull Pink Eye cultivar were grown on the Plant Science Farm, The University of Tennessee, Knoxville, by personnel of the Plant and Soil Science Department. The peas were harvested by hand by personnel of the Food Technology and Science Department. Harvesting was at the stage of maturity at which the pod color was a glossy purple without green coloration. At this stage of maturity the peas were succulent.

B. Preparation of Peas

The peas were shelled with a roller type sheller, blanched for three minutes at 93^{o}C, cooled in tap water, and drained. The peas were weighed in 2.27 kg lots, placed into plastic freezer bags, and held at -30^{o}C overnight. Then the peas were transferred to a freezer at -17^{o}C for storage until used.

C. Tenderization of the Peas

For use, the frozen peas were thawed overnight at 7.2^{o}C. A homogeneous blend of peas was made by combining peas of all the individual bags. Excess moisture resulting from the formation of ice crystals was removed by allowing the peas to drain on a colander for two minutes.

A Mirro-Matic Pressure Cooker was used to tenderize the peas. Fifty ml of deionized water were heated to boiling in the cooker. Then, 134g of peas were added to the water. The cooker was closed and the pressure was allowed to reach 15 pounds per square inch (1 psi = 703.1

kg/square meter) (10). The pressure was maintained for three minutes then relieved rapidly by running cold tap water onto the cooker. The hot peas were poured onto a colander and allowed to drain for a period of less than one minute.

D. Preparation of Samples for Canning

1. <u>Peas Canned in an Acidified Aqueous Solution</u>

Three solutions were made by mixing 40 parts vinegar and 60 parts boiled deionized water, 45 parts vinegar and 55 parts water, and 50 parts each of the two components. Hot, tenderized peas (134g) were placed into a hot half-pint (0.38 liter) Mason jar and 95ml of the boiling vinegar solution were added, leaving approximately 1.23cm head space (10). Hot lids were placed on each jar and secured with bands. The jars of product were processed in boiling water for 10 minutes in a steam-jacketed kettle. The jars were covered with 2.54cm of water.

2. <u>Peas Canned in an Acidified Sauce.</u>

The recipe used for preparing the acidified sauce was similar to that of Miloradovich (51) for spicy chili sauce. Three sauces were prepared by the following procedures. Three vinegar-water-tomato paste mixtures were made by combining 42ml vinegar, 42ml water and 26g tomato paste; 47.3ml vinegar, 36.7ml water and 26g tomato paste; and 57.5ml vinegar, 31.5ml water, and 26g tomato paste. The percentage of vinegar was 38, 43 and 48% (2% error, should be 40, 45, and 50%) respectively. The constant level of tomato paste was used to maintain a uniform consistency.

In addition to the vinegar-water-tomato paste mixture, a constant amount of spices, dehydrated onions, salt, and dried red peppers was added to each of the above mixtures (Table 2). Sugar (light brown) was added to each mixture at three levels which were 26.2, 31.5 and 36.7g. Samples prepared for proximate analysis were prepared with 31.5g sugar only. The aggregation of ingredients of vinegar, water, tomato paste, spices, and sugar constituted the sauces.

Hot jars were filled with 126g of peas and 89ml of one of the sauces. The contents were mixed, leaving approximately 1.23cm head space (10). Hot lids were placed on each jar and secured with bands. The jars of product were processed in boiling water for 10 minutes in a steam-jacketed kettle. One inch (2.54cm) of water covered the top of the jars.

3. Samples for Analyses

Samples were prepared in the aqueous acidic solutions and in the sauces for chemical, physical, and microbiological analyses, and sensory evaluations.

E. Experimental Design for Chemical, Physical and Microbiological Analyses

Samples of peas canned in each of the three acid solutions (Treatment 1) and in each of the three sauces (Treatment 2) were stored up to 32 days at room temperature. After 0, 2, 4, 8, 16, and 32 days of storage, peas which had been canned in the acid solutions were tested for pH, acidity, color and firmness of the peas and for the presence of certain microorganisms. The liquor (liquid drained from the peas) was

TABLE 2

SPICES CONTAINED IN THE ACIDIFIED TOMATO SAUCE

Constituent	Grams
celery seed	1.5
chili powder	0.33
cinnamon	0.44
cloves	0.33
dried red pepper	0.33
ginger	0.33
minced dried onions	5.0
mustard	2.2
nutmeg	0.33
salt	1.0

tested for pH, acidity and turbidity. Peas canned in the sauces were drained and tested for pH, acidity, and color. The mixture of peas and sauce was tested for color, firmness and presence of microorganisms. The sauce was tested for pH. Samples of Treatment 1 (drained peas) and Treatment 2 (peas plus sauce) were analyzed for proximate analysis after 32 days storage. The samples were prepared in three replications and one measurement was made on each sample. Two measurements were made per sample for the microbiological tests.

F. Methods of Chemical Analysis

Samples (Section IV) were prepared for analysis by freeze-drying the entire contents of a jar after 10g of peas were removed from each jar in Treatment 1 and 10g of peas plus sauce were removed from each jar in Treatment 2. The samples removed were used for determination of the moisture content. A Virtis Freeze-Dryer (Model FFD-15W5) was used (31). Five days were required to dry the contents. Tenderized peas similar to the peas used for the canned samples were freeze-dried in triplicate samples of 124g. The freeze-dried material was analyzed for proximate analysis, gross energy content, and neutral detergent fiber content. One analysis was made on the contents of each jar and each sample of tenderized peas.

Proximate analysis was conducted according to AOAC (13) procedures, with one exception for crude fiber test. The moisture content was analyzed by drying the sample in a vacuum oven. The Kjeldahl Method was used to determine the protein content (%N x 6.25 = % protein). Total lipid content was determined by using the Goldfisch apparatus and petroleum ether to extract the material. Samples were ashed in a muffle furnace at 550°C. The crude fiber content was determined by the AOAC (13) procedure except that sea sand (acid washed, ashed, 120 mesh) and a vacuum manifold were used instead of asbestos to filter the samples (31). The carbohydrate content was calculated by difference. The gross energy content was determined with the Parr Oxygen Calorimeter (7) and reported as kilocalories per gram dry material. An 0.8g dried sample of each treatment was analyzed. The neutral detergent fiber content was determined by the AOAC (13) procedure except that sea sand (washed, ashed, 120 mesh) and a vacuum manifold were used instead of asbestos to filter the samples (31). Starch was not removed from the sample by amylolytic enzymes.

G. Methods of Physical Analysis

The physical tests are described below. One measurement was made on the contents of each jar.

1. Peas of Treatment 1

Peas of Treatment 1 were allowed to drain at least two minutes on an 8 mesh sieve prior to analysis. pH was determined on the peas with an Onion Ionalyzer Digital pH meter (Model 801) according to AOAC procedures (13).

Acidity was determined on the samples used for the pH readings (13) and reported as percentage of acetic acid.

The Hunter Color Meter (Model D 25 D2M) was used to measure the L, "a," and "b" color values of the peas (12). The samples were held in a cuvette with an optical glass bottom for the readings. The meter was standardized against a beige tile (Hunter C3-138).

Turbidity of the liquor was measured with the Hatch Portable Water Analysis Laboratory (9). Turbidity was reported in Formanzin Turbidity Units (FTU). The instrument range is 0 - 500 FTU's.

The Instron Food Testing Machine (Model 1132) was used to measure firmness of the peas. The machine was operated with a 500-kg load cell. The crosshead and chart speeds were set at 10cm per minute. The Kramer Shear-Compression Cell was utilized to hold the 60g sample of peas. Firmness was reported in kg force which was required to shear the 60g sample.

2. Peas of Treatment 2

The peas canned in the sauces (Treatment 2) were prepared for testing by rinsing off the sauce with 100ml of deionized water and allowing the peas to drain at least two minutes on an 8 mesh screen. The tests (Section V) performed on the peas and sauce were conducted similarly to the tests made on samples of Treatment 1. pH and acidity were determined on peas rinsed free of sauce by deionized water and on the sauce. Firmness was determined on the rinsed peas.

H. Methods of Microbiological Analysis

Ten g samples were taken from the geometric center of each jar of peas from both treatments. The sample was added to a sterilized dilu-tion bottle which contained 99ml of 0.1% peptone water (1g peptone, 1 l water) and six glass beads. The material was shaken until the sample disintegrated. A 1:10 dilution was made from peas of both treatments (the lowest possible dilution). Plates must have 30 to 300 colonies per g sample at the lowest possible dilution to be considered (significantly) countable.

One ml aliquots were plated for microbiological analysis. Plates were prepared to determine the presence of aerobic and anaerobic mesophiles and thermophiles. Standard Methods Agar was used for detection of aerobes and Anderson's Pork Pea Agar was used for the anaerobes (60). Two drops of triphenyl tetrazolium chloride (TTC) indicator were added to each plate in order to identify the colonies (55). Duplicate plates were prepared for each sample and incubated at 35^{o}C for the mesophiles and 55^{o}C for the thermophiles. Plates for the aerobes and anaerobes were incubated for 24 and 48 hr, respectively. Counts were made on each plate and the number of bacteria per g was calculated using the dilution factor. Counts were reported as the mean log number of organisms per g of sample.

I. Experimental Design for Sensory Evaluation.

Samples from Treatments 1 and 2 (Section IV) which were prepared in three replications were stored for 32 days at room temperature. A homogenous mixture was made from the combined contents of these replications and used for evaluation.

J. Preparation of Samples and Methods of Analysis by Sensory Evaluation.

1. <u>Preparation of Samples for Sensory Evaluation Samples</u>

Preparation of samples for sensory evaluation samples served to the panel consisted of the following preparations. Drained peas from Treatment 1 were covered either with a chili sauce or commercially processed sweet pickle relish. Samples from treatment 2 consisted of peas plus sauce. Individual samples contained 38, 43 and 48% (2% error, should be

40, 45 and 50% respectively) vinegar and samples of each vinegar level contained 26.6, 31.5, and 36.7g of sugar.

The chili sauce was prepared by combining 850g canned stewed tomatoes, 45g chopped onions, 4g Jalapeno peppers, 191g sugar, and 20g salt (51). The mixture of ingredients was blended in a blender at "chop" speed for one minute. Following, the blended material was heated in a pan until it thickened slightly. The pickle relish was purchased from a local grocery store. For serving, about 2g of drained peas (Treatment 1) or peas plus sauce (Treatment 2) were placed in a 60ml souffle cup. One teaspoon of chili sauce or pickle relish was added to the peas of Treatment 1.

2. Methods of Analysis for Sensory Evaluation

Sensory evaluation was conducted by using a laboratory acceptance profile panel (83). An untrained panel of 15 members evaluated each of the 15 samples twice over a six day period. Table 3 presents the description of the smaples and the schedule for testing. Flavor, texture and overall acceptability of the samples were determined using an 8-point hedonic scale. The scale ranged from 1 = dislike extremely to 8 = like extremely. A copy of the score sheet used is in Appendix A.

The laboratory used for evaluation was air conditioned and illuminated with white fluorescent lights. Booths were provided for individual evaluations. At each testing time, each panelist was presented five samples. Therefore, each panelist evaluated samples on six different days. Testing was conducted between 1:00 and 3:00 p.m.

TABLE 3

FORMAT FOR EXPERIMENTAL DESIGN OF SENSORY EVALUATION INCLUDING DAY OF SENSORY EVALUATION, SAMPLE NUMBER AND DESCRIPTION OF THE SAMPLE

Day	1	2	3	4	5	6	10	11	12	13	14	15	16	17	18
1	X	X	X	X	X	X									
2							X	X	X						
3										X	X	X	X	X	X
4	X	X	X							X	X	X			
5				X	X	X									
6							X	X	X				X	X	X

Description:

1 - 3: 40, 45, 50% vinegar plus pepper sauce.

4 - 6: 40, 45, 50% plus pickle relish.

7 - 9: omitted.

10-12: 40, 45 and 50% sauces with 26.2g of sugar.

13-15: 40, 45 and 50% sauces with 31.5g of sugar.

16-18: 40, 45 and 50% sauces with 36.7g sugar.

X indicates order of evaluating samples.

K. Experimental Design and Analysis of Data

Data for the chemical, physical, and microbiological tests were analyzed as a factorial of a complete block (3). The design for chemical tests was 2 x 3 x 3 ((treatment (peas canned in acidified solutions and peas canned in sauces) x percentage of vinegar (40, 45 and 50) x replication)). The design for the physical tests of peas canned in acidified solutions was a 3 x 3 x 3 (percentage of vinegar x day of storage x replication). The design for the physical test of peas canned in sauces was 3 x 3 x 3 (percentage vinegar x level of sugar x replication). The design for microbiological counts from peas canned in an acidified solution was 2 x 3 x 6 x 3 (treatment x percentage of vinegar x days of storage x replication). The design for microbiological examination of peas canned in sauces was similar to that described above for physical tests. Sensory panel data were evaluated a factorial of an incomplete block (4). The design was 6 x 3 x 2 x 3 x 2 (days of evaluation x percentage of vinegar x sauce added to acidified peas x levels of sugar in sauces of treatment 2 x acidified peas served with two sauces vs. peas plus sauce with three levels of sugar).

Analysis of variance was used to analyze the data for the chemical, physical and microbiological tests. The General Linear Model procedure was used to analyze the sensory evaluation data (17). Signifiance among means was determined by Duncan's Multiple Range Test (17). Analysis was conducted at the University of Tennessee Computer Center using the Statistical Analysis System (17).

IV. RESULTS AND DISCUSSION

A. Compositional and Energy Values of Acidified Canned Peas.

F-ratios for the analyses of variance for compositional and energy values of peas which were canned in acidified solutions (Treatment 1) or in sauces (Treatment 2) are presented in Table 4. For all the analyses a significant difference was found between samples of the two treatments. Differences between treatments may have resulted, in part, from the amount of peas contained in each sample. Samples (drained peas) taken from the jars of Treatment 1 contained more peas than samples taken from jars of Treatment 2. In the latter treatment the addition of onions, spices and tomato paste reduced the proportion of peas. The significance level was 0.01 for all analyses except for ash, crude fiber, and gross energy which were significant at the 0.05 level. The percentage of vinegar had an effect (0.01 level) on the amount of ether extract. The interaction between treatment and percentage of vinegar affected the amount of crude protein only at the 0.05 level.

Means for compositional and energy values of the samples (drained peas in Treatment 1 and peas plus sauce in Treatment 2) as affected by treatment and percentage of vinegar are presented in Table 5. The peas of Treatment 1 had the higher percentage of moisture, crude protein, crude fiber, nitrogen free extract, and neutral detergent fiber and the higher amount of gross energy. The peas plus sauce of Treatment 2 had the higher percentage of ash, possible resulting from the addition of spices to the sauce. While difficult to explain, peas canned in the 40% vinegar medium had the highest level of ether extract, while peas canned in the 45% vinegar medium had the lowest level. None of the other means was significantly different.

TABLE 4

F-RATIOS FOR THE ANALYSIS OF VARIANCE OF COMPONENTS AND ENERGY VALUES OF PEAS CANNED IN ACIDIFIED SOLUTIONS OR SAUCES[a]

	D.F.	Moisture	Crude Protein	Ether Extract	Ash	Crude Fiber	Nitrogen Free Extract	Neutral Detergent Fiber	Gross Energy
Total	17								
A Treatment[b]	1	203.85**	52.35**	58.24**	10.01*	5.13*	12.14**	457.50**	6.13*
B Level of Vinegar	2	1.18^{ns}	2.15^{ns}	7.73**	1.67^{ns}	2.64^{ns}	0.84^{ns}	0.32^{ns}	1.16^{ns}
A X B	2	1.15^{ns}	6.61*	3.29^{ns}	3.63^{ns}	0.68^{ns}	0.99^{ns}	0.36^{ns}	0.00^{ns}
Replication	2	0.48^{ns}	1.34^{ns}	0.84^{ns}	0.60^{ns}	0.25^{ns}	2.32^{ns}	1.78^{ns}	1.76^{ns}
Residual Error (Mean Square)	10	1.17	0.88	0.01	0.06	0.14	5.07	3.86	

[a]All analyses were analyzed on a dry basis except moisture which was conducted on the wet basis.

[b]Treatment 1 = Peas canned in an aqueous solution; Treatment 2 = Peas canned in sauces.

**Significant at 0.01 level.

*Significant at 0.05 level.

^{ns}Not significant at 0.05 level.

TABLE 5

MEANS FOR COMPONENTS AND ENERGY VALUES OF PEAS CANNED IN ACIDIFIED SOLUTIONS OR SAUCES AS AFFECTED BY TREATMENT AND PERCENTAGE OF VINEGAR[a]

	%Dry Matter	%Crude Protein	%Ether Extract	%Ash	%Crude Fiber	%Nitrogen Free Extract	%Neutral Detergent Fiber	Gross Energy Kcal p/gram
Treatment[b]								
1	25.3^{e}	17.8^{d}	1.7^{d}	3.1^{f}	4.4^{d}	47.7^{d}	53.3^{d}	4.4^{f}
2	32.7^{d}	14.6^{e}	2.1^{d}	3.5^{g}	4.0^{e}	43.1^{e}	33.5^{e}	3.9^{g}
Level of Vinegar[c]								
40%	29.5^{g}	16.6^{g}	2.0^{d}	3.3^{g}	4.4^{g}	44.2^{g}	43.9^{g}	4.2^{f}
45%	29.0^{g}	15.6^{g}	1.7^{g}	3.1^{g}	4.0^{g}	46.6^{g}	43.0^{g}	4.1^{f}
50%	28.5^{g}	16.6^{g}	1.9^{de}	3.4^{g}	4.1^{g}	45.5^{g}	43.4^{g}	4.2^{f}

[a]All analyses were conducted on the dry basis except moisture

[b]Treatment 1 = Peas canned in an acidified solution; Treatment 2 = Peas canned in acidified sauces.

[c]Means for all analysis were derived from 6 observations.

[d-e]Means for each analysis followed by different letters are significant at the 0.01 level.

[f-g]Means for each analysis followed by different letters are significant at the 0.05 level.

Means for the compositional and energy values of peas (Treatment 1 and Treatment 2) as affected by the interaction between treatment and percentage of vinegar are presented in Table 6. Only the amount of crude protein was affected (0.05 level). Peas canned in the 40% vinegar solution had the highest amount of crude protein, while peas canned in the sauce with 40% vinegar had the lowest amount.

B. pH and Acidity of Canned Peas

F-ratios for the analysis of variance of pH and acidity for peas canned in the acidified solutions (Treatment 1) are presented in Table 7. The percentage of vinegar affected the pH of peas and liquor (vinegar solution drained from the peas) at the 0.01 level, while only acidity of the liquor was affected (0.05 level). Storage time affected acidity of peas and liquor (0.01 level) and pH of the liquor (0.05 level). The interaction between percentage of vinegar and storage time affected (0.01 level) the acidity of liquor only.

Means for pH and acidity of peas from Treatment 1 (three acidified solutions) are presented in Table 8. Mean pH values of the peas and liquor were highest for samples canned in the 40% vinegar solution. The lowest pH values varied between samples canned in the 45 and 50% vinegar solutions. pH between the peas and liquor was similar. Percentage of acid (as acetic acid) of the peas averaged 0.08. Liquor from the samples canned in 50% vinegar solution had the higher level of acid (0.11%), while peas canned in the 45% vinegar solutions had the lower level (0.09). One explanation for the descrepancy in percentages of acid is that varing amounts of the acid might have volatilized during the open-pan heating of the solutions. Seemingly, storage time affected

TABLE 6

MEANS FOR COMPONENTS AND ENERGY VALUES OF PEAS CANNED IN ACIDIFIED SOLUTIONS OR SAUCES AS AFFECTED BY THE INTERACTION BETWEEN TREATMENT AND PERCENTAGE OF VINEGAR[a]

Treatment[bc]	Level of Vinegar[d]	%Dry Matter	%Crude Protein	%Ether Extract	%Ash	%Crude Fiber	Nitrogen %Free Extract	Neutral %Detergent Fiber	Gross Energy Kcal p/gram
1	40%	25.9[i]	19.3[i]	1.7[i]	3.3[i]	4.7[i]	45.1[i]	54.0[h]	4.4[i]
	45%	24.8[i]	16.4[eg]	1.6[i]	3.0[i]	4.0[i]	50.2[i]	53.2[h]	4.5[i]
	50%	25.3[i]	17.9[ef]	1.7[i]	3.0[i]	4.4[i]	47.7[i]	52.7[h]	4.4[i]
2	40%	33.1[i]	13.9[i]	2.3[i]	3.3[i]	4.2[i]	43.2[i]	33.7[h]	4.0[i]
	45%	33.1[i]	14.8[h]	1.9[i]	3.3[i]	3.9[i]	43.0[i]	32.7[h]	3.7[i]
	50%	31.7[i]	15.2[gh]	2.1[i]	3.8[i]	3.8[i]	43.4[i]	34.0[h]	4.1[i]

[a]All analyses were conducted on the dry basis except moisture.

[b]Interaction means were derived from 3 observations.

[c]Treatment 1 = peas canned in an acidified solution; Treatment 2 = peas canned in acidified sauces.

[d]In the acidified solutions and sauces.

[e-i]Means for each analysis followed by the different letters are significantly different at 0.05 level.

TABLE 7

F-RATIOS FOR THE ANALYSIS OF VARIANCE OF pH AND ACIDITY FOR PEAS AND LIQUOR OF SAMPLES CANNED IN ACIDIFIED SOLUTIONS AS AFFECTED BY THE INTERACTION BETWEEN TREATMENT AND PERCENTAGE OF VINEGAR

		pH		Acidity	
	D.F.	Peas	Liquor	Peas	Liquor
Total	53				
A. Level of Vinegar	2	22.88**	21.89**	1.48^{ns}	5.18*
B. Day of Storage	5	0.46^{ns}	3.14*	4.04**	4.73**
A X B	10	1.02^{ns}	1.15^{ns}	1.97^{ns}	5.73**
Replication	2	0.34^{ns}	0.70^{ns}	2.46^{ns}	0.89^{ns}
Residual Error (Mean Squares)	34	0.002	0.002	0.0005	0.0002

**Significantly different at the 0.01 level.

*Significantly different at the 0.05 level.

^{ns}Not significantly different at the 0.05 level.

TABLE 8

MEANS FOR pH AND ACIDITY OF PEAS AND LIQUOR FROM SAMPLES CANNED IN ACIDIFIED SOLUTIONS AS AFFECTED BY PERCENTAGE OF VINEGAR AND DAYS OF STORAGE

	pH		Acidity %	
	Peas	Liquor	Peas	Liquor
Level of Vinegar[a]				
40%	4.44[c]	4.42[c]	0.07[h]	0.10[f]
45%	4.35[d]	4.37[d]	0.09[h]	0.09[f]
50%	4.34[e]	4.31[d]	0.08[h]	0.11[g]
Days of Storage[b]				
0	4.39[h]	4.35[gh]	0.06[g]	0.09[d]
2	4.36[h]	4.35[gh]	0.08[fg]	0.12[d]
4	4.38[h]	4.38[fgh]	0.06[g]	0.10[d]
8	4.39[h]	4.33[h]	0.09[fg]	0.10[d]
16	4.38[h]	4.40[f]	0.10[f]	0.09[d]
32	4.38[h]	4.40[fg]	0.08[fg]	0.10[cd]

[a]Means for level of vinegar were derived from 18 observations.

[b]Means for day of storage were derived from 9 ovservations.

[c-e]Means for each analysis followed by different letters are significantly different at the 0.01 level.

[f-h]Means for each analysis followed by different letters are significantly different at the 0.05 level.

pH and acidity, however, the variability in pH and amounts of acid is most likely due to the loss of acid during heating of the solution prior to adding it to the jars.

Means for pH and acidity of peas and liquor of samples from Treatment 1 as affected by the interaction of percentage of vinegar and storage time are presented in Table 9. The significant differences indicated between amounts of acidity for the liquor may have been due to volatilizion in heating the solution rather than the effect of either treatment.

F-ratios for the analysis of variance of pH and acidity of peas (rinsed free of sauce) and sauce for samples of Treatment 2 are presented in Table 10. Percentage of vinegar, level of sugar, and the interaction between percentage of vinegar and level of sugar did not affect pH or acidity of the samples.

Mean pH and acidity values for samples of Treatment 2 are presented in Table 11. The mean pH of peas and sauce was 4.26 and 4.32, respectively. The mean acidity value of peas was 0.64; the sauce was not titrated for the acid level.

Means for pH and acidity of samples from Treatment 2 as affected by the interaction between percentage of vinegar and level of sugar are presented in Table 12. None of the means were different.

TABLE 9

MEANS FOR pH AND ACIDITY OF PEAS AND LIQUOR FROM SAMPLES CANNED IN ACIDIFIED SOLUTIONS AS AFFECTED BY PERCENTAGE OF VINEGAR X DAYS OF STORAGE[a]

Level of Vinegar	Days of Storage	pH		% Acidity	
		Peas	Liquor	Peas	Liquor
40%	0	4.44[i]	4.38[i]	0.06[i]	0.09[f]
	2	4.41[i]	4.42[i]	0.06[i]	0.11[d]
	4	4.46[i]	4.46[i]	0.06[i]	0.08[g]
	8	4.45[i]	4.33[i]	0.08[i]	0.09[f]
	16	4.43[i]	4.49[i]	0.09[i]	0.07[h]
	32	4.38[i]	4.44[i]	0.09[i]	0.13[b]
45%	0	4.38[i]	4.45[i]	0.06[i]	0.10[e]
	2	4.38[i]	4.35[i]	0.06[i]	0.10[e]
	4	4.36[i]	4.38[i]	0.06[i]	0.10[e]
	8	4.36[i]	4.35[i]	0.11[i]	0.10[e]
	16	4.34[i]	4.41[i]	0.09[i]	0.09[f]
	32	4.38[i]	4.40[i]	0.08[i]	0.08[g]
50%	0	4.37[i]	4.31[i]	0.06[i]	0.09[f]
	2	4.37[i]	4.28[i]	0.06[i]	0.13[b]
	4	4.32[i]	4.30[i]	0.06[i]	0.12[c]
	8	4.35[i]	4.32[i]	0.09[i]	0.10[c]
	16	4.33[i]	4.32[i]	0.12[i]	0.11[d]
	32	4.34[i]	4.35[i]	0.08[i]	0.09[f]

[a]Means derived from 3 observations.

[b-h]Means for each analysis followed by different letters are significantly different at the 0.01 level.

[i]Means for each analysis followed by the same letters are not significantly different at the 0.05 level.

TABLE 10

F-RATIOS FOR THE ANALYSIS OF VARIANCE OF pH AND ACIDITY OF PEAS AND SAUCE FROM SAMPLES CANNED IN SAUCES

	D.F.	pH Peas	pH Sauce	% Acidity of Peas
Total	26			
A. Level of Vinegar	2	1.18^{ns}	0.99^{ns}	1.25^{ns}
B. Level of Sugar	2	0.81^{ns}	1.04^{ns}	0.36^{ns}
A x B	4	0.86^{ns}	0.76^{ns}	0.87^{ns}
Replication	3	0.61^{ns}	0.66^{ns}	0.28^{ns}
Residual Error (Mean Squares)	15	0.78	0.81	0.02

^{ns}Not significantly different at the 0.05 level.

TABLE 11

MEANS FOR pH AND ACIDITY OF PEAS AND SAUCE FROM SAMPLES CANNED IN SAUCES AS AFFECTED BY THE PERCENTAGE OF VINEGAR AND LEVEL OF SUGAR[a]

	pH		% Acidity of Peas
	Peas	Sauce	
Level of Vinegar			
40%	4.5[b]	4.5[b]	0.71[b]
45%	3.9[b]	4.0[b]	0.60[b]
50%	4.5[b]	4.5[b]	0.61[b]
Level of Sugar, grams			
26.2	4.0[b]	4.0[b]	0.65[b]
31.5	4.4[b]	4.5[b]	0.66[b]
36.7	4.4[b]	4.5[b]	0.61[b]

[a]Means for level of vinegar and level of sugar were determined from 9 observations.

[b]Means for each analysis followed by the same letter are not significantly different at the 0.05 level.

TABLE 12

MEANS FOR pH AND ACIDITY OF PEAS AND SAUCE FROM SAMPLES CANNED IN SAUCES AS AFFECTED BY THE INTERACTION BETWEEN PERCENTAGE OF VINEGAR AND LEVEL OF SUGAR[a]

Level of Vinegar	Level of Sugar (g)	pH		% Acidity of Peas
		Peas	Sauce	
40%	26.2[b]	4.44[b]	4.43[b]	0.73[b]
	31.5[b]	4.42[b]	4.48[b]	0.78[b]
	36.7[b]	4.47[b]	4.53[b]	0.64[b]
45%	26.2[b]	2.95[b]	3.01[b]	0.59[b]
	31.5[b]	4.42[b]	4.50[b]	0.70[b]
	36.7[b]	4.42[b]	4.40[b]	0.53[b]
50%	26.2[b]	4.30[b]	4.44[b]	0.65[b]
	31.7[b]	4.47[b]	4.55[b]	0.54[b]
	36.7[b]	4.42[b]	4.50[b]	0.64[b]

[a]Means were derived from 3 observations.

[b]Means for each analysis with the same letters are not significantly different at the 0.05 level.

C. Turbidity

F-ratios for the analysis of variance for turbidity of the liquor from Treatment 1 are presented in Table 13. The percentage of vinegar had an effect (0.05) on the turbidity; storage time and the interaction between the percentage of vinegar and storage time had no effect.

Turbidity of the liquor decreased as the percentage of vinegar was increased (Table 14). The liquor from samples canned in 40% vinegar solution was opaque with a white, chalky appearance. Liquor from samples with 50% vinegar was less opaque and more yellowish in color. Although not significantly different, the means for turbidity exhibited a tendency to decrease between 0 and 2 days storage. The remaining means were similar to each other except the mean for turbidity after 16 days of storage was relatively higher.

Means for turbidity of the liquor as affected by the interaction between percentage of vinegar and storage time are presented in Table 15. The mean for turbidity was 176.1 Formazin Turbidity Units.

D. Firmness of Acidified Canned Peas

F-ratios for the analysis of variance of firmness values of peas from Treatment 1 are presented in Table 16. In Treatment 1 the percentage of vinegar did not affect firmness of the peas. The storage period of 32 days had a significant effect on firmness at 0.01 level. A significant difference (0.01 level) was found between firmness values of the three replications.

TABLE 13

F-RATIOS FOR THE ANALYSIS OF VARIANCE FOR TURBIDITY OF LIQUOR FROM PEAS CANNED IN ACIDIFIED SOLUTIONS

	DF	Turbidity
Total	53	
A. Level of Vinegar	2	4.81*
B. Days of Storage	5	0.94^{ns}
A X B	10	0.85^{ns}
Replication	2	2.50^{ns}
Residual Error (Mean Square)	34	7264.38

*Significant at the 0.05 level.

^{ns}Not significant at the 0.05 level.

TABLE 14

MEANS FOR TURBIDITY OF LIQUOR FROM PEAS CANNED IN ACIDIFIED SOLUTIONS AS AFFECTED BY THE PERCENTAGE OF VINEGAR AND DAYS OF STORAGE

Level of Vinegar[b]	Turbidity, FTU's[a]
Level of Vinegar[b]	
40%	225.2[d]
45%	163.3[de]
50%	139.9[e]
Day of Storage[c]	
0	200.0[f]
2	164.7[f]
4	161.0[f]
8	151.6[f]
16	221.6[f]
32	161.4[f]

[a]FTU's are Formanzin Turbidity Units.

[b]Means were derived from 18 observations.

[c]Means were derived from 9 observations.

[d-e]Means followed by different letters are significantly different at the 0.01 level.

[f]Means followed by the same letter are not significantly different at the 0.05 level.

TABLE 15

MEANS FOR TURBIDITY OF LIQUOR FROM PEAS CANNED IN ACIDIFIED SOLUTIONS AS AFFECTED BY THE INTERACTION BETWEEN PERCENTAGE OF VINEGAR AND DAYS OF STORAGE[a]

Level of Vinegar	Days of Storage	Turbidity, FTU[b]
40%	0	263.0[c]
	2	220.0[c]
	4	173.3[c]
	8	189.0[c]
	16	304.0[c]
	32	201.7[c]
45%	0	211.7[c]
	2	164.7[c]
	4	128.7[c]
	8	121.3[c]
	16	245.9[c]
	32	108.3[c]
50%	0	125.0[c]
	2	106.3[c]
	4	180.0[c]
	8	141.3[c]
	16	112.7[c]
	32	174.3[c]

[a]Means were derived from 3 observations.

[b]FTU's are Formanzin Turbidity Units standardized against distilled water.

[c]Means followed by the same letter are not significantly different at the 0.05 level.

TABLE 16

F-RATIOS FOR THE ANALYSIS OF VARIANCE OF FIRMNESS FOR PEAS CANNED IN ACIDIFIED SOLUTIONS

	D.F.	Firmness
Total	53	
A. Level of Vinegar	2	0.36[ns]
B. Days of Storage	5	6.09**
A X B	10	0.76[ns]
Replication	2	10.28**
Residual Error (Mean Square)	34	44.39

**Significant at the 0.01 level.

ns Not significant at the 0.05 level.

Table 17 presents means for firmness values (kg force) for peas of Treatment 1. The mean firmness value for the three levels of vinegar was 60.3kg force. Firmness values were fairly constant for the first eight days of storage but began a trend of increasing as the samples were held to 32 days. Interaction means for level of vinegar and storage time are presented in Table 18.

F-ratios for analysis of variance of firmness values of peas plus sauce from Treatment 2 are presented in Table 19. Only the level of vinegar affected (0.01 level) firmness of the samples.

Mean firmness values for samples from Treatment 2 as affected by percentage of vinegar and level of sugar are presented in Table 20. Generally, firmness of the peas plus sauce was highest when prepared with 50% vinegar and lowest when prepared with 45% vinegar. While not significantly different, the samples prepared with the two highest amounts of sugar tended to be the firmness. The mean firmness values was 71.8kg force. Mean firmness values as affected by the interaction between level of vinegar and amount of sugar are presented in Table 21.

Data reporting the increases in firmness of peas resulting from the addition of vinegar agree with data of the literature which indicates that acetic acid, in high concentrations, favors the hydrolisis of phytic acid to inositol and phosphoric acid (28). This hydrolytic reaction releases calcium from the phytic acid molecules. Neither of the hydrolytic products binds calcium; therefore, it is available to react with cell wall components to increase firmness of the peas.

Kumar et al. (46) suggested that several parameters such as the presence of phytates, calcium (Ca^{++}), magnesium (Mg^{++}), and free pectin cumulatively account for the hardness of cooked legumes.

TABLE 17

MEANS FOR FIRMNESS OF SAMPLES CANNED IN ACIDIFIED SOLUTIONS AS AFFECTED BY PERCENTAGE OF VINEGAR AND DAYS OF STORAGE

	Firmness, kg force
Level of Vinegar[a]	
40%	59.3[f]
45%	61.2[f]
50%	60.3[f]
Days of Storage[b]	
0	58.4[de]
2	56.0[de]
4	54.0[e]
8	60.5[cde]
16	64.2[cd]
32	68.7[c]

[a]Means were derived from 18 observations.

[b]Means were derived from 9 observations.

[c-e]Means followed by different letters are significantly different at the 0.01 level.

[f]Means followed by the same letter are not significantly different at the 0.05 level.

TABLE 18

MEANS FOR FIRMNESS OF SAMPLES CANNED IN ACIDIFIED SOLUTIONS AS AFFECTED BY THE INTERACTION OF PERCENTAGE OF VINEGAR AND DAYS OF STORAGE[a]

Level of Vinegar	Days of Storage	Firmness, kg force
40%	0	60.0[b]
	2	58.4[b]
	4	48.8[b]
	8	60.0[b]
	16	61.9[b]
	32	66.8[b]
45%	0	54.2[b]
	2	57.0[b]
	4	55.7[b]
	8	60.3[b]
	16	68.5[b]
	32	71.6[b]
50%	0	61.0[b]
	2	52.7[b]
	4	56.8[b]
	8	61.1[b]
	16	62.2[b]
	32	67.7[b]

[a]Means were derived from 3 observations.

[b]Means followed by the same letter are not signficently different of the 0.05 level.

TABLE 19

F-RATIOS FOR THE ANALYSIS OF VARIANCE OF FIRMNESS FOR PEAS CANNED IN SAUCES

	D.F.	Firmness
Total	26	
A. Level of Vinegar	2	4.73*
B. Levels of Sugar	2	0.87^{ns}
A X B	4	1.06^{ns}
Replication	3	1.42^{ns}
Residual Error (Mean Square)	15	198.2

*Significant at the 0.05 level.

^{ns}Not significant at the 0.05 level.

TABLE 20

MEANS FOR FIRMNESS OF SAMPLES CANNED IN SAUCES AS AFFECTED BY PERCENTAGE OF VINEGAR AND LEVEL OF SUGAR[a]

	Firmness, kg force
Level of Vinegar	
40%	72.4[bc]
45%	61.2[c]
50%	81.6[b]
Level of Sugar, gram	
26.2	66.7[d]
31.5	74.1[d]
36.7	74.4[d]

[a]Means were derived from 9 observations.

[b-c]Means followed by different letters are significantly different at the 0.05 level.

[d]Means followed by the same letter are not significantly different at the 0.05 level.

TABLE 21

MEANS FOR FIRMNESS OF SAMPLES CANNED IN SAUCES AS AFFECTED BY THE INTERACTION OF PERCENTAGE OF VINEGAR AND LEVEL OF SUGAR[a]

Level of Vinegar	Level of Sugar, grams	Firmness, kg force
40%	26.2	71.0[b]
	31.5	69.3[b]
	36.7	76.8[b]
45%	26.2	46.2[b]
	31.5	72.1[b]
	36.7	65.4[b]
50%	26.2	82.9[b]
	31.5	80.9[b]
	36.7	81.1[b]

[a]Means were derived from 3 observations.

[b]Means followed by the same letter are not signficently different of the 0.05 level.

Intercellular cementing in the cell wall components resulting from pectin or calcium pectate reaction with acid increased the firmness of cooked peas according to Dovolo et al. (25). Pectins are hydrated and dissolved by boiling water which tenderizes the peas (28, 32, 72, 74). Softening is retarded by the acid and calcium salt (46, 72).

Flora (32) showed increases in firmness of peas when acidified with citric acid. Acid denatures protein and suppresses the hydration of protein and starches, producing firmer peas.

E. Color of Canned Peas

F-ratios for the analysis of variance for Hunter color values of peas canned in acidified solutions (Treatment 1) are presented in Table 22. Percentage of vinegar affected (0.05) Hunter "a" values but did not affect Hunter L and "b" values. Storage up to 32 days affected (0.01 level) Hunter "a" and "b" values. The interaction between percentage of vinegar and days of storage was not significant at 0.05 level. Differences for replication occurred for Hunter L (0.01 level) and "a" (0.05 level) values.

Means for Hunter color values of peas from Treatment 1 as affected by percentage of vinegar and days of storage are presented in Table 23. Peas canned in the solutions of 45 and 50% vinegar had "a" values which indicated a slight green color, while peas canned in the solution of 40% vinegar had "a" values which indicated a slight red color. However, since the "a" values are very close to zero, the peas are actually in the neutral color zone. The mean L value for peas of the three levels of vinegar is 46.9; the mean "b" value, 12.8. When the storage time was

TABLE 22

F-RATIOS FOR THE ANALYSIS OF VARIANCE OF HUNTER COLOR VALUES FROM PEAS CANNED IN ACIDIFIED SOLUTIONS

	D.F.	Hunter L	Hunter "a"	Hunter "b"
Total	53			
A. Level of Vinegar	2	1.55^{ns}	3.89*	1.08^{ns}
B. Days of Storage	5	1.57^{ns}	4.57**	5.49**
A X B	10	1.59^{ns}	0.84^{ns}	1.20^{ns}
Replication	2	5.30**	3.38*	2.08^{ns}
Residual Error (Mean Squares)	34	1.10	2.44	0.75

**Significantly different at the 0.01 level.

*Significantly different at the 0.05 level.

^{ns}Not significantly different at the 0.05 level.

TABLE 23

MEANS FOR THE HUNTER COLOR VALUES OF PEAS CANNED IN ACIDIFIED SOLUTIONS AS AFFECTED BY PERCENTAGE OF VINEGAR AND DAYS OF STORAGE

	Hunter L	Hunter "a"	Hunter "b"
Level of Vinegar[a]			
40%	46.5[f]	0.75[e]	12.5[f]
45%	46.9[f]	-0.54[f]	12.8[f]
50%	47.1[f]	-0.46[f]	12.9[f]
Days of Storage[b]			
0	47.5[f]	1.83[c]	12.7[d]
2	47.3[f]	-0.95[d]	12.7[d]
4	46.9[f]	0.39[cd]	12.2[d]
8	46.6[f]	-0.58[d]	12.2[d]
16	46.5[f]	-1.22[d]	14.0[c]
32	46.4[f]	0.34[cd]	12.7[d]

[a]means were derived from 18 observations.

[b]means were derived from 9 observations.

[c-d]means for each analysis followed by different letters are significantly different at the 0.01 level.

[e-f]means for each analysis followed by different letters are significantly different at the 0.05 level.

extended to 16 days the Hunter "a" values shifted from red (+a) zone to the green (-a) zone. The Hunter "b" value for peas held 16 days was higher (0.01 level) than that of peas held at all the other periods of time. Thus, the peas with the higher "b" value were more yellow. Means for Hunter color values of peas from Treatment 1 as affected by the interaction between percentage of vinegar and days of storage are presented in Table 24.

F-ratios for the analysis of variance for Hunter color values of peas (rinsed prior to measurement) canned in the sauces and peas plus sauce (Treatment 2) are presented in Table 25. The percentage of vinegar affected (0.01 level) Hunter "a" values for the peas plus sauce and Hunter L and "a" values for rinsed peas. Levels of sugar in the sauce had no affect on color of any of the samples. The interaction between percentage of vinegar and sugar level affected (0.05 level) only the Hunter "a" values for the peas plus sauce. Replication was significant (0.01 level) for Hunter "a" values for the peas plus sauce.

Means for Hunter color values of samples from Treatment 2 as affected by percentage of vinegar and levels of sugar are presented in Table 26. Peas canned in the sauce with 40 and 50% vinegar but with the sauce rinsed off had the highest Hunter L values; these means are not different. The Hunter "a" value was highest for peas canned in sauce with 45% vinegar. The lower "a" value for peas of the two other sauces were not different. The "b" value which was not affected by level of vinegar had a mean of 15.2. Level of vinegar in the sauces affected only the "a" values of samples consisting of peas plus sauce. The sample from the 50% vinegar preparation had the highest "a" value; the sample from 45% vinegar preparation had the lowest value. The mean L

TABLE 24

MEANS FOR HUNTER COLOR VALUES OF PEAS CANNED IN ACIDIFIED SOLUTIONS AS AFFECTED BY THE INTERACTION BETWEEN VINEGAR X DAYS OF STORAGE[a]

Level of Vinegar	Days of Storage	Hunter L	Hunter "a"	Hunter "b"
40%	0	46.8[b]	2.74[b]	12.87[b]
	2	47.3[b]	0.61[b]	12.30[b]
	4	46.3[b]	1.00[b]	11.87[b]
	8	45.8[b]	0.10[b]	13.86[b]
	16	46.3[b]	0.07[b]	12.63[b]
	32	46.8[b]	0.06[b]	11.57[b]
45%	0	47.1[b]	1.99[b]	12.90[b]
	2	47.1[b]	-2.43[b]	12.43[b]
	4	46.2[b]	0.06[b]	12.50[b]
	8	47.8[b]	-1.83[b]	14.47[b]
	16	47.1[b]	-1.10[b]	12.96[b]
	32	46.3[b]	0.07[b]	13.57[b]
50%	0	48.5[b]	0.76[b]	13.57[b]
	2	47.6[b]	-1.04[b]	12.80[b]
	4	48.1[b]	0.16[b]	12.60[b]
	8	46.3[b]	0.00[b]	12.30[b]
	16	46.2[b]	-2.64[b]	12.80[b]
	32	46.2[b]	-0.01[b]	12.47[b]

[a]Means derived from 3 observations.

[b]Means for each analysis followed by the same letters are not significantly different at the 0.05 level.

TABLE 25

F-RATIOS FOR THE ANALYSIS OF VARIANCE OF HUNTER COLOR VALUES OF PEAS CANNED IN SAUCE

	D.F.	Peas with Sauce			Peas with Sauce Rinsed Off		
		L	a	b	L	a	b
Total	26						
A. Level of Vinegar	2	1.25^{ns}	497.78**	1.38^{ns}	21.08**	19.72**	0.56^{ns}
B. Level of Sugar	2	1.11^{ns}	2.96^{ns}	0.55^{ns}	1.20^{ns}	0.90^{ns}	2.01^{ns}
A X B	4	0.80^{ns}	4.35*	0.75^{ns}	0.84^{ns}	1.56^{ns}	0.60^{ns}
Replication	3	0.78^{ns}	12.78**	0.55^{ns}	0.91^{ns}	0.36^{ns}	1.16^{ns}
Residual Error (Mean Square)	15	60.51	0.0067	13.36	31.84	0.058	9.76

**Significantly different at the 0.01 level.

*Significantly different at the 0.05 level.

^{ns}Not significantly different at the 0.05 level.

TABLE 26

MEANS FOR HUNTER COLOR VALUES OF PEAS CANNED IN SAUCE AS AFFECTED BY THE PERCENTAGE OF VINEGAR AND LEVEL OF SUGAR[a]

	Peas with Sauce			Peas with Sauce Rinsed Off		
	L	a	b	L	a	b
Level of Vinegar						
40%	30.4[d]	0.33[c]	17.2[d]	39.5[b]	0.03[c]	15.3[d]
45%	34.5[d]	-0.14[d]	14.3[d]	25.3[c]	0.71[b]	14.3[d]
50%	29.1[d]	1.07[b]	15.4[d]	40.9[b]	0.18[c]	15.9[d]
Level of Sugar, gram						
26.2	28.2[d]	0.47[b]	14.8[d]	32.9[d]	0.37[d]	13.5[d]
31.5	32.6[d]	0.38[b]	15.5[d]	36.1[d]	0.32[d]	15.8[d]
36.7	33.3[d]	0.39[b]	16.6[d]	36.7[d]	0.22[d]	16.2[d]

[a]Means from level of vinegar and level of sugar were derived from 9 observations.

[b-d]Means for each analysis followed by different letters are significantly different at the 0.05 level.

value was 31.4, and the mean "b" value was 15.6. The level of sugar in the sauces did not affect any of the color components of the samples of Treatment 2. Means of Hunter values for the samples as affected by the interaction between percentage of vinegar and levels of sugar are presented in Table 27. Only the "a" values for rinsed peas were affected. The values ranged from 1.2 (red zone) to -0.3 (green zone).

According to Flora (32), acetic acid (vinegar) forms complex ions with trace elements such as copper and iron, making them unavailable for reactions with phenolic compounds and sulfides. These free elements cause discoloration (darkening) of canned peas. Sistrunk and Bailey (79) reported discoloration of cooked peas from the leaching of anthocyanins into the liquor, decreasing the amount of red pigment in the peas. Acids convert anthocyanidins to yellow flavyliumions (33, 35, 65). Reactions between certain sugars and proteins produce a dark effect when heated causing browning reactions. Both conditions contribute to discoloration of the peas and liquid.

Oxidization of the porphyrin ring of chlorophyll b (yellow green color) could cause a bleaching effect, thereby increasing the yellow color (33, 35). Chlorophyll under acidic conditions loses the magnesium element and is converted to pheophytin, an olive brown colored pigment that absorbs light at 535 nm. Such changes have an influence on the color of the product (33, 35, 65).

TABLE 27

MEANS FOR HUNTER COLOR VALUES OF PEAS CANNED IN SAUCES AS AFFECTED BY THE INTERACTION OF PERCENTAGE OF VINEGAR AND LEVEL OF SUGAR[a]

Level of Vinegar	Level of Sugar, grams	Peas with Sauce L	Peas with Sauce a	Peas with Sauce b	Peas with Sauce Rinsed Off L	Peas with Sauce Rinsed Off a	Peas with Sauce Rinsed Off b
40%	25	29.6[i]	0.37[d]	17.8[i]	38.8[i]	0.32[i]	14.7[i]
	30	30.8[i]	0.26[e]	15.8[i]	39.5[i]	-0.05[i]	15.2[i]
	35	31.0[i]	0.35[d]	17.9[i]	40.1[i]	-0.19[i]	16.0[i]
45%	25	26.2[i]	0.00[f]	11.1[i]	19.0[i]	0.62[i]	10.7[i]
	30	38.1[i]	-0.26[gh]	15.6[i]	28.3[i]	0.82[i]	16.3[i]
	35	39.6[i]	-0.16[h]	16.3[i]	28.6[i]	0.69[i]	16.0[i]
50%	25	29.0[i]	1.05[bc]	15.4[i]	40.8[i]	0.18[i]	15.0[i]
	30	29.1[i]	1.15[c]	15.2[i]	40.6[i]	0.21[i]	16.1[i]
	35	29.2[i]	1.01[c]	15.5[i]	41.3[i]	0.17[i]	16.5[i]

[a]Interaction means were derived from 3 observations.

[b-h]Means for each analysis followed by different letters are significantly different at the 0.01 level.

[i]means for each analysis followed by the same letter are not significantly different at the 0.05 level.

F. Microbiology of Canned Peas

The mean log counts were less than one for all microorganisms from samples of Treatment 1 (Table 28). Log mean counts for stored samples processed in the different levels of vinegar are presented in Table 29. The highest mean log count determined was one.

The mean log counts for aerobes of samples in Treatment 2 were higher than the counts of samples in Treatment 1 (Table 30). The addition of spices, tomato paste and other flovor ingredients increased the possibility of contamination by microorganisms and decreased the heat penetration throughout the product (16).

The counts for anaerobes of samples in Treatment 2 were not greatly different from the counts in Treatment 1. Table 31 presents the mean log counts of individual samples from Treatment 2. The highest mean log counts for mesophilic and thermophilic aerobes were 1.56 and 1.50, respectively. The highest anaerobic count for all organisims was less than one. In most cases the total number of colonies (per g sample at the lowest possible dilution) was less than 30 for both treatments; therefore, there appears to be no microbioligical problems.

G. Sensory Evaluation of Canned Peas

F-ratios for the analysis of variance of sensory panel scores of the samples are presented in Table 32. Differences in scores between days could have occurred from the panelists dislike of highly spiced or pickled foods (Appendix B). Over the six day period of evaluation the panelists could have become tired of tasting the samples. Only textural scores were affected (0.05 level) only by the percentage of vinegar.

TABLE 28

MEAN MICROBIAL COUNTS (LOG_{10}) FOR MESOPHILIC AND THERMOPHILIC MICROORGANISMS FROM PEAS CANNED IN ACIDIFIED SOLUTIONS AS AFFECTED BY THE PERCENTAGE OF VINEGAR AND DAYS OF STORAGE

	Mesophilic counts/g		Thermophilic counts/g	
	Aerobes	Anaerobes	Aerobes	Anerobes
Level of Vinegar[a]				
40%	<1	<0.04	<0.04	<0.04
45%	<1	<1	<0.04	<0.04
50%	<1	<0.04	<0.04	<0.04
Days of Storage[b]				
0	<1	<1	<0.04	<0.04
2	<0.04	<0.04	<0.04	<0.04
4	<0.04	<0.04	<0.04	<0.04
8	<1	<0.04	<1	<0.04
16	<0.04	<0.04	<1	<0.04
32	<0.04	<0.04	<0.04	<0.04

[a]Means were derived from 12 observations.

[b]Means were derived from 6 observations.

TABLE 29

MEAN MICROBIAL COUNTS (LOG_{10}) OF MESOPHILIC AND THERMOPHILIC MICROORGANISMS FROM PEAS CANNED IN ACIDIFIED SOLUTIONS AS AFFECTED BY THE INTERACTION OF PERCENTAGE OF VINEGAR AND DAYS OF STORAGE[a]

Level of Vinegar	Days of Storage	Mesophilic counts/g		Thermophilic counts/g	
		Aerobes	Anaerobes	Aerobes	Anerobes
40%	0	<1	<0.04	<1	<0.04
	2	<0.04	<0.04	<0.04	<0.04
	4	<0.04	<0.04	<0.04	<0.04
	8	<0.04	<0.04	<0.04	<0.04
	16	<0.04	<0.04	<0.04	<0.04
	32	<0.04	<0.04	<0.04	<0.04
45%	0	<1	<0.04	<1	<0.04
	2	<0.04	<0.04	<0.04	<0.04
	4	<0.04	1.00	1.00	<0.04
	8	<1.00	<0.04	<0.04	<0.04
	16	<0.04	<0.04	<0.04	<0.04
	32	<0.04	<0.04	<0.04	<0.04
50%	0	<1	<0.04	<0.04	<0.04
	2	<0.04	<0.04	<0.04	<0.04
	4	<0.04	<0.04	<0.04	<0.04
	8	<0.04	<0.04	<0.04	<0.04
	16	<0.04	<0.04	<0.04	<0.04
	32	<0.04	<0.04	<0.04	<0.04

[a]Means were derived from 30 observations.

TABLE 30

MEAN MICROBIAL COUNTS (LOG_{10}) FOR MESOPHILIC AND THERMOPHILIC MICROORGANISMS FROM PEAS CANNED IN SAUCES AS AFFECTED BY THE PERCENTAGE OF VINEGAR AND LEVEL OF SUGAR[a]

	Mesophilic counts/g		Thermophilic counts/g	
	Aerobes	Anaerobes	Aerobes	Anerobes
Level of Vinegar				
40%	1.23	<1	1.10	<0.04
45%	1.20	<1	1.13	<0.04
50%	1.30	<0.04	1.17	<1
Level of Sugar, grams				
26.2	1.22	<1	1.29	<0.04
31.5	1.40	<1	1.04	<1
36.7	1.07	<1	1.03	<0.04

[a]Means were derived from 9 observations.

TABLE 31

MEAN MICROBIAL COUNTS (LOG_{10}) OF MESOPHILIC AND THERMOPHILIC MICROORGANISMS FROM PEAS CANNED IN SAUCES AS AFFECTED BY THE INTERACTION OF PERCENTAGE OF VINEGAR AND LEVEL OF SUGAR[a]

Level of Vinegar	Level of Sugar, grams	Mesophilic counts/g		Thermophilic counts/g	
		Aerobes	Anaerobes	Aerobes	Anerobes
40%	25	1	<1	1.14	<0.04
	30	1.48	<1	1.09	<1
	35	1.08	<1	1.08	<0.04
45%	25	1	<1	1.11	<0.04
	30	1.48	<1	1.09	<1
	35	1.09	<1	1.18	<0.04
50%	25	1.56	<0.04	1.50	<1
	30	1.17	<0.04	<1	<1
	35	1.03	<0.04	<1	<0.04

[a]Means were derived from 30 observations.

TABLE 32

F-RATIOS FOR THE ANALYSIS OF VARIANCE OF PANEL SCORES OF PEAS CANNED IN ACIDIFIED SOLUTIONS WITH SAUCE ADDED AND OF PEAS CANNED IN SAUCES

	D.F.	Texture	Flavor	Overall Acceptability
Total	449			
A Day	5	6.43**	3.77**	3.28**
B Group[a]	1	0.01[ns]	0.01[ns]	0.18[ns]
C Level of Vinegar	2	3.86*	0.75[ns]	0.45[ns]
D Level of Sugar	2	0.03[ns]	0.12[ns]	0.26[ns]
E Sauce	2	1.11[ns]	2.31[ns]	0.50[ns]
C X B	4	0.13[ns]	1.00[ns]	
C X D	1	0.49[ns]	1.31[ns]	0.53[ns]
C X E	2	1.55[ns]	0.63[ns]	0.20[ns]
Residual Error (Mean square)	430	1.44	1.43	1.34

[a]Peas with chili sauce or pickle relish as one group and peas plus sauces with the three levels of sugar are the other group.

**Significantly different at the 0.01 level.

*Significantly different at the 0.05 level.

[ns]Not significantly different at the 0.05 level.

None of the remaining scores was affected by any of the variables. Mean scores for texture, flavor, and overall acceptability of samples (Treatment 1) with added chili sauce or pickle relish and samples (Treatment 2) of peas plus sauce are presented in Table 33. No differences in the attributes were found between samples of peas (Treatment 1) in which chili sauce or pickle relish were added. The higher the percentage of vinegar the lower the textural scores of the samples. Flavor and overal acceptability were not affected by level of vinegar. The level of sugar (26.2g to 36.7g) in the sauces (Treatment 2) did not affect any of the attributes.

TABLE 33

MEAN PANEL SCORE FOR SAMPLES PREPARED FROM PEAS CANNED IN ACIDICFIED SOLUTIONS AND SAUCES

	Texture	Flavor	Overall Acceptability
Group[a] drained peas with added sauce	5.28 + 0.21[h]	4.93 + 0.21[h]	4.98 + 0.20[h]
Peas Plus Sauce[b]	4.81 + 0.15[h]	4.51 + 0.15[h]	4.51 + 0.14[h]
Vinegar Percentage[c]			
40%	5.21 + 0.33[f]	4.73 + 0.33[h]	4.76 + 0.32[h]
45%	4.97 + 0.28[fg]	4.71 + 0.28[h]	4.69 + 0.27[h]
50%	4.81 + 0.33[g]	4.58 + 0.33[h]	4.64 + 0.32[h]
Sauce added to[d] drained peas			
Pepper	5.46 + 0.28[h]	5.10 + 0.28[h]	5.19 + 0.27[h]
Pickel Relish	5.10 + 0.21[h]	4.79 + 0.21[h]	4.78 + 0.20[h]
Sugar level, from[e] peas plus sauces, grams			
26.2	4.62 + 0.28[h]	4.48 + 0.28[h]	4.49 + 0.27[h]
31.5	4.82 + 0.21[h]	4.49 + 0.21[h]	4.54 + 0.20[h]
36.7	4.98 + 0.18[h]	4.56 + 0.18[h]	4.49 + 0.18[h]

[a]Means were derived from 180 observations with + one standard deviation.

[b]Means were derived from 270 observations with + one standard deviation.

[c]Means were derived from 150 observations with + one standard deviation.

[d]Means were derived from 90 observations with + one standard deviation.

[e]Means were derived from 90 observations with + one standard deviation.

[f-g]Means for texture followed by different letters are significantly different at the 0.01 level.

[h]Means for each analysis followed by the same letter are not significantly different at the 0.05 level.

V. SUMMARY

The major objective of this experiment was to prepare an acidified canned product of peas which could be processed by a pasteurization method (boiling water bath) rather than by retorting. The effects of acidification on some chemical components, physical properties, microbiological counts and organoleptic characteristics were measured.

The proximate composition of peas canned in acidified aqueous solutions and acidified sauces was determined. Depending upon the percentage of vinegar in the canning media, peas canned in the acidified solutions had 74.1 to 75.2% moisture, 4.0 to 4.7% crude protein, 1.6 to 1.7% ether extract, 3.0 to 3.2% ash and 44.8 to 50.6% nitrogen-free extract. Peas canned in acidified sauces had 66.9 to 68.2% moisture, 13.8 to 15.2% crude protein, 1.8 to 2.2% ether extract, 1.0 to 1.1% ash and 40.5 to 47.2% nitrogen-free extract.

Mean values for neutral detergent fiber (NDF) and gross energy from samples of peas canned in acidified solutions had 52.7 to 54.0% and 4.4 to 4.5 Kcal/g, respectively. Peas canned in acidified sauces contained 32.7 to 34.0% NDF and 3.7 to 4.1 Kcal/g, respectively.

The affect of percentage of vinegar on acidity and turbidity of the liquor, storage time on pH of the liquor and the interaction of the two factors on acidity of the peas was significant (0.05 level) for samples of peas canned in acidified solutions. The pH of peas and the liquor was affected (0.01 level) by percentage of vinegar and storage time, respectively. Mean values for pH, acidity, and turbidity increased as the percentage of vinegar was increased.

The percentage of vinegar, level of sugar, and the level of vinegar x level of sugar interaction did not affect pH and acidity of samples canned in acidified sauces. The mean pH values for both peas and sauce were 4.2 and 4.3, respectively. Average acidity was 0.08% for the peas.

Level of vinegar had an affect on texture of peas canned in acidified solutions. Storage time caused an increase in firmness (0.01 level). Firmness of peas canned in the sauces increased (0.05 level) as the level of vinegar was raised. Peas canned in sauces were firmer (harder) than peas canned in the acidified solutions.

Percentage of vinegar affected (0.05 level) the Hunter "a" (green-red) values and storage time affected "a" and "b" (blue-yellow) values of peas canned in acidified solutions. The interaction between level of vinegar and storage time affected (0.05 level) Hunter L (luminosity) values of peas canned in acidified solutions increases in the percentage of vinegar and extension of storage produced lighter, more yellow peas, while the "a" values shifted toward the green zone.

Percentage of vinegar affected (0.01 level) Hunter L values and "a" values of peas canned in the sauces. The amount of sugar had no affect on the Hunter L, "a," or "b" values. Increases in the percentage of vinegar produced lighter peas which exhibited increases in the red color.

Storage time reduced the growth of thermophilic aerobes in peas canned in the acidified solutions. Except for this finding, neither percentage of vinegar nor storage time had an effect on the microbiological counts of any of these samples. The mesophilic aerobe count for peas canned in sauces were reduced by the level of sugar. The thermophilic aerobe count was reduced by increases in levels of vinegar and sugar. The peas canned in the sauces had a higher count than peas canned in the acidified solutions.

The sensory panel evaluated texture, flavor, and overall acceptability of samples of the canned peas. Firmness was increased (0.05 level) by raising the percentage of vinegar. Flavor and acceptability were not influenced by the level of vinegar. Mean scores for all attributes ranged between 4 (dislike slightly) and 5 (like slightly). Peas canned with the sauces had higher mean scores than peas canned in acidified solutions with sauce added. Peas (canned in acidified solutions) with pickle relish had a higher mean score than peas with pepper sauce.

Additional studies are needed to develope a marketable product; the firming effect of the acidic solutions should be controlled (or prevented) and the excessive spicy, flavor should be reduced.

REFERENCES

REFERENCES

1. Adams, C.F. 1975. "Nutritive Value of American Foods," Agriculture Research Service, United States Department of Agriculture, Washington, D.C.

2. Akpapunam, M. A. and Markakis, P. 1979. Oligosaccharides of 13 American Cultivars of Cowpeas (Vigna sinesis). J. Food Sci. 44:1317.

3. Alder, H. and Roessler, E. B. 1977. "Introduction to Probability and Statistics," 6th ed., W. H. Freeman and Co., San Francisco, CA.

4. American Public Health Association. 1967 "Standard Methods for the Examination of Dairy Products," 12th ed., American Public Health Association, Inc., New York.

5. Ammerman, G. R. and Seale, Jr., A. D. 1970. Canned Southern Peas with Pork and Tomato Sauce. Food Technol. 24(1):46.

6. Ammerman, G. R. and Seale, Jr., A. D. 1970. Canned southern pea quality as affected by fill weight and time and temperature of blanch. Food Technol. 24(4):478.

7. Anonymous. 1960. Oxygen Bob Calorimetery and Combustion Method. Technical Manual 130, Parr Instrument Co., Moline, IL.

8. Anonymous. 1972. Texture Evaluation of Baked Beans. Instron Corporation, 2500 Washington St., Canton, MA 02021.

9. Anonymous. 1973. Hatch Method Manual, Hatch Chemical Co., Ames, IA.

10. Anonymous. 1976. Guide to Home Canning and Freezing. Kerr Glass Manufacturing Corporation, Sand Springs, OK 74063.

11. Anonymous. 1976. Procedure for operating of Food Testing Equipment. Department of Food Science, Nutrition and Food System Administration, College of Home Economics. The University of Tennessee, Knoxville.

12. Anonymous. 1979. D25 Colorimeters. Hunter Associates Laboratory, Inc., 11495 Sunset Hills Road, Reston, VA 22090.

13. AOAC. 1975. "Official Methods of Analysis," 12th ed. Association of Official Analytical Chemists, Washington, D.C. 20250

14. Arora, S. K. and Das, B. 1976, Cowpeas as potential crop for starch. Starke 28(5):158.

15. Ayodeji, O. A. and Potter, N. N., 1980. Production and Quality of canned Moin-moin. J. Food Sci. 45:1359.

16. Ayres, J. C., Mundt, J. O. and Sandine, W. E. 1980 "Microbiology of Foods," W. H. Freeman and Co., San Francisco, CA.

17. Barr, A. J., Goodnight, J. H., Sall, J. P. and Helwig, J. T. 1979 "A Users Guide to the Statistical Analysis System," Student Supply Stores, North Carolina State University, Raleigh, NC.

18. Beroard, J. C. and Filiatre, A. 1976. A comparison of the carbohydrate composition of legume seed horsebeans, peas and lupines. Cereal Chem. 53(6):968.

19. Bianchini, F. and Corbetta, F. 1975. "The Complete Book of Fruits and Vegetables," Crown Publishers, Inc., New York.

20. Bliss, F. A., Baker, L. N., Franckowiak, J. D. and Hall, T. C. 1973. Genetic and environmental variation of seed yield, yield components and see protein quantity and quality of cowpea. Crop Sci. 13.656.

21. Canning, Freezing, Preserving and Allied Industries. 1978. "The Almanac of the Canning, Freezing, Preserving and Allied Industries," 63rd ed., Seventy-Nine Bond St., Westminster, MD.

22. Carasco, J. F., Croy, R., Derbyshire, E. and Boulter, D. 1978. The isolation and characterization of the major polypeptides of the seed globulin of cowpea (Vigna ungiculata, L. Walp) and their sequential synthesis in developing seeds. Experimental Bot. 29(109):309.

23. Chyr, C. Y. L., Walker, H. W. and Hinz, P. 1977. Influence of pH, temperature, curing agents and water activity on germination of PA 3679 spores. J. Fd. Protection 40(6):369.

24. Desrosier, N. W., 1977. "The Technology of Food Preservation," 4th ed., Avi Publ. Co., Inc., Westport, CT.

25. Dovlo, F. E., Williams, C. E. and Zoaka, LK. 1976. "Cowpeas - Home Preparation and use in West Africa," International Development Research Center Publ. Accrea, Africa.

26. Evans, I. M. and Boulter, D. 1974. Chemical methods suitable for screening for protein content and quality in cowpea (Vigna unguiculata) meals. J. Sci. Fd. Agric. 25:311.

27. Evans, I. M., Ford, J. E., Hannah, L. C. and Boulter, D. 1976. Comparison of chemical and microbiological methods in the estimation of methionine in cowpea (Vigna unguiculata) seeds. Br. Fd. Nutr. 36:289.

28. Fale, D. B. 1979. Canning of acidified, low-acid vegetables. M. S. Thesis. Mississippi State University, State College, Jackson, MS 39762.

29. F.A.O. 1980. Production Yearbook, Vol. 33, FAO Statistics Series 15. Food and Agriculture Organization, United Nations, Rome, Italy.

30. Fields, M. L., Zamora, A. F. and Bradsher, M. 1977. Microbiological analysis of home-canned tomatoes and green beans. J. Food Sci. 43:42.

31. Fisher, E. 1962. "Freeze-Drying of Foods," National Academy of Sciences - National Research Council. Washington, D.C.

32. Flora, L. F. 1980. Effect of modified processing procedures on quality of southern crowder peas. J. Food Sci. 45:126.

33. Francis, F. J. and Clyesdale, F. M. 1975. "Food Colorimetry: Theory and Applications," AVI Publ. Co., Inc., Westport, CT.

34. Fryer, M. 1980. Personal Correspondence. Dept. of Animal Science, The University of Tennessee, Knoxville.

35. Goodwin, T. W. 1965. "Chemistry and Biochemistry of Plant Pigments," Academic Press, New York.

36. Gourlay, G. C. 1976. Vinegar. Food Technol. in Australia. 28(5):181.

37. Hayashi, K., Terada, M., Mizunuma, T. and Yokotsuka, T. 1979. Retarding effect of acetic acid on growth of contaminated bacteria during Shoya-Koji making process. J. Food Sci. 44:359.

38. Hurst, W. C. and Schuler, G. A. 1979. Loss of green color of refrigerated and non-refigerated southern peas. J. Food Sci. 44:934.

39. Institute of Food Technologists. 1977. Home Canning. Food Technol. 31(6):44.

40. Jay, J. M., 1978. "Modern Food Microbiology," 2nd ed., D. Van Norstand Co., New York.

41. Jaya, T. V., Krishmamurthy, K. S. and Venkataraman, L. V. 1975. Nutr. Reports Int. 2(3):75.

42. Koehn, M. L. 1979. United States Department of Agriculture Statistics," United States Government Printing Office, United Statem Department of Agriculture, Washington, D.C.

43. Kon, S., Wagner, J. R. and Booth, A. N. 1974. Legume powders: preparation and some nutritional and physicochemical properties. J. Food Sci. 39:897.

44. Kramer, A. 1973. An analytical and integrative approach to sensory evaluation of food. J. Sci. Fd. Agric. 24:1407.

45. Kumar, K. G. and Venkataraman, L. V. 1976. Studies on the in Vitro digestibility of starch in some legumes before and after germination. Nutr. Reports Int. 13(1):115.

46. Kumar, K. G., Venkataraman, L. V., Jaya, T. V. and Krishnamurthy, K. S. 1978. Cooking characteristics of some germinated legumes: changes in phytins, Ca^{++}, Mg^{++} and pectins. J. Food Sci. 43:85.

47. Lewisk, H. and Cassel, K. Jr. 1964. "Botulism," United States Dept. of Health, Education and Welfare, Public Health Service. Cincinnati, OH 45226.

48. Lopez, A. 1981. "A Complete Course in Canning," 11th ed. The Canning Trade. Baltimore, MD.

49. Mahadevappa, V. G. and Raina, P. L. 1978. Nature of some Indian legume lipids. J. Agric Fd. Chem. 26(5):1241.

50. McCarthy, M. A., Murphy, E. W., Ritehey, S. J. and Washburn, K. C. 1977. Mineral content of legumes as related to nutritional labeling. Food Technol. 31(2):86.

51. Miloradovich, M. 1950. "The Art of Cooking with Herbs and Spices," Doubleday and Co., Inc., Garden City, NY.

52. Mundt, J. O., McCarthy, I. E., Collins, J. L. and Bailey, R. 1977. Vacuum, pH, and acidity of home-canned tomatoes and tomato juice. Tenn. Farm and Home Sci. 103:2.

53. National Canners Association Research Laboratory. 1962. Processes for Low-Acid Canned Foods in Metal Containers. Bulletin 26 L. 9th ed. Washington, D.C.

54. National Research Council. 1980. Recommended Dietary Allowances. 9th ed. National Academy of Sciences, Washington, D.C.

55. Neal, C. E. and Calbert, H. E., 1955. The use of 2, 3, 5 - triphenylterazoliumchloride as a test for antibotic substances in milk. J. Dairy Sci. 38:629.

56. Odlaug, T. E. and Pflug, J. I. 1978. Clostridium botulinum and acid foods. J. Fd. Protection. 41(7):566.

57. Ogunmodede, B. K. and Oyenuga, V. A. 1969. Vitamin B content of cowpeas. I. thiamine, riboflavin, and niacin. J. Sci Fd. Agric. 20:101.

58. Ogunmodede, B. K., and Oyenuga, V. A. 1970. Vitamin B content of cowpeas (Vigna unguiculata Walp) II, Pyridorine, pantothenic acid, biotin and folic acid. J. Sci. Fd. Agric. 21:87.

59. Okaka, J. and Potter, N. 1979. Physiochemichemical and functional properties of cowpea powders processed to reduce beany flavor. J. Food Sci. 44:1235.

60. Okaka, J. C. and Potter, N. 1979. Sensory properties of cowpea powders processed to reduce beany flavor. J. Food Sci. 44:1539.

61. Onayemi, O., Pond, W. G. and Krook, L. 1976. Effects of processing on the nutritive value of cowpeas (Vigna sinesis) for the growing rat. Nutr. Reports Intl. 13(3):299.

62. Onayemi, O. and Potter, N. 1976. Cowpea powders dried with methionine preparation, storage stability, organoleptic properties, and nutritional quality. J. Food Sci. 41:48.

63. Park, J. R., Collins, J. C., McCarthy, I. E. and Johnson, M. R. 1971. Chemical changes and amylase activity of freshly shelled southern peas, Vigna sinensis. J. Amer. Soc. Hort. Sci. 96(4):419.

64. Paul, P. C. and Palmer, H. H. 1972. "Food Theory and Applications," John Wiley and Sons, New York.

65. Pflug, I. J. and Odlaug, T. E. 1978. A review of z and f values used to ensure the safety of low-acid canned food. Food Technol. 32(6):63.

66. Pitt, J. I. 1974. Resistance of some food spoilage yeasts to preservatives. Food Technol. in. Australia. 26(6):238.

67. Powers, J. J. and Godwin, D. R. 1978. pH of tomatoes canned at home in Georgia. J. Food Sci. 43:1053.

68. Rao, P. S. 1976. Nature of carbohydrates in pulses. J. Agric. Fd. Chem. 24(5):959.

69. Rao, P. S. and Belavady, B. 1978. Oligosaccharides in pulses: varietal differences and effects of cooking and germination. J. Agric. Fd. Chem. 26(2):316.

70. Riemann, H. 1969. "Food-borne Infections and Intoxications," Academic Press, New York.

71. Rizley, N. F. and Sistrunk, W. H. 1979. Effect of maturity, soaking, treatment, and cooking method on the quality and mineral content of southern peas. J. Food Sci. 44:220.

72. Schoenemann, D. R., Lopez, A. and Cooler, F. W. 1974. pH and acidic stability during storage of acidified and non-acidified canned tomatoes. J. Food Sci. 39:257.

73. Sefa-Dedeh, S., Stanley, D. W. and Voisey, P. M. 1978. Effects of soaking time and cooking conditions on texture and microstructure of cowpeas (Vigna unguiclata). J. Food Sci. 43:1832.

74. Sefa-Dedeh, S., Stanley, D. W. and Voisey, P. W. 1979. Effect of storage time and conditions on the hard-to-cook defect in cowpeas (Vigna ungriculata). J. Food Sci. 44:790.

75. Sefa-Dedeh, S. W. and Stanley, D. 1979. Cowpea proteins. 1. Use of response surface methodology in predicting cowpea (Vigna unguiculata) protein extractability. J Agric. Fd. Chem. 27(6):1238.

76. Sefa-Dedeh, S. and Stanley D. 1979. Cowpea proteins. 2. Characterization of water-extractable proteins. J. Agric. Fd. Chem. 44(1):55.

77. Segner, W. P., 1979. Mesophilic anerobic sporeforming bacteria in the spoilage of low-acid canned foods. Food Technol. 44(1):55.

78. Sistrunk, W. A. and Bailey, F. L. 1965. Relationship of processing procedure to discoloration of canned blackeye peas. Food Technol. 19(5):189.

79. Smittle, D. A. and Kays, S. J. 1976. Quality deterioration of southern peas in commercial operations. Hort Sci. 11(2):151.

80. Smittle, D. A. and Hayes, M. J. 1979. Influence of short-term storage conditions on quality of shelled southern peas. J. Amer. Soc. Hort. Sci. 104(6):783.

81. Speck, M. L. 1976. "Compendium of Methods for Microbiological Examination of Food," American Public Health Assoc., Washington, D.C. 20036.

82. Stombo, C. R. 1973. "Thermobacteriology in Food Processing," Academic Press, New York.

83. Szczesniak, A. S., Loew, J. B. and Skinner, E. Z. 1975. Consumer texture profile techinque. J. Food Sci. 40:1253.

84. U.S.D.A. 1981. Vegetable Outlook and Situation. TVS-220. United States Dept. of Agriculture, Economics and Statistics, Washington, D.C.

85. Venkataraman, L. V., Jaya, T. V. and Krishmamurthey, K. S. 1976. Effect of germination on the biological value, digestibility coefficient and net protein utilization of some legume proteins. Nutr. Reports Int. 13(2):197.

86. Voisey, P. W. 1977. Interpretation of Force deformation curves from the Shear-Compression cell. J. Texture Studies 8:19.

87. Voisey, P. W. and Larmond, E. 1970. Texture of baked beans - a comparison of several methods of measurement. J. Texture Studies 2:97.

88. Wade, B. L., Kanapaux, M. S., Speirs, M., Pickett, T. A., Cowart, F. F., Sheets, O. A., Gregar, M., Mc Permeter, W. L., Bowers, J. L., Cordner, H. B., Reder, R., Mitchell, J. H., Roderick, D. B., Garrison, O. B., Whitacre, J. O., Richardson, L. R., Fudge, J. F., Brittingham, W. H., Reed, H.M. and Wakeley, J. T., 1951. Composition of southern peas. Southern Cooperative Series Bulletin 15.

89. Walker, W. M. and Hymowitz, T. 1972. Simple correlations between certain mineral and organic components of common beans, peanuts, and cowpeas. Communications In Soil Sci. Plant Anal. 3(6):505.

90. Worthington, J. W. and Burns, E. E. 1971. Post-harvest changes in southern peas. J. Amer. Soc. Hort. Sci. 76(6):69.

91. Xezones, H. and Hutchings, T. J. 1965. Thermal resistance of Clostridium botulinum (62A) spores as affected by fundamental food constituents 1. Effect of pH. Food Technol. 19(6):113.

92. Zamora, A. F. and Fields, M. L. 1979. Nutritive quality of fermented cowpeas (Vigna simesis) and chickpeas (Cicer arietinum. J. Food. Sci. 44:928.

93. Zamora, A. F. and Fields, M. L. 1979. Microbiological and toxicological evaluation of fermented cowpeas (Vigna sinesis) and chickpeas (Cicer arietinum). J. Food Sci. 44:928.

APPENDIX

APPENDIX A

DATE______________________ TASTER______________________ PRODUCT______________

Taste test samples of Southern (Black-eye) peas for preference, taking in consideration texture, flavor and overall acceptability. Place some of the peas in the mouth and chew and evaluate for texture, then evaluate for flavor: and overall acceptability (which includes texture, flavor, color and appearance). Rinse the mouth thoroughly between each sample with the water provided on the tray. The peas DO NOT have to be swallowed, expectorate (spit-out) in the empty cup covered with foil on the tray.

Use the appropriate scale below for each attribute by placing the number on the line below the code number for each sample. Feel free to give reasons if so desired. An honest expression of your feeling will be appreciated. If you have any questions, please ask.

	CODE					
	____	____	____	____	____	____
Texture	____	____	____	____	____	____
Reason for your Response						

	CODE					
	____	____	____	____	____	____
Flavor	____	____	____	____	____	____
Reason for your Response						

	CODE					
	____	____	____	____	____	____
Overall Acceptability	____	____	____	____	____	____
Reason for your Response						

SCALE

1. Dislike extremely
2. Dislike very much
3. Dislike moderately
4. Dislike slightly
5. Like slightly
6. Like moderately
7. Like very much
8. Like extremely

APPENDIX B

TABLE B-1

MEAN PANEL SCORES FOR SAMPLES PREPARED FROM PEAS CANNED IN ACIDICFIED SOLUTIONS OR SAUCES AS AFFECTED BY THE DAY OF STORAGE.[a]

Day of Evaluation	Texture	Flavor	Overall Acceptability
1	5.64[b]	5.08[b]	5.13[b]
2	4.71[cde]	4.69[bc]	4.64[bc]
3	5.10[cd]	4.42[c]	4.51[cd]
4	5.36[bc]	5.20[b]	5.33[d]
5	4.62[de]	4.49[c]	4.46[d]
6	4.58[e]	4.44[c]	4.40[d]

a Means were derived from 90 observations.

b-e Means for each analysis followed by different letters are significantly different at the 0.01 level.

VITA

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