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To the Graduate Council:

I am submitting herewith a thesis written by Teresa Lynn Chapman entitled "The Development of Southern Peas (Vigna unguiculata) Into a Salad Bar Item." I have examined the final 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 Technology and Science.

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THE DEVELOPMENT OF SOUTHERN PEAS (*Vigna unguiculata*) INTO A SALAD BAR ITEM

A Thesis

Presented for the

Master of Science

Degree

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ABSTRACT

The objectives of this experiment were to develop southern peas into a product for use as a salad bar item by marinating in either a sweet-flavored or a hot-flavored liquid containing vinegar, oil, and spices and to determine the effect of maturity of peas and flavorings on chemical, physical, and sensory characteristics of the southern peas.

Moisture content of the marinated treatments was lower than the unmarinated controls. Marinating southern peas was found to increase fat and gross energy and decrease protein contents. Marinating the peas increased the ash and crude fiber contents of the hot treatment and decreased the ash content but did not effect the crude fiber content of the sweet treatment. Marinating southern peas had no effect on the protein efficiency ratio.

Marinating southern peas increased the "b" value and decreased the L value. The L values for the marinated treatments were decreased except for the hot treatment of the dry maturity which was not affected. Marinating decreased the "a" values of the dry maturity peas.

Marinated peas were firmer than unmarinated controls. The sweet treatment was firmer than the hot treatment.

Marinating southern peas lowered the pH and increased titratable acidity. The treatment marinades were not

different in pH, but the hot treatment had a higher titratable acidity. The pH values of the peas and marinades were similar.

Marinating southern peas decreased the yeast counts of the sweet treatment, and the hot treatment was not different from the unmarinated control. Other plate counts were not affected by treatment.

The consumer panel did not prefer one sample more than any other. Sensory scores for treatments were between "dislike slightly" and "like moderately."

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CHAPTER I

INTRODUCTION

Southern peas (*Vigna unguiculata*) are an important grain legume in the United States, particularly in the South (Wade et al., 1951). Also, this crop is grown widely in tropical and subtropical areas of the world as an important component of the diets of many people (Elias et al.,1964; Evans and Boulter, 1974; Zamora and Fields, 1979a). In Nigeria, for example, southern peas are commonly called cowpeas and are used as the primary source of protein (Bliss et al., 1973; Dolvo et al., 1976; Ologhobo and Fetuga, 1984a).

Southern peas are grown throughout the southern United States. Peas are harvested at the mature, succulent stage and either commercially processed by freezing or canning. Also, southern peas are harvested and sold in the mature, dry state (McWatters and Flora, 1980).

In the United States southern peas are usually prepared for consumption by boiling in water and eaten with very little seasoning (McWatters and Flora, 1980). Researchers have introduced different ways of using southern peas as food (Adeniji and Potter, 1980; McWatters and Flora, 1980; McWatters and Brantley, 1982).

In recent years there has been an increase in restaurants and fast food chains which offer salad bars to customers. These salad bars offer a variety of vegetables, condiments, and other items. In order to provide a variety of foods on a salad bar, new and different items are being sought (Anon., 1978a). One food that would offer variety as well as an excellent source of protein is southern peas. The objectives of this experiment were to develop southern peas into a product for use as a salad bar item by marinating in a liquid containing vinegar, oil, and spices and to determine the effect of maturity of the peas and flavorings on the chemical, physical, and sensory characteristics of the southern peas.

CHAPTER II

LITERATURE REVIEW

A. PRODUCTION OF SOUTHERN PEAS

The Grain Legume Improvement Program of the International Institute of Tropical Agriculture, Ibadan, Nigeria, (ITTA) has played a major role in selecting cowpea cultivars with higher protein contents and improved amino acid profiles and in production research (Dolvo et al., 1976; Evans and Boulter, 1974). The ITTA reported that in 1973 the world production of southern peas was 1584 kg/ha (Dolvo et al., 1976). In 1982, 10,803 million kg of southern peas were frozen packed in the United States with 7,095 million kg of that being the black-eye variety. Also, in 1982, 1,908 million cases of canned southern peas (all sizes) were processed in the United States (Canning, Freezing, Preserving and Allied Industries, 1983).

B. USES OF SOUTHERN PEAS

In the United States southern peas are usually prepared for consumption by boiling in water. Most often, peas are processed as frozen, canned, or dried and eaten at times other than at harvest (McWatters and Flora, 1980). In other parts of the world, especially in Nigeria, southern peas are prepared and consumed in a variety of ways (Ologhobo and Fetuga, 1984a). Dolvo et al. (1976) have published some methods of home preparation and uses of southern peas in Nigeria. Some of the dishes reported included using peas which are boiled, steamed, fried, roasted, or baked.

A few of the dishes that are popular in Nigeria have also been researched in the United States. Adeniji and Potter (1980, 1981) experimented with moin-moin, a popular dish of Nigeria. Moin-moin was prepared by pureeing decorticated peas, salt, tomato paste, onions, water, and peanut oil. They canned the moin-moin and evaluated the shelf-stability, nutritional value, and sensory properties. Heat penetration characteristics were determined in one study. In another study they showed that the canned moin-moin had no losses of thiamin, total lysine, available lysine, methionine, and tryptophan from processing or storage, but protein efficiency ratio (PER) values decreased for this product. A sensory panel ranked overall acceptability for the canned product slightly lower than that for the traditional steamed moin-moin.

Other studies by McWatters and Flora (1980) and McWatters and Brantley (1982) involved the use of southern peas to produce a highly acceptable deep-fried product. A similar product eaten in Nigeria is called akara. Decorticated peas were blended into a smooth paste, whipped to incorporate air, and mixed with chopped onions and green peppers. The product was formed into individual balls and deep-fried in vegetable oil. Percentages of moisture, oil, and protein and sensory scores were determined on this product. Another study showed that akara could be produced also from cowpea meal(McWatters and Brantley, 1982).

Ammerman and Seale (1970a;b) reported that an acceptable product could be made by canning southern peas with pork and tomato sauce. Nine levels of fill weight, nine levels of pork, and nine levels of tomato solids were evaluated for color and acceptability. Turner (1981) prepared an acceptable acidified canned product. Peas were canned in either acidified aqueous solutions or in an acidified sauce containing vinegar, tomato paste and water. Jars of product were processed in boiling water rather than by retorting. The effect of acidification on chemical components, physical properties, microbiological counts, and organoleptic characteristics was measured.

Legume powders with very low flavor intensity, according to Kon et al. (1974), have potential as extenders and additives for meat and bakery products. Legumes having a high protein content and lysine content are useful as extenders for cereal products. Onayemi and Potter (1976) studied the effects of added methionine during production of drum-dried cowpea powder. Also, the effects of storage on organoleptic and nutritional properties were studied. They found that drum drying eliminated trypsin inhibitors, and addition of methionine increased PER values. Cowpea powders stored 24 weeks showed reductions in PER values. Okaka and

Potter (1979a) reported that methods previously used to produce cowpea powders resulted in a powder with a slight beany flavor which limited its use in certain products. They produced a powder with less beany flavor and superior functional properties by soaking cowpeas in acidified water, dehulling, blanching in 100°C steam prior to grinding, and drum drying. The acid and heat were used to inactivate lipoxygenase, an enzyme that catalyzes the formation of odorous carbonyl compounds from cis, cis-1,4-pentadiene. In another study by Okaka and Potter (1979b) moin-moin was prepared from the low-beany flavored powder and evaluated for sensory, nutritional, and storage properties. Nutritional and storage properties for the reduced beany powders did not differ from those properties of powders which had not been treated to reduce beaniness.

Zamora and Fields (1979a) fermented cowpeas in a natural fermentation for four days at 25°C to decrease trypsin inhibitors and flatulence-producing oligosaccharides. Fermentation was found to increase amounts of methionine and isoleucine by about 6 and 8 fold, respectively, while significantly decreasing niacin content. Thiamin content was not affected while riboflavin content of fermented cowpeas was increased significantly. Trypsin inhibitory substances decreased significantly, and raffinose and stachyose were eliminated completely. Zamora and Fields (1979b) also showed that no toxic substance was detected in fermented cowpeas.

C. SOME TRENDS IN FOOD CONSUMPTION PATTERNS

According to Appledorf (1980) and Sherck (1971), Americans are becoming more nutrition conscious. Also, it has been noted that more than ever Americans are eating away from home. Restaurant owners are continually changing menus to meet consumers demands. They are also trying to provide nutritious menu items. Recently, a trend has begun towards more natural foods with higher nutritional value such as salads (Salvage, 1981). There has been concern that fast food restaurants are not offering nutritious menu items (Appledorf, 1980). But by offering an array of fresh or processed fruits and vegetables on a salad bar, restaurants could offer the consumer an alternative to items currently on menus.

The salad bar concept has been adopted by many restaurants as a way of expanding business and meeting consumer demands (Anon., 1974, 1976, 1978b). In 1975 a Gallup Survey was conducted to show what the customers of restaurants want and what brings them back. Almost half of all respondents selected the self-service salad bar as a feature that they would prefer (Anon., 1975). Also, in order to make salad bars more appealing, top merchandisers must add variety to their salad bars. New and different salad bar items are continually being sought to add variety (Anon., 1978a).

D. NUTRITIONAL VALUE OF SOUTHERN PEAS

Protein Content

Southern peas offer a relatively inexpensive source of high quality protein to help alleviate the protein-calorie malnutrition problems of many developing countries (Dolvo et al., 1976; Onayemi et al., 1976; Onayemi and Potter, 1976). The protein content has been reported between the range of 22.0% and 27.4% on a dry weight basis (Dolvo et al., 1976; Elias et al., 1964; Khan et al., 1979; Wade et al., 1951). Evans and Boulter (1974) reported the range of crude protein content for 79 cowpea cultivars as 21% to 34%.

Researchers have reported that the protein of southern peas is relatively high in the amino acid lysine but has low levels of sulfur amino acids, methionine and cysteine (Dolvo et al., 1976; Elias et al., 1964; Evans and Boulter, 1974; Khan et al., 1979; Onayemi and Potter, 1976). Because southern peas are rich in lysine, they are an excellent supplement to lysine deficient cereal grain diets which are consumed in developing countries (Dolvo et al., 1976; Elias et al., 1964; Onayemi and Potter, 1976).

Carbohydrate Content

It has been reported that legumes contain a large amount of carbohydrates ranging from 55 to 60% (Kumar and Venkataraman, 1976). Southern peas contain from 48.3 to 60% carbohydrates (Akpapunam and Markakis, 1979; Dolvo et al., 1976; Khan et al., 1979; Meiners et al., 1976a). Starch and reducing sugars constitute 54% of the total carbohydrates (Rao, 1976). The oligosaccharides raffinose, stachyose, and verbascose have been found in many legumes and are also present in southern peas. These oligosaccharides are undigestable in the upper intestinal tract and pass into the large intestine where they are fermented by microoragnisms to produce gas. It was reported by Akpapunam and Markakis (1979) that southern peas averaged 3.4% stachyose, 2.2% sucrose, 1.2% raffinose, and 0.9% verbascose. Southern peas have a range of crude fiber from 2.2% to 6.1% (Akpapunam and Markakis, 1979; Elias et al., 1964; Khan et al., 1979; Meiners et al.,1976a; Wade et al., 1951).

Fat Content

Southern peas have a low amount of total lipids and contain between 1.16% to 3.5% total lipids (Akpapunam and Markakis, 1979; Dolvo et al., 1976; Elias et al., 1964; Khan et al., 1979; Mahadevappa and Raina, 1978; Meiners et al., 1976a; Wade et al., 1951). Mahadevappa and Raina (1978) found that peas contain 0.96% neutral lipids. The neutral lipids contained 83.3% triglycerides, free fatty acids, and hydrocarbons. Neutral lipids also consisted of 13.9% sterols and 2.8% esterified sterols. Total lipids also contained 0.18% glycolipids and 0.75% phospholipids on a dry weight basis.

Mineral Content

According to Akpapunam and Markakis (1979), Elias et al. (1964), Khan et al. (1979), Meiners et al. (1976a), and Wade et al. (1951), southern peas consist of between 3.0% and 3.7% ash on a dry weight basis. Southern peas also have relatively high amounts of certain minerals as reported by McCarthy et al. (1977), Meiners et al. (1976b), Rizley and Sistrunk (1979), Walker and Hymowitz (1972), and Wade et al. (1951). Meiners et al. (1976b) reported that 100 g of raw, mature southern peas contained 69.0 mg calcium, 0.9 mg copper, 8.0 mg iron, 206.3 mg magnesium, 1.3 mg manganese, 518.0 mg phosphorous, 838.3 mg potassium, 8.4 mg sodium, and 3.0 mg zinc.

Vitamin Content

A review of the literature shows that southern peas contain certain levels of the B-complex vitamins. Peas of 100 g amount have been found to contain 0.850 mg thiamine, 0.144 mg riboflavin, 1.106 mg niacin, 0.344 mg pyridoxine, 18.400 mg biotin, 2.010 mg pantothenic acid, and 0.161 mg folic acid (Ogunmodede and Oyenuga, 1969, 1970). Frozen unprepared peas contain 11.16 mg ascorbic acid/100 g peas and 84 IU/100 g peas of beta-carotene (provitamin A) (USDA, 1984).

E. ANTI-NUTRITIVE CONSTITUENTS IN SOUTHERN PEAS

Legumes contain some constituents that can be harmful when ingested by man and, therefore, affect nutritional quality (Liener, 1980; Ologhobo and Fetuga, 1984a,b). Some of these constituents found in southern peas are trypsin inhibitor, hemagglutinin, tannic acid, and phytic acid. Trypsin inhibitors are proteins which inhibit the enzymatic activities of trypsin and chymotrypsin. Ten cultivars of raw southern peas were found by Ologhobo and Fetuga (1984b) to contain sufficient inhibitor to inhibit an average of 23.7 trypsin units (TUI)/mg protein.

Hemagglutinins or lectins are proteins which are able to agglutinate red blood cells of humans and animals (Jaffe, 1980). Ologhobo and Fetuga (1984b) investigated haemagglutinin activity in ten southern pea cultivars and found an average of 61.0 hemagglutinin units per mg protein from raw peas.

A large portion of the phosphorous in legumes is in the form of phytic acid which cannot be digested by humans. Phytate has the ability to chelate minerals such as calcium, magnesium, zinc, copper, and iron to form insoluble complexes that are not absorbed by the intestinal tract

(Liener et al., 1980; Oberleas, 1983; Ologhobo and Fetuga, 1984b). Raw southern peas were found to contain an average of 310.0 mg phytic acid per 100g of peas on a dry weight basis.

F. PHYSICAL CHARACTERISTICS OF SOUTHERN PEAS

Color

Color of southern peas is dependent both upon the maturity and cultivar of the seeds. At the mature, succulent stage peas possess more green color and become less green in color as they become mature, dry peas. The USDA Standards for Grades of frozen field peas and black-eye peas require that 10% of the peas have an obvious green color to be considered Grade A (USDA, 1976). Mechanical harvesting and shelling procedures damage the peas and can lead to discoloration and deterioration (Hurst and Schuler, 1979; Smittle and Kays, 1976; Worthington and Burns, 1971). In a study by Hurst and Schuler (1979) it was shown that loss of green color can be controlled by hydrocooling and refrigerating the peas after harvesting.

Firmness

Food texture as defined by Szczesniak (1963) is "the composite of the structural elements of food and the manner in which it registers with physiological senses." Firmness is a popular term for one of the mechanical characteristics of texture which is hardness. Hardness is "the force required to attain a given deformation" (Szczesniak, 1963). The sensory definition for hardness is "the force required to penetrate a substance with the molar teeth" (Szczesniak et al., 1963; Bourne, 1982). Hardness can also be measured objectively by instruments such as the Instron Universal Testing Machine.

Hardness in peas and other legumes is affected by chemical reactions involving phytates, divalent cations, pectates, and lignins (Kumar et al., 1978; Moscoso et al., 1984). Hardness of southern peas and other legumes has been studied by several researchers. Sefa-Dedeh et al. (1978) developed a method to measure texture of raw and soaked southern peas using a wedge type blade mounted on the Instron Testing Machine. Voisey and Larmond (1971) showed a comparison of several objective measurements of texture of baked beans. In this study texture was measured in the Kramer shear-compression cell, a back extrusion cell, the F.M.C. Pea Tenderometer, a plate extrusion cell, and a wire extrusion cell. Microstructure of southern peas was studied by Sefa-Dedeh and Stanley (1979), and it was shown that textural characteristics and microstructure of the peas were related. It was also shown that the microstructure was affected by water absorption characteristics which influenced texture. Southern peas were found to have a thin, amorphous seed coat which allowed for high rate of water absorption.

G. EFFECTS OF PROCESSING ON THE NUTRITIONAL QUALITY OF PEAS

Effect on Protein

Studies have shown that heat only slightly reduced or did not change the protein content of southern peas (Edijala, 1980; Elias et al., 1964; Haytowitz and Matthews, 1983). The effect of microwave cooking on southern peas was studied by Chung et al. (1981), and it was found that microwaving did not result in significant loss of protein when compared to conventional cooking methods. It has also been shown that other processing steps such as soaking, drum drying, and production of moin-moin did not affect the protein content (Edijala, 1980; Onayemi and Potter, 1976).

In a study by Jaya et al. (1975) it was shown that the cooking of southern peas increased PER. Germination, on the other hand, did not improve the PER or biological value of southern peas (Jaya et al., 1975; Venkataraman et al., 1976).

However, over-heating foods can cause losses of the heat-liable amino acids tryptophan, methonine, and lysine (Chichester, 1973). Elias et al. (1964) reported only small losses of amino acids due to cooking. Microwave cooking, on the other hand, caused greater losses of several amino acids as compared to conventional cooking in a study by Chung et al. (1981). According to Adeniji and Potter (1981), there were no losses of lysine, methionine, or tryptophan from canned and stored moin-moin. Okaka and Potter (1979b) showed no losses of amino acids of cowpea powders. In a study by Zamora and Fields (1979a) southern peas were fermented, and it was found that there was an increase in methionine, isoleucine, and tryptophan due to fermentation. Lee (1985) showed that heat processing had no effect on the amino acid profile of southern peas. The effects of drum drying and addition of methionine to southern peas were studied by Onayemi et al. (1976). In this study laboratory rats were used to evaluate the PER of the southern peas. It was found that PER was increased due to drum drying and addition of methionine.

Effect on Vitamins

Heat processing is known to cause losses of the water soluble vitamins from foods. Thiamin, riboflavin, and niacin losses from southern peas have been studied by several researchers. Edijala (1980) and Haytowitz and Matthews (1983) cooked southern peas of several cultivars by boiling in water at atmospheric pressure and reported thiamin losses ranging from 41.7% to 68.2%. Edijala (1980) and Haytowitz and Matthews (1983) also reported riboflavin losses ranging from 24% to 52%. Edijala (1980) also showed that longer cooking times caused greater losses of thiamin and riboflavin. Haytowitz and Matthews (1983) reported a 66% retention of niacin. In a study by Kilgore and Sistrunk (1981) southern peas were cooked by boiling and by steam processing. They found higher retention of pantothenate, niacin, and folicin in the steam-processed peas. Lee (1985) reported that niacin and riboflavin contents were reduced with cooking time. Water processing of the peas caused greater losses of niacin and riboflavin than steam processing. Chung et al. (1981) showed greater retention of thiamin and riboflavin in southern peas cooked by microwaving than those cooked by boiling.

Onayemi and Potter (1976) studied the effects of the production of powders from southern peas. They found that soaking and drum drying had little effect on the loss of thiamin. Miller et al. (1973) found that drum drying pinto beans and milling into powders resulted in an 18.8% loss in thiamin and a 19.6% loss in niacin.

Some researchers have studied the effects of the production and canning of moin-moin on vitamin losses. Edijala (1980) reported average thiamin losses of 15.4% for moin-moin. It was shown this loss due to production of moin-moin was small compared to a 57% loss due to cooking. A riboflavin loss of 25% for moin-moin was also reported. Adeniji and Potter (1981) reported a thiamin retention of 91% for freshly prepared, steamed moin-moin. Also, thiamin loss of 46% in canned moin-moin was measured. Only a slight loss was reported after canned moin-moin was stored. Zamora and Fields (1979a) showed a significant decrease in niacin and a significant increase in riboflavin contents of fermented southern peas. Thiamin content was not affected by fermentation.

Another highly sensative vitamin which can be affected by processing is ascorbic acid. Ascorbic acid is very heat-labile and is highly affected by air and other oxidizing agents (Chichester, 1973; DeRitter, 1976). Chung et al. (1981) studied the effects of microwave cooking on ascorbic acid content of peas. They found that both conventional methods and microwave cooking caused significant losses of vitamin C. Lathrop and Leung (1980) studied the effects of processing on green peas. They found that blanching and thermal processing accounted for major losses of vitamin C. They reported losses of as much as 67.9% of ascorbic acid due to thermal processing.

Effect on the Mineral Content

Processing causes losses of the various minerals found in southern peas. Researchers have shown losses of minerals from southern peas due to boiling. Haytowitz and Matthews (1983) reported retention of the mineral potassium, iron, zinc, and copper as 76%, 92%, 100%, and 85%, respectively. Also, in boiled southern peas, Meiners et al. (1976b) reported losses of nine minerals. Greatest loss was found for magnesium which only exhibited a 22.7% retention. Calcium, copper, iron, manganese, phosphorous, and potassium had losses ranging from 61% to 68%. Sodium and zinc had the lowest losses of 42% and 57%, respectively. Chung et al. (1981) found losses of calcium, potassium, sodium, magnesium, zinc, and manganese due to both conventional and microwave cooking of southern peas. Neither cooking method affected copper or iron contents.

Kumar et al. (1978) studied the effects of germination on calcium and magnesium contents of southern peas. They reported that losses of calcium and magnesium decreased with increased germination time. Calcium and magnesium losses were 47% and 16%, respectively, after 72 hours of germination.

Effect on Carbohydrates

According to Chichester (1973), carbohydrates of some foods can become more digestible by mild processing. This was shown by Kumar and Venkataraman (1976) with the use of laboratory rats. Carbohydrate digestibility was increased in cooked southern peas. Also, it was shown that digestibility was increased by germinating uncooked peas. Silva and Luh (1979) also studied the effects of germination of southern peas on carbohydrates. They found that germination decreased the content of flatulence-causing raffinose and stachyose while the content of sucrose and fructose increased. Raffinose and stachyose were shown to be totally eliminated in fermented southern peas (Zamora and Fields, 1979a).

H. EFFECT OF PROCESSING ON TWO ANTI-NUTRITIVE CONSTITUENTS

Effect on Trypsin Inhibitor

Cooking, germinating, and fermenting southern peas and autoclaving the powders have all been shown to significantly decrease trypsin inhibitor content. Heat processing was shown by Ologhobo and Fetuga (1984b) to completely eliminate trypsin inhibitor of southern peas. Also, autoclaving southern pea powder was shown to completely eliminate trypsin inhibitor (Ologhobo and Fetuga, 1984b). Elias et al. (1976) reported a 42% loss of trypsin inhibitor units for autoclaved southern peas. Chung et al. (1981) reported 92-97% losses of trypsin inhibitor by both conventional and microwave cooking methods. Drum drying of southern pea puree to form a powder was shown to cause an 83% loss in trypsin inhibitor (Onayemi and Potter, 1976). Zamora and Fields also showed a significant decrease in trypsin inhibitor of southern peas due to fermentation.

Effect on Phytate

Phytate which binds minerals and makes them nutritionally unavailable can also be decreased by cooking and germination. Ologhobo and Fetuga (1984a) reported 10.3% to 13.0% reduction of phytate in southern peas due to cooking. Lee (1985) found no difference between water-processed and steam-processed peas in phytate content.

Germination resulted in a significant decrease in phytate content of southern peas (Kumar et al., 1978; Ologhobo and Fetuga, 1984a,b).

I. EFFECT OF PROCESSING ON THE PHYSICAL CHARACTERISTICS OF SOUTHERN PEAS

Effect on Color

Commerical operations such as harvesting, shelling, and heat processing can affect color of southern peas (Ammerman and Seale, 1970b; Hurst and Schuler, 1979; Rizley and Sistrunk, 1979; Sistrunk and Bailey, 1965; Smith, 1980; Smittle and Kays, 1976). Soaking southern peas in acids, phosphate, and ethylenediaminetetraacetic acid (EDTA) has been shown to decrease discoloration during thermal processing (Ammerman and Seale, 1970a; Kilgore and Sistrunk, 1981; Sistrunk and Bailey, 1965). Flora (1980) also showed improved color of a Crowder-type southern pea with the use of EDTA.

Effect on Firmness

Cookability of legumes, or the condition in which they achieve a degree of tenderness during cooking, has received extensive research. Cookability is usually measured as the time required to soften the peas. The effect of high humidity and high temperature of storage on cookability of red kidney beans was studied by Moscoso et al. (1984), Dos Santos Garruti and Bourne (1985), and Sefa-Dedeh et al.

(1979). They found that softening rates decreased with increased storage time under these conditions. Dos Santos Garruti and Bourne (1985) reported that a sensory panel also found that stored beans were harder than unstored control beans.

Sefa-Dedeh et al. (1978) found that soaking southern peas prior to cooking produced softer peas. Also, cooking was found to breakdown the middle lamella which in the raw state binds the cell walls together. Sefa-Dedeh and Stanley (1979) found that cooking also caused gelatinization of cell starch.

Firmness in legumes is dependent upon the presence of phytate, divalent cations, pectates, and lignins. Moscoso et al. (1984) found that cooking resulted in losses of phytate and pectic substances of red kidney beans which produced softer beans. Kumar et al. (1978) reported a loss of phytate from southern peas after germination which resulted in shorter cooking times. Lee (1985) showed that water processing produced softer peas than steam processing. Also, for each processing method firmness decreased with increased cooking time.

J. EFFECTS OF VINEGAR ON MICROORGANISMS

Vinegar has long been used to flavor foods and to preserve them (Gourlay, 1976). Pitt (1974) studied the effects of acetic acid on growth of yeasts and found that acetic acid had greater inhibitory effects than other acidulents tested. Turner (1981) showed that a safe product could be made from southern peas acidified with vinegar, and they could by processed by pasteurization rather than by boiling.

CHAPTER III

MATERIALS AND METHODS

A. SOURCE OF SOUTHERN PEAS

Southern peas (California Blackeye cultivar) were grown on the Plant and Soil Science Farm, University of Tennessee, Knoxville, by personnel of the Plant and Soil Science Department. The peas were harvested by hand in August and September, 1984, at the mature, succulent stage. Peas were transported to the McLeod Food Technology Building to be shelled and processed. Mature, dry peas were purchased from Siler's Bean Company, a local wholesaler.

B. PREPARATION OF THE PEAS

Mature, succulent peas were passed through a roller-type sheller ("Little Sheller," Taylor Manufacturing Co., Moultrie, Ga.) to remove the pods. Peas were blanched in 87°C water for 3 minutes and individually quick frozen at -35°C in an air-blast freezer. Peas were packaged in plastic bags and stored at -17°C in a still-air freezer. Before the peas were used, the separate bags of peas were combined in a large plastic container and mixed to ensure a homogenous sample.

C. PROCESSING OF THE PEAS

Mature, succulent peas were thawed inside small platic bags that were immersed in water at room temperature. Mature, dry peas were rehydrated in tap water at room temperature for 16 hours. Each maturity of peas was weighed into 2721-g samples.

Both maturities of peas were cooked in 2721-g batches. Peas were placed in stainless steel blanching baskets and processed in a retort at 103.5 Pascal (15 psi) at 121^{o}C for 12 minutes. Water was added to the bottom of the retort to allow for development of an atmosphere of wet steam. After being tenderized, the peas were put into food grade, plastic containers, and tap water at room temperature was added to cover the peas. Both maturities of peas were allowed to soak in water at room temperature for 3 hours to fully rehydrate the peas.

Peas were drained and weighed into 907-g batches. One, 907-g batch from each maturity was used as a control. Other 907-g batches were added to the treatment marinades.

D. PREPARATION OF THE MARINADE TREATMENTS

Peas from both maturities were flavored by marinating in a liquid containing vinegar, oil, dehydrated green pepper, onion powder, garlic powder, sugar, salt, and ground black pepper. Spices were obtained from Spicecraft, Inc., St. Louis, Missouri. Two flavors of the marinating liquid were prepared, one a sweet flavored and the other a hot flavored marinade. Dehydrated granulated jalapeño peppers were used in the hot flavored marinade. The two formulas for the marinades are shown in Table 1.

Marinades were prepared by first weighing all dry ingredients. Then, the vinegar and oil were weighed into a stainless steel pan, and the dry ingredients were added slowly and stirred well. The mixture was heated on an electric heating element while being stirred constantly. The marinade was brought to a boil at 98°C and then removed from the heat. These steps were repeated for all four treatment marinades. Marinades were stored in labeled food grade, plastic containers at 7°C for 24 hours.

E. ADDITION OF MARINADE TO THE PEAS

The processed peas were placed into the marinades in the plastic containers. Batches of 907 g of peas of both maturities were marinated in each of the two flavors of marinades to allow the development of four marinated treatments. Also, two controls from both the mature, succulent and mature, dry peas were stored in plastic containers at the same time as the marinated treatments. Each treatment was allowed to marinate for 16 hours at 7°C.

After 16 hours of marinating, the remaining marinade was drained off the peas, and both the peas and the marinades were kept for analyses. For chemical and physical

TABLE 1

FORMULAS FOR HOT AND SWEET FLAVORED MARINADES

Constituent	Hot Flavor (g)	Sweet Flavor (g)
Vinegar	800	720
Oil	232	208
Sugar	80	208
Onion powder	64	48
Green bell pepper flakes	48	64
Garlic powder	12	12
Granulated jalapeño pepper	8.64	---
Salt	8	8
Black pepper	4.8	4.8

analyses, 340 g of drained peas were taken from each marinated treatment and each control. Eleven grams of drained peas were taken from each marinated treatment and each control for microbiological analysis. Also, 11-ml samples were taken from the marinade for microbiological analysis. The remaining drained peas in each marinated treatment were placed back into the appropriate containers, held at 7^{o}C, and used for sensory evaluation.

F. PREPARATION OF PEAS FOR CHEMICAL ANALYSIS

After the peas had been marinated and the marinade drained off, the peas were frozen in plastic bags in a still-air freezer at -17^{o}C and held until used for analysis. Also, the two control treatments were stored in the same manner. Frozen peas were then removed from the plastic bags, placed on freeze dryer pans, and blast frozen at -37^{o}C for one hour. The peas were freeze-dried in a Virtis Freeze Dryer (model FFP-15W5). The dried peas were ground to a fine powder in an IKA Universal Colloid Mill (model M20). The ground pea powder for each treatment was stored in glass jars along with a packet of desiccant. All samples were stored in a still-air freezer until used.

G. METHODS OF PHYSICAL ANALYSIS

Color

Color was measured with a Hunter Color Meter (model D25D2M) on the four marinated pea treatments and the two unmarinated controls according to methods described by Anon. (1979). The meter was standardized against a beige tile (Hunter Standard No. C2-21128) with L, "a," and "b" values of 77.0, -1.6, and 21.0, respectively. Samples were placed in a cuvette with an optical glass bottom, and L, "a," and "b" values were measured.

Firmness

The Instron Universal Testing Machine (model 1132) was used to measure firmness of peas of all treatments (Anon., 1970). A Kramer Shear Compression cell was filled with a 60-g sample of peas, and the force (expressed as kg) required to shear the sample was measured. Samples were measured for firmness immediately after being taken from the marinade. The Instron Machine was operated with a 500-kg load cell and with the crosshead and chart speeds at 10 cm per minute.

pH and Titratable Acidity

The pH of the marinated peas, unmarinated control peas, and of the four marinades was measured with a Fisher Accumet pH Meter (model 600) according to AOAC (1980) methods. For the peas, a slurry was made of 10 g of peas and 40 ml of deionized water. For the marinades, 10 ml of marinade was diluted with 40 ml of deionized water. Titratable acidity was measured on the samples used for the pH readings. Samples were titrated with 0.1 N sodium hydroxide. A pH meter was used to determine the end point at pH 8.1. Titratable acidity was expressed as percentage of acetic acid.

H. METHODS OF CHEMICAL ANALYSIS

Proximate Analysis

Proximate analysis was performed according to AOAC (1980) methods on all treatments of peas in three replications. Moisture was determined on peas soon after the peas were removed from the marinade. Samples of peas were dried at 80°C in a vacuum oven. Protein content was determined by the Kjeldahl method (% N X 6.25). Percentage of ash was determined by ashing the freeze-dried samples at 580°C in a muffle furnace. Ground oven-dried samples were analyzed for fat content by the soxlet method using petroleum ether as the solvent. Crude fiber content was analyzed by a modified AOAC method. For filtering samples in the test, acid washed, ashed sea sand (120 mesh) was used instead of asbestos. Nitrogen-free extract, or carbohydrate content, was calculated by subtracting the percentages of moisture, fat, fiber, protein, and ash from 100%.

Gross energy value was determined using a Parr Oxygen Bomb Calorimeter (model 124) (Anon., 1960). Approximately 0.8 g of ground freeze-dried sample was tested, and energy was reported as kilo Joules/100 g sample on dry weight basis.

I. METHODS OF MICROBIOLOGICAL ANALYSIS

Microbiological analysis was conducted on all marinated pea treatments, unmarinated control peas, and all marinades. Also, raw peas of both maturities were analyzed. Methods described by Speck (1976) were used for this analysis. For the peas, 11 g were weighed into sterilized beakers; and for the marinades, 11 ml were pipeted into sterile flasks. Peas were stomached in a sterile plastic bag with 99 ml of 0.1% peptone buffer for 30 seconds. Samples were then plated at 10^{-1} to 10^{-4} dilutions. Marinades were also diluted with 99 ml of 0.1% peptone buffer and plated at 10^{-1} and 10^{-4} dilutions.

Standard Methods Agar (SMA) was used to analyze peas and marinades for total plate counts, and the plates were incubated at 32°C for 48 hours. Violet Red Bile (VRB) agar was used to analyze for coliform counts. These plates were incubated at 32°C for 24 hours. Acidified Potato Dextrose (PDA) agar was used to analyze for yeast and mold counts. PDA plates were incubated at 21°C for 5 days. Plates were counted according to rules by Speck (1976). Counts were reported as colony forming units (CFU) per g or ml of sample.

J. METHODS OF PROTEIN EFFICIENCY RATIO DETERMINATION

Use of Laboratory Animals

A feeding study was conducted to determine the PER of the marinated peas. The feeding was conducted as described by Lee (1985). For the study weanling, male, albino rats of the Sprague Dawley strain were used. The study was conducted in the animal laboratory in McLeod Food Technology and Science building temperature in the laboratory was maintained at 21^{o}C. Ten rats were used for each of the four marinated pea treatments. Also, ten rats were used for both unmarinated control treatments, and ten rats were used for a casein reference treatment. Each rat was held in an indiviual cage, measuring 18 cm wide X 24 cm long X 18 cm high. The cages were made with a 1-cm mesh hardware screen for the botton and front of the cage. The sides of the cages were solid so that no contact could be made between rats. Cages were held in racks which held a total of 60 cages. Rats were randomly assigned to cages, and treatment diets were randomly assigned to rats.

Preparation of Peas

Peas for experimental diets were processed and marinated as described in Sections C, D, and E with the exception that the amount of each treatment was doubled to allow enough for the entire feeding study. For each treatment a total of 5442 g of peas was used, but the peas were processed and marinated in 2721-g batches. Marinades were heated in a steam kettle to boiling at 98°C. After draining off the marinade, peas were partially dried at 38°C in a forced-air dehydrator. After the peas lost approximately one-half of the original weight, they were air-blast frozen on freeze-dryer pans. The peas were then freeze-dried for 24 hours. To grind the freeze-dried peas, they were first frozen then ground in a Waring Blendor (model 3113L92). Ground peas were stored in plastic bags at 7°C until used for diet formulation.

Diet Formulation

Diets for the PER determination were prepared according to AOAC (1980) methods. The amount of crude fiber of the marinated treatments was greater than the AOAC recommended level for the diets. The crude fiber was adjusted so that all diets had the same amount of crude fiber. All diets were isocaloric and had 1610.84 kJ/100 g of diet. Ingredients for each diet were weighed out and mixed into a homogeneous mixture with the use of a Urschel Comitrol (model 3600).

Feeding Study Procedure

Rats were weighed at the beginning of the study, every other day, and on the 28th day. The feeder cup plus the feed were weighed every other day, and additional feed was added to the feeder cup every other weighing period. Feed was held in aluminum feed cups and the feed was covered with a screen to prevent rats from scratching feed out of the cups. To the outer side of each cage a water bottle was attached to supply water. Rats were given free access to feed and water. PER values for each diet were calculated by the AOAC (1980) method. The ratio of the average amount of weight gain to the average amount of protein consumed by the 10 rats of each treatment was calcuated.

K. METHODS OF ANALYSIS BY SENSORY EVALUATION

Peas of both maturities which were marinated in both flavors were evaluated by a sensory panel. The marinades and the peas were prepared as described in Sections C, D, and E. The sensory evaluation was conducted in the Sensory Laboratory in McLeod Food Technology Building. A total of 52 panelists evaluated the four samples over a three-day period. Panelists included faculty, staff, and students of the Agricultural Campus of the University of Tennessee.

Samples were evaluated on a 8-point hedonic scale for preference, with 1 equal to "dislike extremely" and 8 equal to "like extremely." A sample score sheet is presented in the appendix. Panelists were given samples in 59 ml portion cups coded with 3-digit random numbers. Samples were also given different code numbers each day. Each panelist was presented one sample at a time and instructed to taste the sample both alone and with lettuce. Also, a slice of apple was given to each panelist to aid in cleansing the mouth between the tasting of samples. The order of presentation of samples to the panelists was randomized. Cool, white flourscent lights were used in the booths for the evaluation. Sensory methodology used was similar to that described by Larmond (1977) and Kramer (1973).

L. EXPERIMENTAL DESIGN AND STATISTICAL ANALYSIS

Chemical, physical, microbiological, PER, and sensory tests were performed as a Randomized Complete Block Design according to Little and Hills (1978). The design for chemical tests, firmness, and color was 2 X 3 X 3 (maturities X 2 marinades and 1 control X replications). The design for pH and titratable acidity on peas was 2 X 3 X 3 (maturities X 2 marinades and 1 control X replications). A 2 X 2 X 3 (maturities X marinade flavors X replications) factorial was used on the marinades for pH and titratable acidity tests.

The design for microbiological tests on peas was 2 X 4 X 3 (maturities X 2 marinade flavors, 1 cooked control and 1 uncooked control X replications). For the microbiological

tests on the marinades a 2 X 2 X 3 (maturities X marinade flavors X replications) factorial was used.
For the feeding study a 2 X 3 X 10 (maturities X marinade flavors and 1 control X rats) factorial was used. For the sensory analysis a 2 X 2 X 52 (maturities X marinade flavors X panelists) factorial was used.

Analysis of Variance was used to analyze data from all tests to determine any significant differences between treatments. Models were reduced for moisture, PER, color, firmness, microbiological, and sensory tests by removing variables that were not significant. Significance between treatment means for each test was determined by Student-Newmen-Kuel mean separation test. The Statistical Analysis System (SAS, 1982) was used to perform the stastical analysis.

CHAPTER IV

RESULTS AND DISCUSSION

A. PROXIMATE COMPOSITION

Moisture

The F-ratios for the analysis of variance of the effect of marinating and maturity on moisture content of southern peas are shown in Table 2. Moisture content was affected by treatment (two marinated flavors and one unmarinated control) at the 0.01 level and by maturity and replication at the 0.05 level.

Mean moisture contents are presented in Table 3. The sweet treatment had a significantly lower moisture content than the hot treatment, and both were lower in moisture content than the unmarinated control. Possibly the sugar in the marinades was absorbed by the peas causing moisture to be replaced in the peas. The dry maturity peas were significantly lower in moisture content than the succulent peas.

Other Proximate Components

The F-ratios for analysis of variance for the remaining proximate components of the peas are shown in Table 4. Treatment had an effect on protein, fat, crude fiber, ash, carbohydrate, and gross energy contents of the peas at the 0.01 level. All proximate components were affected by

TABLE 2

F-RATIOS FOR ANALYSIS OF VARIANCE OF MOISTURE CONTENT OF MARINATED SOUTHERN PEAS

Source	d.f.	F-Ratio
Treatment	2	50.51**
Maturity	1	5.51*
Replication	2	4.35*
Error	48	
Total	53	

*Significant at the 0.05 level.

**Significant at the 0.01 level.

TABLE 3

MEAN MOISTURE CONTENT OF MARINATED SOUTHERN PEAS AS AFFECTED BY TREATMENT AND MATURITY

	Moisture Content (g/100g Sample)
Treatment	
Control	68.00[a]
Sweet	56.92[c]
Hot	62.08[b]
Maturity	
Dry	61.28[e]
Succulent	63.39[d]

[a-c]Means followed by the same letter are not significantly different at the 0.05 level, N=18.

[d-e]Means followed by the same letter are not significantly different at the 0.05 level, N=27.

TABLE 4

F-RATIOS FOR ANALYSIS OF VARIANCE FOR PROXIMATE ANALYSIS OF SOUTHERN PEAS

Source	d.f.	F-Ratios					
		Protein	Fat	Crude Fiber	Ash	NFE[a]	Gross Energy
Treatment	2	1802.82**	11865.82**	34.94**	2773.79**	346.78**	160.87**
Maturity	1	58.21**	53.69**	29.41**	1605.13**	102.95**	0.51ns
Replication	2	0.84ns	3.76*	8.25**	0.11ns	1.50ns	13.62**
T X M	2	5.62*	95.06**	0.08ns	450.56**	8.52**	4.51*
T X R	4	0.46ns	70.20**	3.70*	28.53**	12.24**	5.13**
M X R	2	0.64ns	24.52**	16.78**	2.53ns	3.22ns	2.16ns

TABLE 4 (continued)

Source	d.f.	F-Ratios					
		Protein	Fat	Crude Fiber	Ash	NFE[a]	Gross Energy
T X M X R	4	4.29*	105.39**	0.81ns	26.04**	8.10**	1.13ns
Error[b]	18						
Total	35						

nsNot significant.

*Significant at the 0.05 level.

**Significant at the 0.01 level.

[a]Nitrogen-free extract.

[b]Error term for Fat analysis was 36 and total was 53.

maturity at the 0.01 level. Replication was significant for fat (0.05 level) and crude fiber (0.01 level) contents. Some other significant interactions were identified.

Mean proximate analysis values for marinated southern peas are shown in Table 5. The two marinated treatments had higher fat and gross energy contents and lower protein and nitrogen-free extract contents than the unmarinated control. The lower amount of protein, approximately a 9 to 11 g reduction, for the marinated treatments was due to the addition of marinade ingredients (green bell pepper flakes, oil, spices, and other ingredients) which reduced the proportion of peas. Protein content of the marinating ingredients was lower than that of southern peas (USDA, 1984). The higher fat content for the marinated peas, approximately a 11 to 13 g increase, compared to the control peas was due also to the marinade ingredients. Also, the hot-treatment peas had higher fat, protein, and gross energy contents and lower nitrogen-free extract than the sweet-treatment peas. Crude fiber content was the highest for the hot-treatment peas, and the sweet-treatment peas and the control peas did not differ in crude fiber. The higher crude fiber content for the hot-treatment peas might be due to the addition of the jalapeño pepper. According to USDA (1984) jalapeño pepper contains 22.77% crude fiber on a dry

TABLE 5

MEAN PROXIMATE ANALYSIS VALUES FOR MARINATED SOUTHERN PEAS

	Proximate Analysis (g/100g DWB*)					
	Protein	Fat	Crude Fiber	Ash	NFE	Gross Energy (kJ/100g)
Treatment						
Control	25.72^{a}	0.91^{c}	3.48^{b}	2.49^{b}	67.41^{a}	1892.02^{c}
Sweet	14.87^{c}	12.33^{b}	3.56^{b}	2.47^{c}	66.84^{b}	2022.42^{b}
Hot	16.87^{b}	14.00^{a}	3.91^{a}	2.89^{a}	62.43^{c}	2069.79^{a}

TABLE 5 (continued)

	Proximate Analysis (g/100g DWB*)					
	Protein	Fat	Crude Fiber	Ash	NFE**	Gross Energy (kJ/100g)
Maturity						
Dry	19.72^{d}	9.35^{d}	3.53^{e}	2.72^{d}	64.71^{e}	1997.74^{d}
Succulent	18.52^{e}	8.80^{e}	3.77^{d}	2.51^{e}	66.42^{d}	1991.75^{d}

*DWB indicates values are reported on a 100% dry weight basis.

**Nitrogen-free extract.

$^{a-c}$Means in a column followed by the same letter are not different at the 0.05 level; N=18 for Fat, N=12 for other components.

$^{d-e}$Means in a column followed by the same letter are not different at the 0.05 level; N=27 for Fat, N=18 for other components.

weight basis. The sweet-treatment peas had the lowest ash content, and the hot-treatment peas had the highest ash content.

Southern pea treatments of the dry maturity had the highest protein, fat, and ash contents and the lowest crude fiber content and nitrogen-free extract. The two maturities of peas did not differ in gross energy values.

Mean proximate analysis values for marinated peas as affected by the interaction between treatment and maturity are shown in Table 6. The control treatment peas of the dry maturity had a higher protein content than succulent peas of the control treatment, and both had a higher protein content than the other treatment-maturity combinations. Also, the hot-treatment peas of the succulent maturity and the sweet-treatment peas of the dry maturity did not differ in protein content. The difference in protein contents between the sweet and hot marinated peas of the succulent maturity was 2.50 g and was greater than the difference between protein contents of the sweet and hot marinated peas of the dry maturity, which was 1.33 g.

All the marinated treatments made with both maturities of peas had higher fat content than either the control succulent or control dry peas, which did not contain any added oil. The sweet treatment made with dry peas and the marinated treatments made with succulent peas did not differ in percentage of fat while the hot treatment made with dry

TABLE 6

MEAN PROXIMATE ANALYSIS FOR MARINATED SOUTHERN PEAS AS AFFECTED BY THE INTERACTION BETWEEN TREATMENT AND MATURITY

		Proximate Analysis (g/100g DWB*)					
Maturity	Treatment	Protein	Fat	Crude Fiber	Ash	NFE**	Gross Energy (KJ/100g)
Dry	Control	26.16^{a}	0.90^{c}	3.36^{a}	2.70^{c}	66.90^{ab}	1877.89^{c}
	Sweet	15.84^{d}	12.16^{b}	3.42^{a}	2.53^{d}	66.12^{b}	2038.22^{ab}
	Hot	17.17^{c}	15.00^{a}	3.80^{a}	2.92^{a}	61.10^{d}	2077.09^{a}
Succulent	Control	25.28^{b}	0.91^{c}	3.61^{a}	2.27^{f}	67.93^{a}	1906.15^{c}
	Sweet	13.89^{e}	12.51^{b}	3.69^{a}	2.40^{e}	67.57^{a}	2006.63^{b}
	Hot	16.39^{d}	12.99^{b}	4.02^{a}	2.85^{b}	63.77^{c}	2062.49^{a}

*DWB indicates values are reported on a 100% dry weight basis.

**Nitrogen-free extract.

a-f Treatment-maturity means in a column followed by the same letter are not different at the 0.05 level; N=9 for Fat, N=6 for other constituents.

peas was significantly higher than all other treatments. There was no difference in percentage of crude fiber for the treatment-maturity combinations.

The hot treatment peas of both maturities had the highest ash content of all the treatment-maturity combinations. The control treatment peas of the succulent maturity had the lowest percentage of ash with the sweet treatment significantly higher. However, the sweet treatment was significantly lower than the control treaatment for the dry peas.

Nitrogen-free extract values were highest for the control and sweet treatments of the succulent maturity and the control treatment of the dry maturity. Peas of the hot treatment and dry maturity had the lowest nitrogen-free extract values, 5.02 g less than the sweet treatment of the dry maturity. The hot-treatment peas were only 3.80 g less than the sweet-treatment peas of the succulent maturity.

Southern peas of the hot succulent treatment-maturity combination and peas of the sweet dry and hot dry treatment-maturity combinations had the highest gross energy values. Also, the values for the peas of the hot treatment and dry maturity were not different from the values for peas of the sweet treatment and succulent maturity. The marinated treatment had higher fat content than the unmarinated control treatments. The marinated treatments had more gross energy since fat contains more energy per gram than protein or nitrogen-free extract.

B. PROTEIN EFFICIENCY RATIO

The F-ratios for analysis of variance of the protein efficiency ratio (PER) of the marinated peas are shown in Table 7. Treatment affected PER at the 0.01 level, but maturity had no effect on PER.

Means for PER are shown in Table 8. All diets containing peas had lower PER than the casein diet. Southern peas are low in the sulpho-amino acids, cysteine and methionine (Elias et al., 1964; Evans and Boulter, 1974; Khan, et al., 1979; Lee, 1985). This could be the cause for the lower PER of the diets containing peas. The marinated treatments did not differ from the unmarinated control in PER. The quality of the protein was not affected by the addition of the marinating ingredients.

C. PHYSICAL CHARACTERISTICS

Color

The F-ratios for the analysis of variance of the effect of marinating and maturity on the color of southern peas are presented in Table 9. Treatment had a significant effect on

TABLE 7

F-RATIOS FOR ANALYSIS OF VARIANCE OF PROTEIN EFFICIENCY RATIO OF SOUTHERN PEAS

Source	d.f.	F-Ratio
Treatment	3	23.81^{**}
Maturity	1	0.22^{ns}
Error	65	
Total	69	

^{ns}Not significant.

**Significant at the 0.01 level.

TABLE 8

MEAN PROTEIN EFFICIENCY RATIOS
FOR MARINATED AND CONTROL
SOUTHERN PEAS

Treatment	PER*
Control	1.88[b]
Sweet	1.85[b]
Hot	1.75[b]
Casein	2.50[a]

*Means were adjusted to 2.5 for the casein diet.

[a-b]Means followed by the same letter are not significantly different at the 0.05 level; N=10.

TABLE 9

F-RATIOS FOR ANALYSIS OF VARIANCE OF COLOR VALUES OF SOUTHERN PEAS

		F-Ratios		
Source	d.f.	L	"a"	"b"
Treatment	2	82.66**	0.38ns	205.18**
Maturity	1	38.01**	226.13**	17.69**
T X M	2	8.77**	35.50**	0.02ns
Error	48			
Total	53			

nsNot significant.

**Significant at the 0.01 level.

the Hunter L and "b" values. Hunter L, "a," and "b" values were affected by maturity. Also, a treatment-maturity interaction affected L and "a" values.

Table 10 shows the mean Hunter color values for marinated southern peas. The L value for both marinated treatments were lower than that of the control with the value of the sweet treatment being the lowest. A lower L value indicated that the peas were darker. This could be due to the sweet treatment containing a higher percentage of green bell pepper flakes causing them to be darker. The marinated treatments did not have significantly different "a" values than the control treatment, but both had higher "b" values than the control. The higher "b" values indicated more yellow color than the control. Peas of the succulent maturity had higher L and "b" values and a lower "a" value than peas of the dry maturity. Rizley and Sistrunk (1979) showed that succulent peas possessed greater lightness and greenness than dry peas.

Means for color values for marinated southern peas as affected by the interaction between treatment and maturity are shown in Table 11. Peas of the sweet treatment and each maturity had the lowest L values indicating that they were the darkest. Also, the hot treatment peas of the dry maturity had a lower L value than the hot treatment peas of the succulent maturity.

TABLE 10

MEAN COLOR VALUES FOR MARINATED SOUTHERN PEAS

	Hunter Color Values		
	L	"a"	"b"
Treatment			
Control	38.11[a]	2.84[a]	11.25[c]
Sweet	34.22[c]	2.70[a]	14.41[b]
Hot	36.99[b]	2.79[a]	14.92[a]
Maturity			
Dry	35.66[e]	3.82[d]	13.19[e]
Succulent	37.23[d]	1.74[e]	13.86[d]

[a-c]Means in each column followed by the same letter are not different at the 0.05 level, N=18.

[d-e]Means in each column followed by the same letter are not different at the 0.05 level, N=27.

TABLE 11

MEANS FOR COLOR VALUES FOR MARINATED SOUTHERN PEAS AS AFFECTED BY THE INTERACTION BETWEEN TREATMENT AND MATURITY

		Hunter Color Values		
Maturity	Treatment	L	"a"	"b"
Dry	Control	36.58[c]	4.67[a]	10.93[a]
	Sweet	33.89[d]	3.57[b]	14.06[a]
	Hot	36.50[c]	3.22[b]	14.58[a]
Succulent	Control	39.64[a]	1.02[e]	11.57[a]
	Sweet	34.54[d]	1.83[d]	14.76[a]
	Hot	37.49[b]	2.37[c]	15.27[a]

[a-e]Treatment-maturity combination means in each column followed by the same letter are not significantly different at the 0.05 level, N=9.

The "a" value was lower for the sweet treatment peas of the succulent maturity than other marinated treatments indicating less redness. The higher content of green bell pepper flakes and the greenness of the succulent peas contributed the lower "a" value. The sweet and hot treatment peas of the dry maturity had the highest "a" values and were not different from each other. Flora (1980) found that crowder-type peas when acidified with citric acid possessed less red color than unacidified peas. The treatment-maturity combination means did not differ in "b" values.

Firmness

The F-ratios for firmness values are shown in Table 12. Treatment, maturity, and replication had an effect on firmness values at the 0.01 level. Also, there were significant treatment-maturity and maturity-replication interactions.

Mean firmness values for marinated southern peas are presented in Table 13. The marinated treatment peas were more firm than the unmarinated control peas. Flora (1980) also found that crowder-type peas acidified with citric acid were firmer than unacidified peas. This phenomenon was attributed to denaturation of some of the proteins and to decreasing hydration of proteins and starches by the acid. Turner (1981) also found that peas acidified with acetic acid were firmer than unacidified peas. Maturity means were

TABLE 12

F-RATIOS FOR ANALYSIS OF VARIANCE
OF FIRMNESS VALUES OF
SOUTHERN PEAS

Source		F-Ratio
Treatment	2	194.39**
Maturity	1	408.77**
Replication	2	47.60**
T X M	2	5.91**
M X R	2	7.65**
Error	43	
Total	52	

**Significant at the 0.01 level.

TABLE 13

MEAN FIRMNESS VALUES OF MARINATED SOUTHERN PEAS AS AFFECTED BY THE INTERACTION BETWEEN TREATMENT AND MATURITY

	Firmness (kg force/60g Sample)		
Treatment	Dry	Succulent	Treatment Means
Control	41.40^{c}	28.24^{e}	35.21^{z}
Sweet	62.84^{a}	43.92^{c}	53.38^{x}
Hot	49.86^{b}	35.34^{d}	42.60^{y}
Maturity Means	51.37^{l}	36.13^{m}	

$^{a-e}$Treatment-maturity combination means followed by the same letter are not significantly different at the 0.05 level, N=9.

$^{l-m}$Maturity means followed by the same letter are not different at the 0.05 level, N=27.

$^{x-z}$Treatment means followed by the same letter are not different at the 0.05 level, N=18.

higher for the dry maturity peas indicating that they were firmer than the succulent maturity peas. Treatment-maturity combination means are also shown in Table 13. The sweet-treatment peas of the dry maturity had the highest firmness values, but the hot-treatment peas of the dry maturity had higher shear values than the sweet treatment peas of the succulent maturity. Firmness values were lowest for the hot-treatment peas of the succulent maturity when compared to all other marinated treatments.

pH and Titratable Acidity

The F-ratios for pH and titratable acidity values of the peas are shown in Table 14. Treatment, maturity, treatment-maturity interaction, treatment-replication interaction had effects on pH values at the 0.01 level. Treatment and the treatment-maturity interaction were significant for titratable acidity values at the 0.01 level.

Mean values for pH and titratable acidity of the peas are shown in Table 15. Marinated peas had lower pH values and higher titratable acidity than the unmarinated-control peas. This was due to the absorbtion of the vinegar by the peas. Also, the hot treatment peas had a lower pH than the sweet treatment peas. This could be due to the higher content of vinegar in the hot treatment marinade. The hot-treatment peas had the highest titratable acidity indicating a higher percentage of acetic acid. The hot-flavored formula contained more vinegar and made more

TABLE 14

F-RATIOS FOR ANALYSIS OF VARIANCE
OF PH AND TITRATABLE ACIDITY
ANALYSIS OF SOUTHERN PEAS

		F-Ratios	
Source	d.f.	pH	Titratable Acidity
Treatment	2	38853.91**	19822.12**
Maturity	1	66.27**	1.72ns
Replication	2	1.73ns	1.12ns
T X M	2	15.55**	11.8**
T X R	4	11.41**	2.79ns
M X R	2	0.27ns	2.99ns
T X M X R	4	4.77**	2.41ns
Error	18		
Total	35		

nsNot significant.

**Significant at the 0.01 level.

TABLE 15

MEAN PH AND TITRATABLE ACIDITY VALUES
FOR MARINATED SOUTHERN PEAS

	pH	Titratable Acidity (g Acetic Acid/100g Sample)
---Treatment---		
Control	6.63[a]	0.11[c]
Sweet	3.95[b]	1.71[b]
Hot	3.87[c]	2.00[a]
---Maturity---		
Dry	4.86[d]	1.27[d]
Succulent	4.78[e]	1.33[d]

[a-c]Means in each column followed by the same letter are not different at the 0.05 level, N=12.

[d-e]Means in each column followed by the same letter are not different at the 0.05 level, N=18.

vinegar available to the peas. Peas of the dry maturity had a higher pH but did not differ in titratable acidity with the succulent maturity peas.

Mean pH and titratable acidity values for marinated southern peas as affected by the interaction between treatment and maturity are presented in Table 16. Control dry and control succulent treatment-maturity combinations had the highest pH values and the lowest titratable acidity when compared to the other marinated treatments. The sweet-succulent and hot-succulent combinations did not have different pH values than the hot-dry combination. The hot-dry and hot-succulent treatment-maturity combination peas had the highest titratable acidity. The sweet treatment peas of the succulent maturity had a higher titratable acidity than the sweet-treatment peas of the dry maturity.

The F-ratios for analysis of variance of pH and titratable acidity values of the marinades (drained from the peas) are shown in Table 17. Treatment and treatment-replication interaction had a significant effect on pH values at the 0.05 level. Maturity and replication had a significant effect on pH at the 0.01 level. Maturity had a significant effect on titratable acidity at the 0.05 level. Treatment, replication, treatment-maturity

TABLE 16

MEAN PH AND TITRATABLE ACIDITY VALUES FOR MARINATED SOUTHERN PEAS AS AFFECTED BY THE INTERACTION BETWEEN TREATMENT AND MATURITY

Maturity	Treatment	pH	Titratable Acidity (g Acetic Acid/100g Sample)
Dry	Control	6.64[a]	0.12[d]
	Sweet	4.03[b]	1.68[c]
	Hot	3.90[c]	2.01[a]
Succulent	Control	6.63[a]	0.10[d]
	Sweet	3.88[c]	1.75[b]
	Hot	3.83[c]	2.00[a]

[a-d]Treatment-maturity combination means in each column followed by the same letter are not significant at the 0.05 level, N=6.

TABLE 17
F-RATIOS FOR ANALYSIS OF VARIANCE OF
PH AND TITRATABLE ACIDITY ANALYSIS
OF THE MARINADES

Source	d.f.	F-Ratios pH	F-Ratios Titratable Acidity
Treatment	1	8.33^{*}	198.95^{**}
Maturity	1	40.33^{**}	8.00^{*}
Replication	2	46.33^{**}	31.33^{**}
T X M	1	0.33^{ns}	20.23^{**}
T X R	2	4.33^{*}	31.49^{**}
M X R	2	2.33^{ns}	7.20^{**}
T X M X R	2	0.33^{ns}	2.84^{ns}
Error	12		
Total	23		

^{ns}Not significant.

*Significant at the 0.05 level.

**Significant a the the 0.01 level.

interaction, treatment-replication interaction, and maturity-replication interaction had effects on titratable acidity at the 0.01 level.

Mean pH and titratable acidity values for the marinades are presented in Table 18. The pH of the hot-treatment marinade was lower and the titratable acidity value was higher than the values for the sweet-treatment marinade. Marinades decanted from succulent peas had a lower pH and a higher titratable acidity than marinades decanted from dry peas.

Mean pH and titratable acidity values for the marinades as affected by the interaction between treatment and maturity are shown in Table 19. The treatment-maturity combination means did not differ in pH values.

The hot-treatment marinade decanted from the succulent matutity had the highest titratable acidity when compared to other marinades. The sweet marinades decanted from each maturity did not differ in titratable acidity and had the lowest values.

D. MICROBIOLOGICAL COUNTS

The F-ratios for analysis of variance of plate counts of peas are shown in Table 20. Treatment, replication, and a treatment-replication interaction only affected yeast counts at the 0.01 level. Mean SMA, VRB, and mold counts of the peas were 3.9 X 10^3 CFU/g, 2.7 X 10^3 CFU/g, and 10

TABLE 18

MEAN PH AND TITRATABLE ACIDITY VALUES
FOR TREATMENT MARINADES

	pH	Titratable Acidity (g Acetic Acid/100g Sample)
	Treatment	
Sweet	3.91[a]	1.81[b]
Hot	3.89[b]	2.03[a]
	Maturity	
Dry	3.93[d]	1.90[e]
Succulent	3.88[e]	1.94[d]

[a-b]Means in each column followed by the same letter are not different at the 0.05 level, N=12.

[d-e]Means in each column followed by the same letter are not different at the 0.05 level, N=12.

TABLE 19

MEAN PH AND TITRATABLE ACIDITY VALUES OF MARINADES AS AFFECTED BY THE INTERACTION BETWEEN TREATMENT AND MATURITY

Maturity	Treatment	pH	Titratable Acidity (g Acetic Acid/100g Sample)
Dry	Sweet	3.93[a]	1.83[c]
	Hot	3.92[a]	1.97[b]
Succulent	Sweet	3.89[a]	1.80[c]
	Hot	3.87[a]	2.09[a]

[a-c]Treatment-maturity combination means in each column followed by the same letter are not significantly different at the 0.05 level, N=6.

TABLE 20

F-RATIOS FOR ANALYSIS OF VARIANCE OF PLATE COUNTS OF MARINATED SOUTHERN PEAS

		F-Ratios			
Source	d.f.	SMA[a]	VRB[b]	Molds[c]	Yeasts[c]
Treatment	3	1.79[ns]	1.57[ns]	4.27[ns]	8552.52**
Maturity	1	0.00[ns]	1.17[ns]	4.49[ns]	1.40[ns]
Replication	2	0.11[ns]	1.59[ns]	3.95[ns]	8707.93**
T X M	3	0.00[ns]	1.85[ns]	2.75[ns]	1.40[ns]
T X R	6	0.13[ns]	0.73[ns]	1.49[ns]	9284.39**
Error	8				
Total	23				

[ns]Not significant.

**Significant at the 0.05 level.

[a]Standards Methods Agar counts.

[b]Violet Red Bile Agar counts.

[c]Acidified Potato Dextrose Agar counts.

estimated CFU/g. For both maturities, the raw peas had the highest mean yeast counts of 1.9×10^4 CFU/g peas. The sweet-treatment peas of both maturities had the lowest mean yeast count, which was 4.2×10^3 CFU/g peas. Cooked peas and the hot-treatment peas did not differ in yeast counts and had mean counts of 8.9×10^3 and 1.1×10^4 CFU/g peas, respectively.

The F-ratios from the analysis of variance of plate counts of the marinades are shown in Table 21. Marinades had a mean SMA plate count of 1.2×10^3 CFU/ml marinade, a VRB plate count of 8.2×10^2 CFU/ml marinade, a yeast count of 5.4 CFU/ml marinade, and a mold count of <10 estimated CFU/ml marinade.

E. SENSORY EVALUATION

The F-ratios for the analysis of variance for the sensory scores for the marinated peas are shown in Table 22. Neither treatment nor maturity had an effect on the sensory preference scores. Table 23 shows the mean preference scores of peas as affected by treatment and maturity. The scores for peas of the sweet and hot treatments were 5.14 and 4.73, respectively, and the scores for the dry and succulent maturities were 4.92 and 4.95, respectively. These scores were between the two terms "dislike slightly" and "like moderately."

TABLE 21

F-RATIOS FOR ANALYSIS OF VARIANCE OF PLATE COUNTS OF THE MARINADES

		F-Ratios		
Source	d.f.	SMA[a]	VRB[b]	Yeasts[c]
Treatment	1	3.96[ns]	0.11[ns]	0.08[ns]
Maturity	1	0.24[ns]	0.00[ns]	0.14[ns]
Replication	2	12.81*	7.64*	2.73[ns]
T X M	1	0.18[ns]	16.96*	0.69[ns]
T X R	2	5.37[ns]	4.02[ns]	0.04[ns]
Error	4			
Total	11			

[ns]Not Significant.

*Significant at the 0.05 level.

[a]Standard Methods Agar counts.

[b]Violet Red Bile Agar counts.

[c]Acidified Potato Dextrose Agar counts.

TABLE 22

F-RATIOS FOR ANALYSIS OF VARIANCE
OF SENSORY PREFERENCE SCORES
OF MARINATED SOUTHERN PEAS

Source	d.f.	F-Ratio
Treatment	1	3.31^{ns}
Maturity	1	0.01^{ns}
Error	205	
Total	207	

^{ns}Not significant.

TABLE 23

MEAN PREFERENCE SCORES FOR MARINATED SOUTHERN PEAS

	Preference Scores*
Treatment	
Sweet	5.14[a]
Hot	4.73[a]
Maturity	
Dry	4.92[b]
Succulent	4.95[b]

*Scale range from 1=dislike extremely to 8=like extremely.

[a]Means followed by the same letter are not significantly different at the 0.05 level, N=52.

[b]Means followed by the same letter are not significantly different at the 0.05 level, N=52.

The panelists were also asked if they liked hot/spicy foods and were given the choice to answer "yes" or "no." Of all the panelists 73% indicated that they liked hot/spicy foods. When the data were analyzed separately for those who answered "yes" and those who answered "no," for those who indicated that they liked hot/spicy foods there was no difference between the two treatments. Also, for the panelists who indicated that they did not like hot/spicy foods, scores for the two treatments were not significantly different. Panelists were also asked whether they liked salads and were asked if they ate at salad bars in restaurants. Ninety-six percent of the panelists indicated that they liked salads, and 92% indicated that they ate at salad bars in restaurants.

CHAPTER V

SUMMARY

The objectives of this experiment were to develop southern peas into a product for use as a salad bar item by marinating in either a hot flavored or a sweet flavored liquid containing vinegar, oil, and spices and to determine the effect of maturity of the peas and flavorings on the chemical, physical, and sensory characteristics of the southern peas.

Moisture content of the marinated treatment peas was lower than the unmarinated control. The moisture content of the sweet treatment peas of both maturities had lower moisture content than the hot treatment peas. The succulent maturity peas had higher moisture content than the dry maturity peas. The mean moisture contents for the hot treatment and sweet treatment was 62.1% and 56.9%, respectively.

Marinating the peas increased the fat content of both maturities. The protein contents of the two marinated peas of both maturities were reduced by marinating. Most likely this was caused by the reduced porportion of peas due to the addition of oil and spices. The hot treatment had the highest crude fiber, ash, and gross energy and the lowest carbohydrate contents for both maturities. The sweet treatment peas had protein, fat, crude fiber, ash, and nitrogen-free extract of 14.9%, 12.3%, 3.6%, 2.5%, and 66.8%, respectively. The hot treatment peas had protein, fat, crude fiber, ash, and nitrogen-free extract of 16.9%, 14.0%, 3.9%, 2.9%, and 62.4%, respectively. Gross energy contents for sweet and hot treataments were 2022.4 and 2069.8 kJ/100 g of peas, respectively.

Marinating southern peas had no effect on the protein efficiency ratio (PER). The average PER for marinated treatments of both maturities was 1.8. The PER for the two control treatments was 1.9.

Marinating southern peas increased the "b" value and decreased the L value. The L value for the sweet treatment of the dry maturity was lower than the control, and the hot treatment was not different from the control. The L values for the sweet and hot treatments of the succulent maturity were lower than the control. The "a" values for the two marinated-treatment peas of the dry maturity were lower than the control-treatment peas.

The marinated peas of both maturities were firmer than the unmarinated controls. The sweet and hot treatments of the dry maturity had shear values of 62.8 and 49.9 kg force, respectively. The sweet and hot treatments of the succulent maturity had shear values of 43.9 and 35.3 kg force, respectively.

Marinated southern peas had lower pH and higher titratable acidity than the unmarinated controls. The sweet and hot treatments of the dry maturity had pH values of 4.0 and 3.9 and titratable acidity values of 1.7% and 2.0%, respectively. The sweet and hot treatments of the succulent maturity had pH values of 3.9 and 3.8 and titratable acidity values of 1.8% and 2.0%, respecitively.

The average pH value of the sweet and hot marinades of the dry maturity was 3.9, and the average pH value of the sweet and hot marinades of the succulent maturity was 3.9. The titratable acidities of the sweet and hot treatments of the dry marinades were 1.8% and 2.0% and of the sweet and hot treatments of the succulent maturity were 1.8% and 2.1%, respectively.

Marinated peas had lower yeast counts than raw southern peas. The raw, unmarinated controls, and the sweet and hot treatments had mean yeast counts of 1.9×10^4, 8.9×10^3, 4.2×10^3, and 1.1×10^4 CFU/g peas, respectively. All pea treatments had mold counts of <10 estimated CFU/g peas.

The consumer panel did not like any one marinated treatment more than any other. The average preference score for all treatments was 4.9 which was between the two terms "dislike slightly" and like slightly."

The findings from this study suggest that an acceptable product can be made from southern peas by the addition of marinating ingredients such as vinegar, oil, and spices. Additional studies are needed to determine the marketability of a product such as this. In comparison to most other vegetable-type products currently offerred on salad bars, this product could add variety as well as provide a good source of protein.

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APPENDIX

SCORE SHEET

NAME______________________ DATE______________

PRODUCT______________________

You will be presented four samples, one at a time. Follow these steps for each sample.

1. Taste the coded sample without lettuce.
2. Taste the coded sample with a bite of lettuce.
3. Check how much you like or dislike the coded sample.
4. Expectorate all samples.
5. Cleanse your mouth with a bite of apple, then expectorate.
6. Rinse your mouth with water.
7. You may need to repeat Steps 5 and 6.
8. Close the hatch toward you to indicate that you are ready for the next sample.

Code ____	Code ____	Code ____	Code ____
____like extremely	____like extremely	____like extremely	____like extremely
____like very much	____like very much	____like very much	____like very much
____like moderately	____like moderately	____like moderately	____like moderately
____like slightly	____like slightly	____like slightly	____like slightly
____dislike slightly	____dislike slightly	____dislike slightly	____dislike slightly
____dislike moderately	____dislike moderately	____dislike moderately	____dislike moderately
____dislike very much	____dislike very much	____dislike very much	____dislike very much
____dislike extremely	____dislike extremely	____dislike extremely	____dislike extremely

Which sample would you like best on a salad bar? Code________

Why?______________________________________

Do you like hot/spicy foods? ____YES ____NO

Do you like salads? ____YES ____NO

Do you eat at salad bars in restaurants? ____YES ____NO

Comments: ______________________________________

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VITA

Teresa Lynn Chapman was born in Los Angeles, California, on May 14, 1961. She attended elementary school in New Cuyama, California. Her family moved to Soddy Daisy, Tennessee, in 1972, and she attended secondary schools in that city. She was graduated from Soddy Daisy High School in 1979. The following September she attended the University of Tennessee and in December, 1983, she received a Bachelor of Science Degree, majoring in Food Technology and Science. She entered the Graduate program in January of 1983, and she received a Master of Science Degree, majoring in Food Technology and Science, in June 1986. During her graduate program she was employed as a Graduate Research Assistant and was a member of Gamma Sigma Delta.