To the Graduate Council :

I am submitting herewith a thesis written by Kamarudin bin Hasim entitled "Development of a Baked, Breaded Vegetable Product with Defined Nutrient Level." 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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DEVELOPMENT OF A BAKED, BREADED VEGETABLE PRODUCT WITH DEFINED NUTRIENT LEVEL

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Kamarudin bin Hasim

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DEDICATION

This thesis is specially dedicated to my late father who passed away while I was here in Knoxville struggling with my study and also to my mother who was in the hospital while this thesis was written.

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ABSTRACT

The objectives of this study were to explore the potential for preparing a baked, breaded vegetable product with a defined nutrient level, to evaluate the use of a hot air impingement oven to cook the product, and to determine the effect of selected vegetable matrices and reheating methods on chemical, physical, and sensory attributes of the product.

Two vegetable matrices with defined nutrient levels were selected by a computer program designed to combine the nutrient densities of four vegetables such that their maximum nutrient levels were obtained. The vegetables were obtained and frozen, mixed with 1 % yeast, compressed inside a mold, sliced, covered with a thin dough, and cooked in a hot air impingement oven. The composition of the products before cooking were 75 % of vegetables + yeast and 25 % of dough. The cooked product was kept frozen until it was evaluated. Two reheating methods were used, heating in a conventional oven and in a microwave oven.

The product with the vegetables designated as matrix 1 contained a greater amount of crude fat and yielded greater total and maximum shear forces as compared to the product with vegetables of matrix 2. The hot air impingement oven that was used to cook the product produced a product with a lighter color on the top side of the product as it was passed through the oven as compared to the color on the bottom side. Heating the frozen, cooked product in a microwave oven produced an external color that was less yellow color product as compared to heating in a conventional oven. Samples of the product were cooked in a deep-fryer also. The mean percentage crude fat in the deep-fried samples was 44 % higher than the mean fat content of samples cooked in hot air.

The panel scores for color of the vegetable, moistness of crust, overall texture, flavor, and overall acceptability of the product were widely dispersed on the scale from

"like extremely" to "dislike extremely." The means for overall acceptability were in the range of "dislike slightly" to "like slightly."

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Most people, regardless of their nutritional knowledge, consider fruits and vegetables as important foods for good health. In 1971, this group of foods provided over 90 % of the vitamin C, one-half the vitamin A value, one-third the vitamin B6 and approximately one-fifth the niacin and thiamin contents in the food supply (White and Selvey, 1974).

There are increasing demands for snack and convenience foods. In 1985, for example, the snack food industry introduced 2,608 new products in the market place compared to 272 new products introduced in 1984. Vegetables can be processed to form a frozen block; this block can consist of a single vegetable or mixture of vegetables. For use, the block can be cut into pieces, breaded, and cooked to serve as a nutritional snack or convenience food (Anon., 1985a; Bradley et al., 1986).

Consumers are becoming increasingly interested in low fat food (Andres, 1987; Blendford, 1986a; Mancuso et al., 1971). The hot air impingement oven is a relatively new appliance with potential for cooking foods instead of deep-frying, a procedure that adds a high level of fat to the product.

The objectives of this study were:

1). To explore the potential for using only natural ingredients to prepare breaded vegetable products that will contain a nutrient density of at least 10 % of the RDA's for protein, vitamin A value, vitamin C, thiamin (B1), riboflavin (B2), niacin, calcium, and iron.

2). To evaluate the use of a hot air impingement oven for cooking the product.

3). To determine/measure some of the sensory attributes, physical qualities, and chemical components of the product.

CHAPTER II

REVIEW OF LITERATURE

A. Snack and Convenience Foods.

1. Definition.

There are increasing demands for convenience and snack foods in the United States. In 1985, for example, the snack food industry introduced 2,608 new products, whereas only 272 new products were introduced in 1984 (Blendford, 1986a.) Ensminger et al. (1983) defined snack foods as "... those small portions of food eaten between meals; hence, no certain food is really a snack food." He defined convenience foods as "... partially or fully prepared items that have been combined, processed, and/or cooked by the manufacturer and/or distributor so that only minimal amounts of preparation time are required in the home. Some of the old standbys in this category are baby foods in jars, baking mixes, canned fruits and vegetables, and ready-to-eat breakfast cereals."

2. Hot Snack Foods.

In the market today there are many products that fit the definitions of snack and convenience foods. There is also another category of products called "hot snacks" that fits the definition. Hot snacks are frozen foods that have been reheated prior to serving. They are primarily coated products, ranging from nugget-like poultry, seafood, and meat items to coated vegetables . Since they are designed to be eaten informally, they are normally small bite-size food products (Anon., 1985a; Jones and Hutchinson, 1984).

3. Nutritional Value and Convenience.

Salunkhe and Desai (1988) stated that the main force that influenced the food industry to develop new products, including hot snacks, was the increased consciousness about nutrition, food, and health among consumers. This claim is supported by the fact that over one-fifth of the snack products introduced in 1985 had some form of health orientation, either in terms of being all natural or reduced calorie products containing a low level of salt or no salt (Blenford, 1986b).

Another reason for the success of "healthy" food products is due to their convenience of preparation (Anon., 1986b). Because of the convenience aspect of hot snacks they should fit well in fast food restaurants and bars (Andres, 1987; Anon., 1985a).

B. Chemical Composition and Nutritive Value of Vegetables.

1. Manufacturer and Consumer Attribute of Vegetables.

Despite the fact that the recent development of the new snack food industry is due to the increased consciousness about nutrition among the consumer, manufacturers still believe that snack foods are widely thought to be "junk food," and they feel that consumers must be educated as to "how good snacks are for you" (Anon., 1987c).

Nutrition is not new to the foodservice industry; what is new is the manner in which nutrition is perceived. In the past, nutrition was of most concern to clinical and regulatory bodies. Today, promoters of nutrition concentrate on ways and means of gaining attention or fulfilling consumer needs (Carlson, 1986.) In other words, nutrition has been identified as a marketing tool and opportunity by the food industry to channel its products to the consumer.

Carlson (1986) reported results of a survey that showed consumer attitudes toward food can divided into four major groups: (a) nutrition/fitness, 32 %; (b) conventional taste, 26 %; (c) convenience, 22 %; (d) and dieter, 20 %. Thirty-two percent of consumers, which is the largest group, choose nutritional value over taste, convenience, or caloric value in their choice of food. The survey also reported an increased consumption of fruit, vegetables, and whole grain by 60% of the consumers in the United States between 1960 to 1970.

2. Nutritional Value of Vegetables.

In general, consumers look upon fruits and vegetables as important foods for good health. In 1971, fruits and vegetables provided over 90% of vitamin C, one-half of the vitamin A value, one-third of vitamin B6, and approximately one-fifth of niacin and thiamin contents in the food supply (White and Selvey, 1974.) The Household Food Consumption Survey conducted by the United States Department of Agriculture for 1977 to 1978 showed that fruits and vegetables furnished from one-third to over one-half the vitamin A value and over two-thirds the vitamin C requirement of most sex-age groups of the American population (Pao, 1981). On the caloric basis, vegetable products provided approximately 90% of the world's food supply (Salunkhe and Desai, 1988). Another important dietary nutrient contributed by vegetables is dietary fiber, the plant material that is resistant to hydrolysis by the enzymes of the mammalian digestive tract. Epidermiological studies show a strong relationship among chronic bowel diseases, a common problem in the Western and other developed countries, caused by insufficient fiber in the diet (Schneeman, 1986). An epidermiological study on the vegetarian diet showed that vegetarians have lower blood pressure and low density lipoprotein cholesterol levels and exhibited a reduced risk of coronary heart disease compared to individuals who are omnivores (Rouse, 1987).

3. United States Recommended Daily Allowance for Dietary Nutrients.

There is an increasing realization among consumers in the United States that the most apparent causes of death and disability in the United States, including cancers, diabetes, liver and lung diseases, can be prevented or reduced by changing one's daily habits, including diet, exercise, and other lifestyle practices (Nestle, 1988). In this respect, Dietary Guidelines for Americans included recommendations for the consumer to eat a variety of foods, to eat foods with adequate starch and fiber, and to avoid too much fat, saturated fat, cholesterol, sugar, salt, and alcohol (Nestle, 1988). Consumption of vegetables can contribute in large measure toward fulfilling these recommendations.

In order to provide a balanced diet and to reduce the risk of consuming an excessive amount of nutrients, the United States Recommended Daily Allowance (USRDA) was established for the vitamins and minerals as follows (FDA, 1987):

Protein (plants)	65	g
Vitamin A	5000	International Unit (I.U.)
Vitamin C	60	mg
Thiamine	1.5	mg
Riboflavin	1.7	mg
Niacin	20	mg
Calcium	1	g
Iron	18	mg
Vitamin D	400	I.U.
Vitamin E	30	I.U.
Vitamin B6	2	mg
Folic Acid	0	mg
Vitamin B12	6	mcg
Phosphorus	1	g
Iodine	150	mcg
Magnesium	400	mg
Zinc	15	mg

Copper	2	mg
Biotin	0.3	mg
Panthothenic Acid	10	mg

C. Development of Vegetable Snacks.

1. Product Design.

Today, many new snack foods are entering the market place either in the ready-to-eat form or the frozen form which requires reheating prior to consumption. Previously, manufacturers had seen the positive prospects of snack foods, especially health snack foods, on future markets. One such product that is gaining wide acceptance and increasing interest by food manufacturers is vegetable based products (Anon., 1986a). The manufacturer also must be aware that such demands for vegetable products by consumers are gradually moving towards the more sophisticated items and those with a specific difference (Anon., 1986a). To meet these demands, many factors must be followed and practiced by the manufacturer in order for the product to become successfull in the market place.

Horton (1979) listed four factors which determine suitability of products in a new product design. These include the following.

1. The product must be viewed by the consumer as representing high quality and sufficient quantity.
2. The product must complement the intended menu segment, i.e. appetizers, platters, dinners, and sandwiches.
3. The selling price must be within the range set for the menu segment.
4. The preparation must be practical.

With people tending to eat small amounts of food throughout the day, the new snack foods with suitable size for this purpose will be in great demand (Anon., 1985a, 1986a). According to Jones and Hutchinson (1984), shape of the product is not so important in the United States because consumers apparently will accept the unexpected, even though the product shape and contour may bear little or no relationship to the basic food materials. The authors stated that in the international markets novelty and quality of the snack foods are gaining in popularity. This trend must be considered in developing any new snack food product.

2. Marketing Aspects

a). Frozen Foods - Sales of frozen foods for 1985 increased by 5.5 percent, outselling all other food categories. Przybyla (1987) provided statistics on frozen food products and dishes which contributed to the $4,550 million in sales for 1986. With such a figure, the frozen food department in the supermarket has become one of the most profitable departments.

Three types of frozen foods, based on use by the consumer, are available in the supermarket today; the categories include foods that are intended for a) eating while frozen, b) thawing and serving, and c) heating and serving. Of these types, the entree tailored vegetables have become a fast growing item. Such growth phenomenon is due, in part, to the increased demand for convenience of product preparation.

b). Convenience Prepared Food - More and more people are placing increased emphasis on convenience regarding the use of prepared foods. This emphasis may be the result of the increasing number of one and two member households and to the modern consumer's lifestyle (Anon., 1987b). The shortcut method for preparing convenience prepared foods, as seen by the consumer, is by the use of the microwave oven for heating. Today, more than one-half of the homes in the United States have microwave ovens (Anon., 1986a). Thus, it is not surprising that many food companies are gearing up their research and developmental resources for producing prepared foods that can be heated by the microwave oven. Today, over 25% of all frozen food items in the market requiring some form of heat preparation may be prepared in the microwave oven (Anon., 1987b).

c). Health and Older Age Groups - Americans are becoming more concerned about their diet and health (Anon., 1987a). This concern will boost the health and diet oriented food market. One study predicted the market for the health and diet oriented food products will grow at the average annual rate of seven percent, reaching $3.3 billion by 1990 (Anon., 1987b).

Older people as a group comprise another segment of the population that represents a potential market for convenience snack foods, especially of fruit and vegetable bases. Pao (1981) reported a survey in 1977 that showed consumers over 50 years of age had increased their intake of fruit and vegetables.

D. General Aspect of Baked, Breaded Vegetable Products.

1. Mixed Ingredients.

Developing any new product with more than one ingredient requires considerable research to determine the proportion of each ingredient to be used in the mixture. It is impossible to vary one ingredient while holding all other components at a constant level. When the amount of one component is altered, the percentage of the other components will be altered also since the total sum of all the components is always 100% (Hare, 1974).

Variations in the nutrient content of raw or fresh vegetables are due to many factors such as generic variation, climatic conditions, and maturity at harvest (Anon., 1974, 1984). These variations may be so extreme that it will effect the final expected calculated nutrient content of the finished product. In other words, the quality of the final product is dependent on the quality of the raw materials (Anon., 1984). Additionally, choosing the correct processing method or appropriate combination of unit operations is important. It is difficult to optimize within each unit operation because nutrients may show a unique degradation rate (Lund, 1979).

2. <u>Blanching and Freezing.</u>

The term "blanching" was originally used to designate the heat treatment operation in the processing of certain foods for frozen storage (Williams et al., 1986). Reportedly, the blanching of vegetables prior to drying was practiced in England as early as 1780 (Poulsen, 1986). The most common method of blanching consists of a mild heat treatment produced by exposing the vegetables to hot water or steam at 60 to 100^{0}C for several minutes. The loss of peroxidase activity in the vegetables is used widely as an index of adequate blanching (Muftugil, 1985).

After being blanched, vegetables may be frozen and stored. Various types of freezing units are available on the market. For individually quick frozen purposes, liquid nitrogen or carbon dioxide freezers may be used. Freezing and thawing the food products often results in changes such as loss of protein solubility and water-holding capacity (Lind and Huthen, 1986). Nutrients may be lost in the liquid that drips from the frozen, thawed product, but the freezing process does not result in significant destruction of vitamins, except vitamin E (Anon., 1974). Lind and Huthen (1986) reported that cooked foods maintain quality more so after freezing and thawing than raw foods.

3. Molding.

When the vegetable mixture is frozen at 10 to -10^0F and pressed in a mold while frozen, a frozen block is formed and the vegetables retain their natural shape (Anon., 1985a; Bradley et al., 1986). Bradley et al. (1986) stated that the vegetable pieces became bound during the pressing operation. He reasoned that the ice crystals in the frozen pieces reacted with the ice crystals on the adjacent food pieces to cause them to weld together into an integral block.

The press used for this purpose must have the capability of exerting constant pressures in the range of 3,447 - 10,342 kPa (500 - 1500 Ibs/in^2) to ensure that the product will form an adequate bond (Anon., 1983, 1985a). At these pressures the vegetable pieces will not be crushed (Bradley et al., 1986).

4. Cutting.

The solidly frozen block of vegetables produced by pressing can be cut into pieces of any desired shape and size. Thickness of each slice must be greater than 3.175 mm (1/8 inch) in order to produce adequate binding (Anon., 1985a). Pieces cut from the frozen block immediately after it is taken from the mold must be prepared within 4 to 5 minutes to avoid falling apart (Bradley et al., 1986). The slice can be breaded, coated, or enveloped with dough before being cooked.

5. Cooking.

Today's consumer is becoming increasingly interested in consuming a low-fat diet or 'light diet' (Andres, 1987; Blendford, 1986a; Mancuso et al., 1971.) Heating with a hot air impingement oven is a relatively new procedure with potential for cooking foods as opposed to use of the deep-fryer which adds high levels of fat to the product. The hot air impingement oven transfers heat at a greater rate than the conventional oven because it forces the hot air onto the product. Another advantage of this type of oven is that it is equipped with variable speed and heat controls. A variable speed conveyer system facilitates movement of the product through the oven.

6. Reheating.

Hot snacks or any cook/chill food product must be reheated prior to being served. The two common procedures of reheating such foods are the use of conventional and microwave ovens.

Microwave ovens are becoming very popular among consumers because of their convenience to use and operate and the short time needed to heat the product. Reportedly, 12.4 million microwave ovens were shipped from the factories to retailers in 1986, up from 314,000 in 1972 and 3.6 million in 1982 (Anon., 1987b).

There are some limitations on the use of the microwave oven for heating. Ohlsson and Thorsell (1984) stated that microwaves penetrate most foods 10 to 15 mm. They also stated that microwaves do not heat uniformly those products of 25 to 30 mm or greater thickness.

Microwaves are electromagnetic waves. Heat is produced by dipole excitation and ion migration; friction energy is produced then as a result of the orientation of the dipoles in the alternating electromagnetic field. Therefore, electromagnetic energy is converted to thermal energy which produces heat in the food product (Roseberg and Bogl, 1987; Chung et al., 1981)

Conventional cooking involves surface absorption of thermal energy from external sources of radiation or conduction; this type of heating produces an uneven temperature throughout the product. Consequently, longer cooking time is required to develop a given temperature in the product as compared with microwave cooking (Chung et al., 1981).

E. Major Ingredients in Baked, Breaded Vegetable products.

1. Soybean.

Soybean protein has played an increasing role in human nutrition over the last two decades in both the developing and industrialized countries (Bressani, 1981; Torum et al., 1981). Torum et al. listed some of the major applications of soy protein products; examples include infant formulas, hypoallergeric foods, vegetable protein mixtures, protein supplements, bakery products, traditional food items, snacks, food analogs, replacers and extruders for use in products such as dairy, processed fish, and meat products, and a variety of formulated or fabricated food products.

There are some limitations on the use of soybean in human foods. In terms of essential amino acid requirements soy protein is limited in the sulfur amino acid content. One of the major limiting factors in using soybean in the human diet is the development of flatulence (Liener, 1981).

2. Yeast and Yeast Preparations.

Yeasts are unicellular fungi that reproduce by budding and fission (Rij, 1987). Yeast and yeast derivatives are frequently added to processed foods as a means of boosting the food's protein and vitamin contents or refining the flavor (Anon., 1987d). Fungal protein as an ingredient in the food improves the amino acid balance of the human diet. Brewer's dried yeast has approximately 48 % protein and 9 % ash (Anon., 1987e).

For use in foods the processing parameters during the growth of the yeast must be modified slightly to meet the specific requirements of different foods. For example, inactive brewers' yeast, after centrifugal separation, is concentrated to 10 - 15 % of its original volume and must be followed by pasteurization (Anon., 1987e). Yeast production is growing at a steady rate. For example, baker's yeast (Saccharomyces cerevisiae) is produced at the rate of over 1.8 million tons (at 30% solids) annually (Anon., 1987e).

By using yeast as one of the ingredients, a food product may be perceived as wholesome or all-natural (Anon., 1987d). This attitude toward a food product will serve indirectly as a major marketing tool in boosting sales of the product.

3. Frozen Pastry Dough.

There are many types of frozen doughs available on the market for different purposes and functions. One type of dough useful for overwrapping other food items for cooking is available to serve as a "shell" to enclose the items. This type of dough is referred to as freeze pastry dough. When this product is packaged in a container under vacuum, the dough will keep without spoilage for up to three months in the freezer (Anon., 1985b). This practice is important in order to maintain the cohesiveness and viscoelasticity of the dough.

The strong cohesive and viscoelastic properties are the result of the properties of the gluten protein of the wheat flour. The properties are manifested when the gluten is mixed and kneaded in the presence of water (Cheftel and Cuq, 1985).

CHAPTER III

MATERIAL AND METHODS

A. Choosing the Vegetables.

A computer program using Fortran language was developed to select the vegetables for this experiment (Appendix 1). Input into the program consisted of the arrays of eight nutrient densities for twenty vegetables (USDA, 1984). The outline of the program is shown in Figure 1.

The Fortran program developed was used to "read" the arrays of the nutrient densities for all the vegetables. Then, it choose at random sets of four vegetables. After choosing all possible sets of four vegetables, the program assigned individual weights to each vegetable in the set. The weight assigned began at 5 g and was increased by increments of 5 g until a total weight of the set reached 100 g. Based on the weight assigned, the percentage of the United States Recommended Daily Allowance (USRDA) for the eight nutrients (listed in objective 1) was calculated. This calculation was accomplished by dividing the weight of the individual nutrients in the set by the amount shown in the USRDA. Then the program incorporated the nutrient density of 1% yeast (based on the weight of the vegetables in the set). The last calculation to be completed by the program added 75% of the total nutrient density from the vegetables and yeast to 25% of the nutrient density of the dough used. The nutrient composition of the yeast preparation was provided by the manufacturer; nutrient composition of the dough was taken from the label of the container in which the dough was packaged. All the fixed variables used in this calculation are shown in the Appendices 2 and 3.

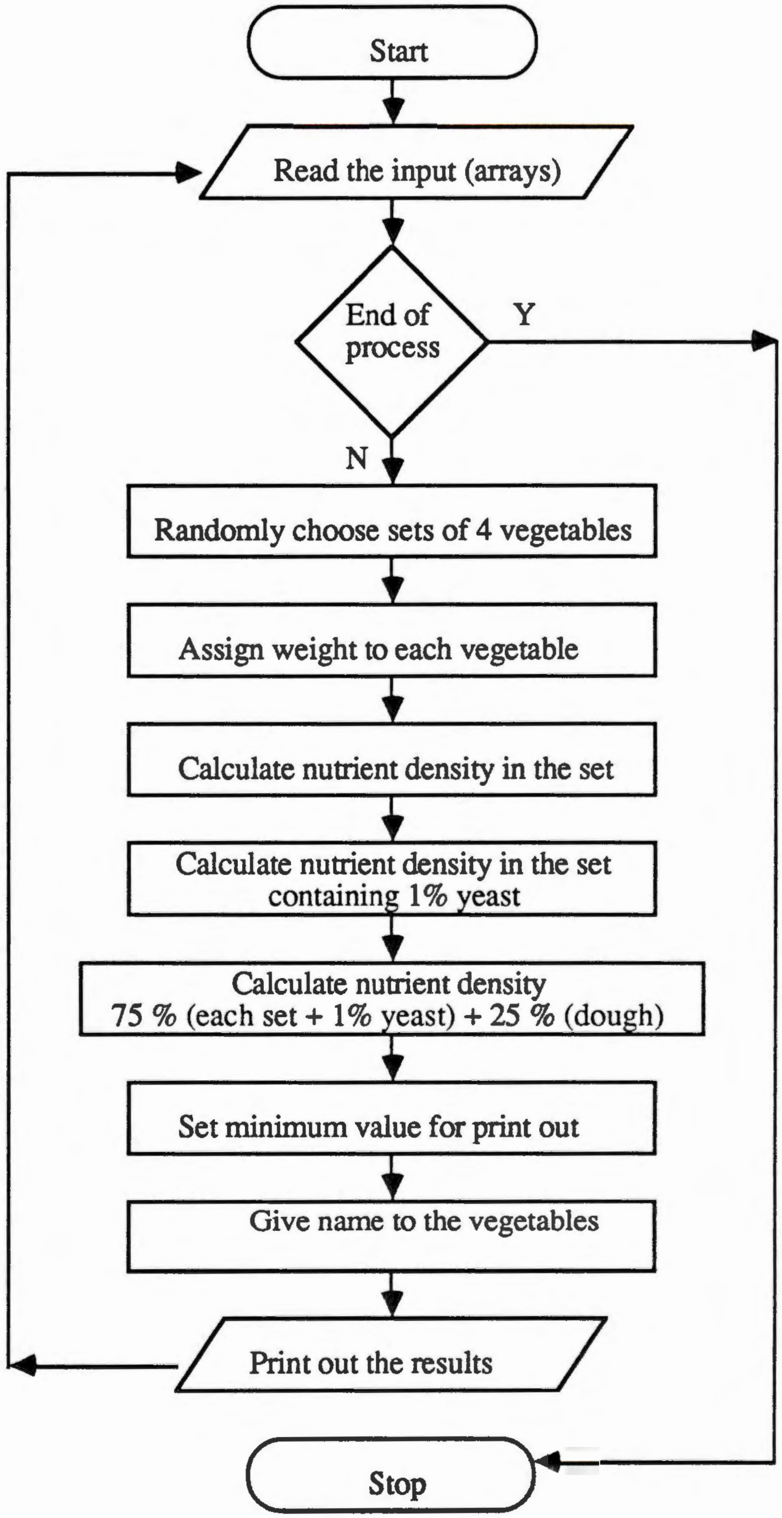

FIGURE 1. Flow Chart of the Fortran Program Used to Select the Vegetables.

Before the program could assign the name for the respective vegetables in a set, the program set the minimum value of the nutrient. For consideration as an acceptable product for this study, the minimum USRDA for the final product was established at 10% for each of the nutrients under consideration.

The output of the program provided the names of the four vegetables in the set with their respective assigned weights. This information was followed by the name of the nutrients and their respective percentage based on the USRDA.

B. Source of the Vegetables and Other Ingredients.

1). Soybean.

Mature, green soybeans were used as the major source of protein. The beans were obtained from the Plant Science Field Laboratory, The University of Tennessee, Knoxville. The beans were grown in 1987 by personnel of the Plant & Soil Science Department.

2). Other Vegetables.

Whenever possible, prepared, frozen vegetables were purchased from the local market. Raw, unprocessed vegetables, if needed, were purchased and prepared as frozen vegetables (Poulsen, 1986; Williams et al., 1986).

3). Yeast.

The yeast ingredient, marketed as Amberex E. P. 695 and supplied by Universal Foods Corporation (Fermentation Division), Milwaukee, WI, consisted of a spray dried sample of brewer's yeast. Prior to being dried, the material was hydrolyzed by the autolytic action of yeast proteases. The protein content was water soluble. The material consisted of a fine powder of medium brown color. The composition of the yeast preparation is shown in Appendix 3.

4). Dough.

A commercial frozen dough was purchased from the local grocery store. The dough was marketed as "Pastry Pockets" and supplied by The Pillsbury Company, Minneapolis, MN. There were four pastry pockets or dough pieces in each container. The dough was held under refrigeration in the original container until used.

C. Preparation of the Product Prototype.

1). Preparation of the Vegetables.

a). Soybean. - The soybeans were harvested by hand at the mature, green stage. The pods were placed into a pressure cooker and held at 103.5 kPa (15 lb/in^2) for 15 minutes to tenderize the beans. One liter of water was added to the cooker for each kilogram weight of beans. After being heated, the beans were easily separated from the pod by hand. The beans were cooled, frozen, and held frozen until used.

b). Other Vegetables. - Processed, frozen corn and lima beans were purchased from a local grocery store and held frozen until used. The products were packaged in a retailer size container. Carrots, sweet potatoes, and mushrooms were bought in the raw, unprocessed form. Carrots and sweet potatoes were peeled and cut into pieces of approximately 0.5 cm x 0.5 cm cubes using a manually operated dicer, and the pieces were blanched in steam for 3 minutes. Mushrooms were cut into pieces 0.3 cm thick with a Hobart slicer, model 84142. The pieces were blanched in steam by the procedure used for carrot and sweet potato. After blanching and cooling, the vegetables were frozen individually in a carbon dioxide (CO_2) freezer and stored at -17^{0}C to -20^{0}C until used.

2). Preparation of the Vegetable Block.

The vegetable mixtures consisted of the amounts of vegetables determined by the computer program. The vegetable pieces were combined and mixed in a plastic bag to obtain a uniform composition. Following the mixing, the vegetable mixture was spread onto waxed paper and sprinkled with a yeast preparation (Brewer's yeast extract, spray dried). The mixture was placed in a plastic bag, returned to freezer and held for use at a later time.

The vegetable mixture was molded into a cylindrical form by filling a stainless cylinder of 76 mm diameter (Figure 2a) with approximately 200 g of the mixed, frozen vegetables and compressing the mixture at 6,895 kPa (1000 lbs/in^2) for 30 seconds with a Carver press, model C (Fred S. Carver Inc., Menomonee Falls, WI) (Figure 2b). The frozen block of vegetables was removed from the cylinder and cut across the diameter of the cylinder with a hacksaw to yield slices of 37.5 g (about 13 mm thick). The schematic chart for the product prototype development is presented in Figure 3.

3). Dough Applied to the Vegetable Piece.

A commercially prepared frozen dough was purchased for use as a coating material for the vegetable pieces. The thawed dough was rolled to about 1.6 mm thickness and covered with a moist towel and waxed paper to retain moistness during holding. The dough was cut with a circular biscuit cutter into pieces of such dimensions that two pieces were used to form an "envelope" over the frozen vegetable piece. The cut dough pieces were applied manually to cover both sides of the vegetable piece. Pressure was applied along the edge of the dough pieces to fuse the pieces together. The product resembled a biscuit at this point. Holes were punched into the dough with a fork to allow water vapor to escape when the product was heated later.

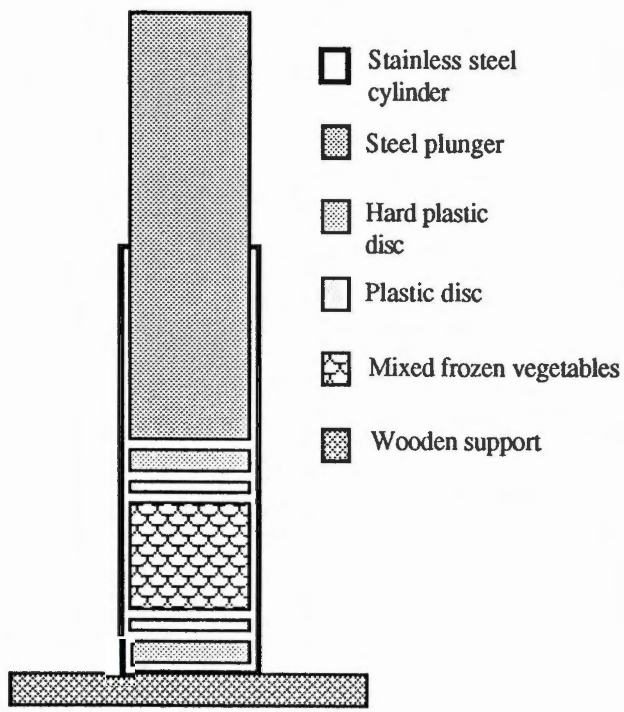

FIGURE 2a. Mold for compressing the mixture of frozen vegetables

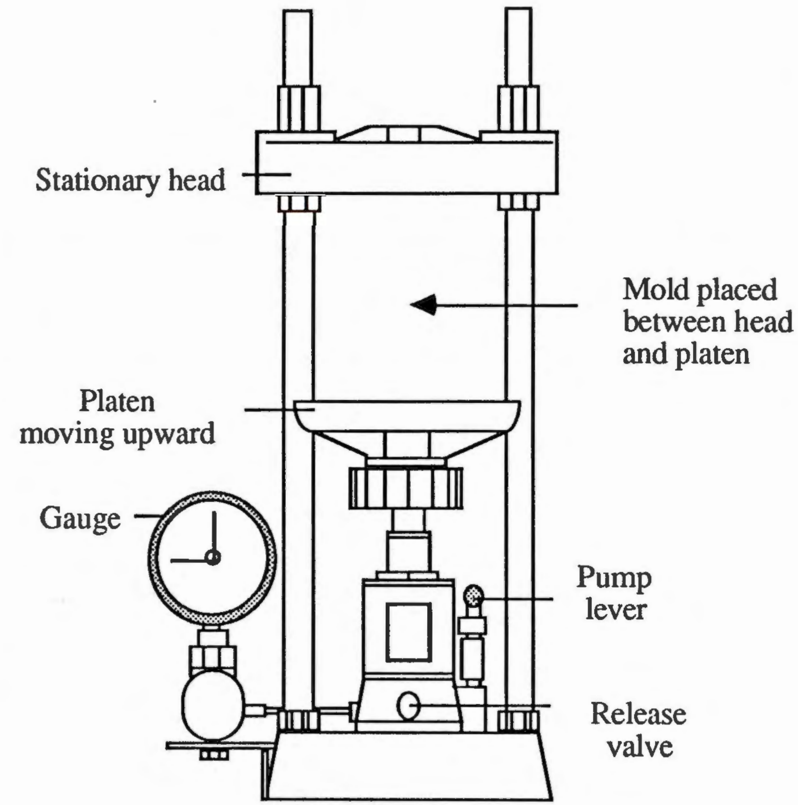

FIGURE 2b. Carver Laboratory Press used to compress the vegetables

FIGURE 2. Instruments Used for Making a Cylindrical Block of Mixed, Frozen Vegetables

Individually frozen vegetables

↓

Mixed

↓

Sprinkled with dried yeast

↓

Refrozen

↓

Molded into a cylinder

↓

Refrozen

↓

Cut into slices

↓

Coated with thin dough pieces

↓

Cooked

↓

Frozen and held

↓

Reheated before being consumed

FIGURE 3. Processing Steps Used to Prepare a Vegetable Item Consisting of a Mixture of Four Vegetables, Yeast Preparation, and a Dough Coating

4). Cooking

a) Preliminary Study (ranking test) - Based on the cooking time suggested by the label from the package of dough four cooking times (10, 11, 12, and 13 minutes) were selected to cook the product. The hot air oven temperature was set at 375^0F. Three replicates of each temperature were carried out.

Out of these four times, cooking time of 11 and 12 minutes were selected for further color sensory evaluation. The selection was made based on the color and appearance of the cooked dough and the appearance and texture of the vegetables.

The samples for the color sensory measurement were cooked at the same temperature (375^0F) but at two different times, 11 and 12 minutes, respectively, using the impingement oven and were kept frozen until used. Before the samples were displayed for the color sensory measurement the samples were reheated using a microwave oven or convection oven. The reheating time and temperature for the conventional oven was 15 minutes and 400^0C, respectively. Heating time of 4.5 minutes was used in the microwave reheating process.

Six sensory booths were used and in each booth one sample of each treatment was displayed. Each panelist was asked to rank the samples in one booth and then move to the next booth to continue the ranking process. Seventy-three panelists ranked the samples. The panel data were analyzed by the rank sum procedure in which critical difference values were calculated and used to determine significant differences among the samples (Basker, 1988).

b) Cooking Method - From the preliminary study, a cooking time of 11 minutes was established. A hot air impingement oven was used to cook the product. The temperature of the oven was set at 375^0C as suggested by the label from the package of dough.

Additional samples were deep-fried to allow for comparison of the fat content between samples cooked by the two methods. The time and temperature used were selected according to the normal practice for deep-frying products of similar size. The temperature and time of frying were 375^0C and 3 minutes, respectively.

5). <u>Freezing.</u>

The cooked samples were placed on wire trays and allowed to cool to room temperature. Samples were wrapped in plastic bags in groups of 6 and frozen and held at -17^0C until used.

6). <u>Reheating Method.</u>

Before evaluation, the frozen samples were reheated to approximately 60^0C, a temperature suitable for eating (Sawyer et al., 1982; Sawyer and Neidu, 1984). A domestic conventional oven and a microwave oven (2450 MHz; 720 W) were used for reheating the product. Temperature and time for reheating with the conventional oven were 400^0C and 15 minutes, respectively. The oven was loaded with 20 samples during the period of heating. A time of 4.5 minutes was used for the microwave reheating process. The microwave oven was loaded with 10 samples during the period of heating.

D. <u>Proximate Analyses.</u>

Samples of finished, ready-to-consume product from each treatment were analyzed for the components presented below. Three replications of each treatment were prepared and two analyses were made on samples from each replicate.

Analytical samples were prepared by freeze-drying the whole product piece in a Virtis Freeze-dryer (model FFp-15W5) overnight. The amount of moisture lost during freeze drying was determined. The dried material was ground in a pulverizing mill for 30 seconds and placed in a plastic bag over a desiccant until analyzed. The analyses made on the samples are presented below:

1). Moisture.

Moisture content of the freeze-dried product was determined by the AOAC Vacuum Oven Method (AOAC, 1984). Duplicate samples of two grams were dried to constant weight at 70^0C overnight at a vacuum of 163 torr. Percentage of moisture was calculated.

The moisture content of the samples on the eating basis was also determined. The whole samples were frozen inside liquid nitrogen, ground with a blender, and dried to a constant weight at 70^0C overnight at a vacuum of 163 torr. Percentage of moisture was calculated.

2). Crude Fat.

Samples of oven-dried material were extracted for 16 hours with petroleum ether in a Goldfisch Apparatus according to the AOAC (1984) procedure. Percentage of crude fat was calculated on dry weight basis.

3). Crude Protein.

Total nitrogen was determined by a modification of the Kjeldahl method (AOAC, 1984). Two grams of freeze-dried samples were analyzed in duplicate for total nitrogen content. Percentage of crude protein was calculated (% N x 6.25) on dry weight basis.

4). Ash.

The percentage of ash was determined according to AOAC (1984) procedure. Two grams of samples were ashed in a muffle furnance at 525^{0}C until the sample reached constant weight. Percentage of ash was calculated on the dry weight basis.

5). Dietary Fiber.

Total dietary fiber was determined by an enzymatic - gravimetric method (Alstin, 1985; Prosky et al., 1985), using the Fibertec System, module E (Tecator Co., Hoganas, Sweden).

6). Carbohydrates.

Percentage of carbohydrate was calculated by subtracting the percentages of crude fat , crude protein, ash, and dietary fiber from 100%.

E. Physical Analyses.

1). Caloric Value.

The gross energy value of the sample was determined with the Parr Adiabatic Oxygen Bomb Calorimeter (Model 124) (Anonymous, 1960). Approximately 0.7 g of the freeze-dried sample was tested, and the energy was reported as kilo joules (kJoules) per 100 g of sample on dry weight basis. Three replications of each treatment were prepared and two analyses were made on samples from each replicate.

Caloric values of the samples were determined also by the Atwater method. The percentages of protein, fat, carbohydrate were multiplied by the factor of 4, 9, and 4, respectively. The sum of these products equals the calculated caloric value (Watt and Merrill, 1963).

2). Color.

Color was measured on the surface areas (crust) of the samples with the Hunter Colormeter (Model D25 D2M). L, "a," and "b" values were recorded The meter was standardized against a white tile (Hunter C2 136). The sample was placed in a cuvette with an optical glass bottom for measurement and two readings were recorded.

3). Firmness.

The Instron Food Testing Machine (model 1132) was used to measure the force required to shear the sample. The whole sample was held in a Kramer shear compression cell for measurement. The firmer the sample, the greater the force required. The 50 kg capacity load cell was used with crosshead and chart speeds set at 20 cm per min. Three replications and two duplicates of each replicate were prepared and measured. Firmness was determined by two procedures and reported as total work-force (cm^2) as determined by measuring the area under the integrator curve with a planimeter and as maximum force (kg) to produce the peak of the curve.

F. Hedonic Evaluation

Four treatments were selected for hedonic evaluation (2 x 2; reheating x matrix). Evaluation was performed in the sensory evaluation laboratory. Sessions were held between 10:00 am and 12:00 noon in a laboratory equipped for sensory testing with individual judges seated in lighted (cool, white light) booths (IFT, 1981). Members of the panel consisted of faculty, staff, and students of the Institute of Agriculture, The University of Tennessee. An 8-point hedonic scale (1 for dislike extremely; 8 for like extremely) was used to evaluate the samples for the color of the vegetables, overall texture, moistness of crust, flavor, and overall acceptability (Larmond, 1977).

Samples evaluated were cut vertically into half sections and placed on warming trays. The panelists were served with cut samples at approximately 60^0C. Samples coded with 3-digits numbers and placed on a white plastic plate was delivered to the panelist one at a time. No instructions were given to the panelists regarding the order of sample evaluated. Thirty-seven panelists evaluated the samples. The scorecard of the evaluation is shown in Appendix 4.

G. Experimental Design and Analysis of Data.

Data from the ranking test in the preliminary study were analyzed and presented by the critical values of differences among rank sums (Baker, 1988).

Data for the percentage moisture, fat, ash, dietary fiber, protein and carbohydrate contents, gross energy , color, and firmness were analyzed by analysis of variance as a factorial of a completely randomized block (2 x 2 x 3; vegetable matrix x reheating method x replication) (Steel and Torrie, 1980).

The data from the hedonic evaluations were analyzed by analysis of variance as a factorial of completely randomized block (2 x 2 x 37; vegetable matrix x reheating method x panelists).

Student - Newman - Keul's multiple range test (Steel and Torrie, 1980) at the 0.05 and 0.01 probability levels was used to determine significance among the means in all the experiments . All the data were analyzed using the Statistical Analysis System (SAS, 1985) and computing was conducted at The University of Tennessee Computing Center.

CHAPTER IV

RESULTS AND DISCUSSION

A. Program Output.

From all the sets printed out in the program output, two sets of the vegetable matrix were chosen for this study. The selection was based on the variability of vegetable colors, the price of the vegetables, and the availability of the vegetables in the market. The minimum level of each nutrient was established to be at least 10 % of the USRDA. The sets and the nutrient density of each set are shown in Table 1.

B. Crust Color Evaluation.

Table 2 presents the rank sums of the sensory panel evaluations of the four treatments and the critical differences between the sum scores at both the 0.05 and 0.01 levels of significance. At the 0.01 of probability treatment C was preferred over treatments A and D among which no differences were found. At the 0.05 level of probability treatment C was preferred over all the other treatments among which no differences were found. For all practical purposes, treatment C, cooked 11 minutes in the impingement oven and reheated later in a conventional oven, was preferred for crust color.

TABLE 1. Vegetable Matrices Used and Their Respective Nutrient Composition.

	Matrix One	Matrix Two
Vegetables	Weight (gm)	
Soybean	55	50
Mushroom	30	35
Sweet Corn	10	-
Carrot	5	-
Sweet Potato	-	10
Lima Bean	-	5
Nutrients	% USRDA*	
Protein	10.51	10.09
Vitamin A value	14.94	25.91
Ascorbic Acid	13.69	13.88
Thiamine	11.18	10.80
Riboflavin	10.15	10.43
Niacin	10.18	10.57
Calcium	62.36	59.62
Iron	10.12	10.38

*% USRDA for the product before cooking

TABLE 2. Rank Sums[1] and Critical Differences for Multiple Comparisons of Scores for Crust Color Scores by a Sensory Panel for the Baked, Breaded Vegetable Product.

Rank Sums

Treatment[2]		A	B	C	D
Rank Sum[3]		120	109	76.6	129.3
Difference vs	A		11	43.3	9.3
	B			32.4	20.3
	C				52.7

Critical Differences

Significance Level		P = 0.05	P = 0.01
Critical Difference		30.8	37.7
Treatment[2]	C	a	a
	B	b	ab
	A	b	b
	D	b	b

[1]Rank sum of 43 panelists.
[2]Treatment: A = 12 minutes cooking; reheated by conventional oven
B = 12 minutes cooking; reheated by microwave oven
C = 11 minutes cooking; reheating by conventional oven
D = 11 minutes cooking; reheated by microwave oven.
[3]The lower the sum, the more preferred the color.
[ab]Treatments followed by the same lower case letter under the critical difference values of 0.05 and 0.01 levels of probability are not different within the respective level.

C. Crude Fat Content of Products Cooked by Hot Air and by Deep-frying.

Table 3 presents the F-ratios of the analysis of variance (ANOVA) for the crude fat content of the cooked, baked, breaded vegetable products as a function of vegetable matrix and cooking method: hot air impingement and deep-fry. The crude fat percentage of the final product was affected by the mixture of vegetables (0.05 level) and the cooking method (0.01 level). The interaction between these two factors also affected (0.01 level) the fat content.

The mean crude fat percentages (dry weight basis) of the samples as affected by matrix composition and cooking method are presented in Table 4. The sample composed of matrix 1 had 5.9% less fat (0.05 level) than the sample composed of matrix 2. This finding is in opposition to the finding in the proximate analysis study. There, the fat content of the samples composed of matrix 1 had 14.9% more fat than samples composed of matrix 2. Matrix 1 consisted of 5% more soybean, a rich source of fat, than matrix 2. Therefore, the difference found in Table 4 suggests that the deep-fried sample of matrix 2 absorbed a greater proportional amount of fat than samples of matrix 1.

Samples that were cooked in the impingement oven contained 44.0% less fat (dry weight basis) than samples cooked in the deep-fryer. The deep-fried samples consisted of approximately one-third fat, while the samples cooked by hot air consisted of approximately one-fifth fat. It is apparent that the hot air method of cooking should be preferred over deep-frying to minimize the percentage of fat, and, consequently, keep the caloric content at the lowest level possible.

The means for the interaction of matrix and cooking method are presented in Table 5. Samples of matrix 1 had 15.2% more fat than samples of matrix 2 when cooked by hot air. Conversely, deep-fried samples of matrix 1 contained less fat than samples of matrix 2. It is apparent that the vegetable mixture of matrix 2 influenced the absorption of

TABLE 3. F-Values from the Analysis of Variance for Crude Fat Content of the Baked, Breaded Vegetable Products.

Source	D.F.	Crude Fat
		F-Ratios
A. Matrix	1	6.66*
B. Cooking Method	1	576.79**
A x B	1	47.58**
Replication	2	0.01ns
		Mean Square
Residual Error	6	1.229

*Significant at 0.05 level.
**Significant at 0.01 level.
nsNot significant at the 0.05 level.

TABLE 4. Mean[1] Crude Fat Content of the Baked, Breaded Vegetable Product as Affected by Matrix and Cooking Methods.

Factor	Crude Fat, % [2]
<u>Matrix</u>[3]	
1	26.45[b]
2	28.11[a]
<u>Cooking Methods</u>	
Impingement Oven	19.60[y]
Deep-Fryer	34.97[x]

[1]Means of 6 measurements.
[2]Calculated on a dry weight basis.
[3]See Table 1 for matrix composition.
[ab]Means are significantly different at 0.05 level.
[xy]Means are significantly different at 0.01 level.

TABLE 5. Mean[1] Crude Fat Content of the Baked, Breaded Vegetable Product as Affected by the Matrix x Cooking Method Interaction.

	Cooking Methods	
Matrix[2]	Impingement Oven	Deep-Fryer
1	20.98[c]	31.93[b]
2	18.21[c]	38.00[a]

[1]Means of 3 measurements.

[2]See page 29 for matrix composition.

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

a greater amount of fat than the vegetable mixture of matrix 1 of the deep-fried samples, those of matrix 1 contained 16% less fat than samples of matrix 2.

D. Proximate Composition of the Baked, Breaded Vegetable Product.

Table 6 presents the F-values for the ANOVA of the proximate composition of the baked, breaded vegetable product as a function of vegetable matrix and reheating method. The vegetable matrix had an effect (0.05 level) on the crude fat and ash contents, but heating method had no effect.

The means for proximate analysis of the baked, breaded vegetable as affected by the matrix composition and reheating methods are presented in Table 7. The mean percentage crude fat in samples of matrix 1 was 14.8 % higher than that of samples of matrix 2. Since soybean was the major vegetable in the product, the differences in the crude fat content between the two groups of samples may be due to differences in the percentage of the soybean used. Samples of matrix 1 had 5 % more soybean than samples of matrix 2. According to Bressani (1981), typical whole soybean contains about 20.0 % fat (dry weight basis). The higher mean percentage ash in samples of matrix 2 is probably due to the higher percentage of mushroom in matrix 2. Samples of matrix 2 contained 5 % more mushroom than samples of matrix 1. Mushroom has 11.1 % ash while soybean has 5.1 % ash (dry weight basis) (USDA, 1984).

E. Caloric Value.

The F-values of the ANOVA for the gross energy content of the samples as determined by the calculated and Bomb Calorimeter methods are shown in Table 8.

TABLE 6. F-Values from the Analysis of Variance for Proximate Composition of the Baked, Breaded Vegetable Product.

Source	D.F.	Moisture	Crude Protein	Crude Fat	Ash	Dietary Fiber	Carbohydrate
				F-Ratios			
A. Matrix	1	0.39^{ns}	2.36^{ns}	11.44^{*}	5.99^{*}	0.06^{ns}	3.71^{ns}
B. Reheating Methods	1	0.09^{ns}	0.39^{ns}	0.14^{ns}	0.04^{ns}	3.01^{ns}	0.95^{ns}
C. Replication	2	0.77^{ns}	0.44^{ns}	2.33^{ns}	0.04^{ns}	0.04^{ns}	0.24^{ns}
				Mean Squares			
Residual Error	7	20.074	2.030	1.932	0.015	1.042	10.807

*Significant at 0.05 level.

^{ns}Not significant at the 0.05 level.

TABLE 7. Mean[1] Proximate Composition of the Baked, Breaded Vegetable Product After Being Frozen and Reheated.

Factor	Moisture, %	Proximate Composition of Solids, % (dry matter basis)				
		Crude Protein	Crude Fat	Ash	Dietry Fiber	Carbohydrate
Matrix[2]						
1	58.0[a]	24.1[a]	20.9[a]	4.4[b]	8.5[a]	42.1[a]
2	56.3[a]	22.8[a]	18.2[b]	4.6[a]	8.7[a]	45.7[a]
Reheating Methods						
Microwave Oven	57.5[a]	23.2[a]	19.4[a]	4.5[a]	8.1[a]	44.8[a]
Conventional Oven	56.8[a]	23.7[a]	19.7[a]	4.5[a]	9.1[a]	43.0[a]

[1]Means of six measurements.

[2]See page 29 for matrix composition.

[ab]Means for a given factor within a column followed by different letters are significantly different at 0.05 level.

TABLE 8. F-Values from the Analysis of Variance for the Energy Content of the Baked, Breaded Vegetable Product Reheated in Conventional and Microwave Oven.

		Gross Energy		
		Calculated		
Source	D.F.	Dry Weight Basis	Eating Basis	Bomb Calorimeter
		F-Ratios		
A. Matrix	1	15.63**	0.02ns	0.43ns
B. Reheating Methods	1	0.60ns	0.08ns	1.14ns
C. Replication	2	2.52ns	0.48ns	0.83ns
		Mean Square		
Residual Error	7	0.722	0.747	2.546

**Significant at 0.01 level.

nsNot significant at the 0.05 level.

Neither the vegetable matrix nor the reheating methods had an effect on the gross energy content of the final product when determined by the Bomb Calorimeter method. When the gross energy content was determined by the calculation method, vegetable matrix had an effect on the gross energy content at 0.01 level.

Table 9 shows the means for the energy content of the samples. Samples of matrix 1 had a higher (0.01 level) energy content than samples of matrix 2 according to the calculated method. Since the calculated value depends on the three major components of the food, protein, fat, and carbohydrate, this method of determining caloric value reflects more closely the compositional differences between the samples (see Table 7). The samples of matrix 1 had the higher percentage of fat and the higher caloric content. When the caloric content of the samples was considered on the eating basis, there were no differences between samples of the two matrices or between samples reheated by the two methods. Differences in caloric content of samples of the two matrices was negated by the differences in moisture content of the respective samples. The Bomb Calorimeter method did not show a difference in caloric values between samples of the matrices, or between samples of the two reheating method.

F. Color Measurement of the Baked, Breaded Vegetable Product.

The F-values for the color measurements of the surface of the baked, breaded vegetable samples are shown in Table 10. Reheating methods had a significant effect (0.01 level) on the Hunter "b" values only, but matrix composition did not affect any aspect of color. There was a difference (0.01 level) between each of the color measurements of the two sides of the product.

Table 11 presents the means for the color values of samples as affected by matrix composition, reheating methods, and the side of the product measured. Samples reheated

TABLE 9. Mean[1] Gross Energy Content of the Baked, Breaded Vegetable Product After Being Frozen and Reheated.

Factor	Calculated: Dry weight basis	Calculated: Eating basis	Bomb Calorimeter[3]
	Caloric Values (kJoules/g)[2]		
Matrix[4]			
1	18.9[a]	7.99[a]	23.5[a]
2	18.3[b]	8.04[a]	22.9[a]
Reheating Methods			
Microwave Oven	18.7[a]	7.93[a]	23.7[a]
Conventional Oven	18.6[a]	8.07[a]	22.7[a]

[1]Means of three replications.

[2]To convert kJoules to Kcal, use the following equation: Kcal = kJoules/4.184.

[3]Values are reported on a 100% dry weight basis.

[4]See page 29 for matrix composition.

[ab]Means for a given factor and within a column followed by different letters are significantly different at 0.01 level.

TABLE 10. F-Values from the Analysis of Variance for Hunter Color Measurement of the Baked, Breaded Vegetable Product.

Source	D.F	L	"a"	"b"
			F-Value	
A. Matrix	1	1.61^{ns}	2.62^{ns}	0.01^{ns}
B. Reheating Methods	1	3.30^{ns}	2.93^{ns}	7.88^{**}
C. Side	1	49.77^{**}	20.10^{**}	19.50^{**}
D. Replication	3	0.19^{ns}	1.01^{ns}	0.76^{ns}
			Mean Square	
Residual Error	25	6.005	2.340	1.357

**Significant at 0.01 level.

^{ns}Not significant at the 0.05 level

TABLE 11. Mean[1] Hunter Color Values[2] of the Baked, Breaded Vegetable Product After Being Frozen and Reheated.

Factor	L	"a"	"b"
Matrix[3]			
1	47.26[a]	7.42[a]	19.52[a]
2	46.16[a]	8.29[a]	19.56[a]
Reheating Methods			
Microwave Oven	45.92[a]	7.39[a]	18.96[b]
Conventional Oven	47.50[a]	8.32[a]	20.12[a]
Side			
Top Side	49.77[a]	6.64[b]	20.45[a]
Bottom Side	43.66[b]	9.07[a]	18.63[b]

[1]Mean of sixteen measurements.

[2]L = luminosity, 0 = black, 100 = pure white; "a" = redness; "b" = yellowness; the higher the value of "a" or "b" the more intense the color.

[3]See page 29 for matrix composition.

[ab]Means for a given factor within a column followed by different letters are significantly different at 0.01 level.

by the microwave oven were less yellow (lower "b" value) than samples reheated by the conventional oven. The difference in values, however, could not be detected with the eye. The top side of the product was lighter (higher L value) with less redness (lower "a" value) and more yellowness (higher "b" value) as compared to the bottom side of the product. The darker appearance on the bottom side of the product was visually evident immediately after the product was removed from the impingement oven. This difference may be due to the uneven distribution of the hot air in the impingement oven. Redness and yellowness between the top and bottom sides of the product were not visually evident.

G. Shear Stress of the Baked, Breaded Vegetable Product.

F-values of the ANOVA for force required to shear the product are shown in Table 12. The vegetable matrix composition had an effect (0.01 level) on total force area and maximum force value. Total force area was affected (0.01 level) by the methods of reheating, but maximum force was not affected. The matrix x reheat interaction was significant for both total force area (0.01 level) and maximum force (0.05 level) measurements.

Means for the shear measurements of samples of the baked, breaded vegetable product as affected by matrix composition and reheating methods are shown in Table 13. Both the maximum force and total force values for the product of matrix 1 were higher (0.01 level) than the force values for the product of matrix 2. These differences, it is believed, are due to the differences in the vegetable composition. Matrix 1 samples had 5% more soybean and 5% less mushroom than samples of matrix 2. Soybean is firmer than mushroom. Heating the samples in the conventional oven caused the product to

TABLE 12. F-Values from the Analysis of Variance for the Instron Shear Stress of the Baked, Breaded Vegetable Products.

Source	D.F.	Total Force	Maximum Force
		F-Ratios	
A. Matrix	1	33.64**	20.27**
B. Reheating Methods	1	23.45**	2.68ns
A x B	1	9.94**	7.44*
Replication	5	1.43ns	2.46ns
		Mean Square	
Residual Error	15	0.121	8.955

*Significant at 0.05 level.
**Significant at 0.01 level.
nsNot significant at the 0.05 level.

TABLE 13. Mean[1] Instron Shear Stress Measurements of the Baked, Breaded Vegetable Product After Being Frozen and Reheated.

	Instron Force	
	Total Force area, cm^2	Maximum Force, gm.
Matrix[3]		
1	4.95[a]	43.00[a]
2	4.13[b]	37.50[b]
Reheating Methods		
Microwave Oven	4.19[b]	39.25[a]
Conventional Oven	4.88[a]	41.25[a]

[1]Means of 12 measurements.

[3]See page 29 for matrix composition.

[ab]Means for a given factor within a column followed by the different letters are significantly different at 0.01 level.

exhibit a greater total force resistance, whereas the maximum force peak was not different between samples of the two reheating methods.

Table 14 presents the mean shear values for the baked, breaded vegetable product as affected by the matrix composition x reheating interaction. Samples of matrix 1 that were reheated by the conventional oven were higher in total force area (0.01 level) and maximum force (0.05 level) than samples of the three other treatments. Total force and maximum force were not different among the three other treatments. The higher values for the stated samples may be due to the higher percentage of soybean in samples of matrix 1. Also the reheating in the conventional oven tended to produce a more crispy crust as compared to the microwave oven.

H. Hedonic Evaluation

A summary of the ANOVA of panel scores for the hedonic evaluation of the baked, breaded vegetable product is shown in Table 15. The vegetable matrix and the reheating method did not affect (0.05 level) the panel scores of the five attributes evaluated. For all the attributes, however, panelist was significant (0.01 level) and vegetable color was affected by a matrix x reheat interaction (0.05 level).

Table 16 shows the mean panel scores for the hedonic evaluation of the samples as a function of the vegetable matrix and the reheating methods. Most sample attributes were evaluated as being between "liked slightly" and "liked moderately."

The mean panel scores for hedonic evaluation of the product as affected by the matrix x reheat interaction are shown in Table 17. There were differences (0.05 level) in the means only for vegetable color. When reheated by the conventional oven method, the product containing vegetables in matrix 2 received a higher (0.05 level) vegetable color score than the product containing vegetables in matrix 1. The vegetable color scores of

TABLE 14. Mean[1] Instron Shear Stress Measurements of the Baked, Breaded Vegetable Product as Affected by the Matrix x Reheat Interaction.

	Reheating Methods	
Matrix[3]	Microwave Oven	Conventional Oven
	Total Force area, cm^2	
1	4.38[d]	5.51[c]
2	4.01[d]	4.24[d]
	Maximum Force, gm.	
1	40.33[b]	45.67[a]
2	38.17[b]	36.83[b]

[1]Mean of six measurements.

[3]See page 29 for matrix composition.

[ab]Means followed by different letters are significantly different at 0.05 level.

[cd]Means followed by the different letters are significantly different at 0.01 level.

TABLE 15. F-Values from the Analysis of Variance for Hedonic Scores of the Sensory Panel for the Baked, Breaded Vegetable Product.

Source	D.F.	Vegetable Color	Moistness of Crust	Overall Texture	Flavor	Overall Acceptability
				F-Ratios		
A. Matrix	1	2.20^{ns}	0.14^{ns}	0.01^{ns}	0.07^{ns}	0.08^{ns}
B. Reheating Methods	1	0.24^{ns}	0.14^{ns}	2.42^{ns}	0.01^{ns}	0.73^{ns}
A x B	1	5.33^{*}	0.01^{ns}	0.33^{ns}	0.38^{ns}	3.97^{ns}
C. Panelists	36	4.97^{**}	3.80^{**}	3.74^{**}	6.99^{**}	8.44^{**}
				Mean Square		
Residual Error	108	0.993	1.203	1.009	0.869	0.752

*Significant at 0.05level.
**Significant at 0.01 level.
^{ns}Not significant at 0.05 level.

TABLE 16. Mean[1,2] Panel Scores for the Hedonic Evaluation of the Baked, Breaded Vegetable Product as Affected by the Vegetable Matrix and Reheating Methods.

Factor	Vegetable Color	Moistness of Crust	Overall Texture	Flavor	Overall Acceptability
Matrix[3]					
1	5.07[a]	5.50[a]	5.28[a]	5.03[a]	4.99[a]
2	5.31[a]	5.43[a]	5.27[a]	4.99[a]	5.03[a]
Reheating Methods					
Microwave Oven	5.15[a]	5.50[a]	5.40[a]	5.01[a]	5.07[a]
Conventional Oven	5.23[a]	5.43[a]	5.15[a]	5.00[a]	4.95[a]

[1]Scoring system: 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.

[2]Mean of 74 measurements.

[3]See page 29 for matrix composition.

[a]Means for a given factor within a column are not significantly different at 0.05 level.

TABLE 17. Mean[1,2] for Panel Scores for the Hedonic Evaluation of the Baked, Breaded Vegetable Product as Affected by the Vegetable Matrix x Reheat Interaction.

Matrix[3]	Reheating Methods	
	Microwave Oven	Conventional Oven
	Vegetable Color	
1	5.2[ab]	4.9[b]
2	5.1[ab]	5.5[a]
	Moistness of Crust	
1	5.5[a]	5.5[a]
2	5.5[a]	5.4[a]
	Overall Texture	
1	5.5[a]	5.1[a]
2	5.3[a]	5.2[a]
	Flavor	
1	5.1[a]	5.0[a]
2	5.0[a]	5.0[a]
	Overall Acceptability	
1	5.2[a]	4.8[a]
2	4.9[a]	5.1[a]

[1]See footnote in Table 18 for scoring system.

[2]Means of thirty-seven measurements.

[3]See page 29 for matrix composition.

[ab]Means of individual attributes followed by different letters are significantly different at the 0.05 level.

the products reheated by the microwave oven were not different between each other or from values of either product heated by the conventional oven. These results indicate that consumers might prefer the vegetable color of the product containing sweet potatoes and lima beans (matrix 2) compared to the product containing sweet corn and carrots (matrix 1) when they were reheated in a conventional oven.

CHAPTER V

SUMMARY AND CONCLUSIONS

The objectives of this study were to explore the potential for preparing a baked, breaded vegetable product with a defined minimum nutrient level, to evaluate the use of a hot air impingement oven to cook the product, and to determine the effect of the vegetable matrix and reheating methods on chemical, physical, and sensory attributes of the product.

A Fortran program was developed to select two vegetable matrices of four vegetables in each set. These vegetables were frozen, mixed with yeast, compressed in a mold, cut into thin slices and coated with a dough before being cooked in a hot air impingement oven. Two reheating methods, microwave oven and conventional oven, were used in this study.

From this study, the following conclusions can be made:

1). The proximate composition of the products differed in fat and ash contents only. The sample of matrix 1 contained 14.8 % more fat than the sample of matrix 2. The higher proportion of soybean in matrix 1 vegetables was probably responsible for the higher value for fat. The sample of matrix 2 contained a greater amount of ash than the sample of matrix 1. The higher proportion of mushroom in matrix 2 vegetables was probably responsible for the higher value for ash. The effect of composition on caloric content depended on the method of determination. According to the Atwater procedure, the mean caloric content of the sample from matrix 1 was 3.3 % higher (DWB). Cooked samples of the two matrices of vegetables did not differ in caloric content on fresh weight basis. No differences were found in caloric content for samples of the two vegetable matrices as determined by the bomb calorimeter method.

2). Color of the outer coating of the samples was not affected by the enclosed vegetable mixture. The Hunter "b" value (yellowness) was higher for samples reheated in the conventional oven. Luminosity and redness were not affected by reheating methods. The top and bottom sides of the products had different color values: the top side (as it passed through the hot air oven) had a higher luminosity (L value), lower redness ("a" value), and higher yellowness ("b" value).

3). Both measurements for shear stress (firmness) of the samples were affected by the vegetable composition. Values were higher for the samples of matrix 1. Total force (cm^2) was higher only for the samples that were reheated in the conventional oven.

4). Of the five attributes evaluated by the sensory panel, only color of the vegetables was found to differ among the treatments. Vegetable color was preferred for the sample of matrix 2 when reheated in the conventional oven. The sample of matrix 1 was preferred least when reheated in the conventional oven. Scores for samples of both matrices when reheated in the microwave oven were intermediate between the scores of the samples reheated in the conventional oven.

5). The mean percentage crude fat in the deep-fried samples was 44 % higher than the mean fat content of samples cooked in hot air. This condition leads to production of a fried product with a much higher caloric content as compared to product cooked in hot air.

6). In future research to improve the product, the following points should be considered:

a). A binding agent should be investigated as a binder of the individual vegetable pieces.

b). Add flavoring to the vegetable either by marinating the vegetables or by direct addition of flavoring ingredients.

c). determine the nutrient density of the vegetables used in the product instead of using general published values. Measure nutrient density of the cooked product to determine the effect of heating on rate of destruction of the nutrients during cooking/reheating.

d). Explore the use of a batter-breading coating for the product instead of a dough.

e). Investigate more fully the advantages of using a hot air impingement oven for cooking similar products instead of using a deep-fryer.

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APPENDICES

APPENDIX 1

Fortran Program

```
c               Program :   NUTRIVEGI
c               Date :      December 1987
c               Written by : Kamarudin bin Hasim
c                              Food Technology and Science Department,
c                              The University of Tennessee,
c                              Knoxville, Tennessee 37996.
c               Program Intent :
c                              This program is the part of the Master thesis project. The input to
c                              this program consist of the arrays of the nutrient values of 20
c                              vegetables.

c               Dictionary of constant and variables :
c                        a) The vegetables used in the program :
c                              1). Soybeans (green, cooked, boiled, drained).
c                              2). Spinach (frozen, cooked, boiled, drained).
c                              3). Carrots (frozen, cooked, boiled, drained).
c                              4). Brocolli (frozen, chopped, cooked, boiled, drained).
c                              5). Snap beans (frozen, cooked, boiled, drained).
c                              6). Asparagus (frozen, cooked, boiled, drained).
c                              7). Pinto beans (frozen, cooked, boiled, drained).
c                              8). Brussel sprouts (frozen, cooked, boiled, drained).
c                              9). Lima beans (frozen, cooked, boiled, drained).
c                              10). Green beats (cooked, boiled, drained).
c                              11). Broad beans (cooked, boiled, drained).
c                              12). Butterbur (cooked, boiled, drained).
c                              13). Cabbage (cooked, boiled, drained).
c                              14). Sweet corn (frozen, kernel, cut of cob, cooked, boiled, drained).
c                              15). Mushroom (cooked, boiled, drained).
c                              16). Okra (frozen, cooked, boiled, drained).
c                              17). Onions (frozen, cooked, boiled, drained).
c                              18). Peas, edible potted (frozen, cooked, boiled, drained).
c                              19). Potatoes (boiled, cooked without skin, flesh).
c                              20). Sweet potatoes (frozen, cooked, baked).

c                        b). The nutrients                  value for % calculation
c                              1). Protein                  65 grams.
c                              2). Vitamin A                5000 mgs.
c                              3). Ascorbic acid            60 mgs.
c                              4). Thiamine                 1.5 mgs.
c                              5). Riboflavin               1.7 mgs.
c                              6). Niacin                   20 mgs.
c                              7). Calcium                  100 mgs.
c                              8). Iron                     18 mgs.

c --------------------------------------------------------------------------------------------

c       *** DECLARATION OF THE VARIABLES ***

        Integer In/1/, out/2/,r,w,x,a,b,c,d,I,J,u,v,p,q
        Real Pro,VA,AA,THI,RI,NI,CA,FE,
     c  Pro1,VA1,AA1,THI1,RI1,NI1,CA1,FE1
```

```
      c  Pro2,VA2,AA2,THI2,RI2,NI2,CA2,FE2
      c  Pro3,VA3,AA3,THI3,RI3,NI3,CA3,FE3
         Dimention da(20,8)
         Character vegi*25

c     *** OPENING OF INPUT AND OUTPUT FILE ***

         Open (unit=1, file='vegput.dat', status='old')
         Open (unit=2, file='vegout.dat', status='new')

c     *** READING THE INPUT FILE ***

         Do 10 I=1,20,1
         Read (1,*) (da(I,J),J=1,8)
10           Continue

c     *** CHOOSE 5 VEGETABLES AT RANDOM ***

         Do 20 a=1,17
             p=a+1
           Do 30 b=p,18
               q=b+1
             Do 40 c=q,19
                 r=c+1
               Do 50 d=r,20

c     *** ASSIGN INDIVIDUAL WEIGHT (GMS) TO THE 5
         VEGETABLES.***

         Do 80 u=5,85,5
           Do 90 v=5,85,5
             Do 100 w=5,85,5
               Do 110 x=5,85,5

         Total = u+v+w+x
         If (total .eq. 100) then

c     *** CALCULATE THE NUTRIENTS OF EACH SET ***

         Pro=((u*da(a,1))+(v*da(b,1))+(w*da(c,1))+(x*da(d,1)))/100
         VA=((u*da(a,2))+(v*da(b,2))+(w*da(c,2))+(x*da(d,2)))/100
         AA=((u*da(a,3))+(v*da(b,3))+(w*da(c,3))+(x*da(d,3)))/100
         THI=((u*da(a,4))+(v*da(b,4))+(w*da(c,4))+(x*da(d,4)))/100
         RI=((u*da(a,5))+(v*da(b,5))+(w*da(c,5))+(x*da(d,5)))/100
         NI=((u*da(a,6))+(v*da(b,6))+(w*da(c,6))+(x*da(d,6)))/100
         CA=((u*da(a,12))+(v*da(b,12))+(w*da(c,12))+(x*da(d,12)))/100
         FE=((u*da(a,13))+(v*da(b,13))+(w*da(c,13))+(x*da(d,13)))/100

c     *** CALCULATE % USRDA IN EACH SET OF VEGETABLES ***

         PRO1= PRO*100/65
         VA1= VA*100/5000
         AA1= AA*100/60
         THI1= THI*100/1.5
         RI1= RI*100/1.7
         NI1= NI*100/20
```

```
        CA1= CA*100/100
        FE1= FE*100/18

c     *** CALCULATE THE % USRDA OF VEGI + YEAST ***

        PRO2= PRO1+(0.68/65)
        VA2= VA1+0
        AA2= AA1+0
        THI2= THI1+(0.05/1.5)
        RI2= RI1+(0.035/1.7)
        NI2= NI1+(0.55/20)
        CA2= CA1+(0.00008/100)
        FE2= FE1+(0.0025/18)

c     *** CALCULATE THE % USRDA OF VEGI + YEAST + DOUGH ***

        PRO3= (PRO2*0.75)+(6*0.25)
        VA3= VA2+0
        AA3= AA2+0
        THI3= (THI2*0.75)+(10*0.25)
        RI3= (RI2*0.75)+(8*0.25)
        NI3= (NI2*0.75)+(8*0.25)
        CA3= CA2+0
        FE3= (FE2*0.75)+(8*0.25)

c     *** SET THE MIN VALUE FOR PRINT OUT ***

        If (PRO3.GE.10 .AND. VA3.GE.10 .AND. AA3.GE.10 .AND.
     c  THI3.GE.10.AND. RI3.GE.10 .AND. NI3.GE.10 .AND. CA3.GE.10 .AND.
     c  FE3.GE.10)
        Then

c     *** PRINT OUT THE RESULT HEADING ***

        Write (2,*)'@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@@'
        Write (2,*)'VEGETABLES                    WEIGHTS(GMS)'
        write (2,*)'--------------              --------------'
c     *** ASSIGN NAME TO THE VEGETABLES IN THE ARRAYS ***
c     *** PRINT OUT THE ASSIGN NAME ***

        If (a.eq.1) then
            vegi='soybeans'
        elseif (a.eq.2) then
            vegi='spinach'
        elseif (a.eq.3) then
            vegi='carrots'
        elseif (a.eq.4) then
            vegi='brocolli'
        elseif (a.eq.5) then
            vegi='snap beans'
        elseif (a.eq.6) then
            vegi='asparagus'
        elseif (a.eq.7) then
            vegi='pinto beans'
        elseif (a.eq.8) then
            vegi='brussel sprouts'
```

```
elseif (a.eq.9) then
      vegi='lima beans'
elseif (a.eq.10) then
      vegi='green beats'
elseif (a.eq.11) then
      vegi='broad beans'
elseif (a.eq.12) then
      vegi='butterbur (fuki)'
elseif (a.eq.13) then
      vegi='cabbage'
elseif (a.eq.14) then
      vegi='sweet corn'
elseif (a.eq.15) then
      vegi='mushroom'
elseif (a.eq.16) then
      vegi='okra'
elseif (a.eq.17) then
      vegi='onions'
Endif

Write (2,*) vegi,u

If (b.eq.2) then
      vegi='spinach'
elseif (b.eq.3) then
      vegi='carrots'
elseif (b.eq.4) then
      vegi='brocolli'
elseif (b.eq.5) then
      vegi='snap beans'
elseif (b.eq.6) then
      vegi='asparagus'
elseif (b.eq.7) then
      vegi='pinto beans'
elseif (b.eq.8) then
      vegi='brussel sprouts'
elseif (b.eq.9) then
      vegi='lima beans'
elseif (b.eq.10) then
      vegi='green beats'
elseif (b.eq.11) then
      vegi='broad beans'
elseif (b.eq.12) then
      vegi='butterbur (fuki)'
elseif (b.eq.13) then
      vegi='cabbage'
elseif (b.eq.14) then
      vegi='sweet corn'
elseif (b.eq.15) then
      vegi='mushrooms'
elseif (b.eq.16) then
      vegi='okra'
elseif (b.eq.17) then
      vegi='onions'
elseif (b.eq.18) then
      vegi='peas'
```

```
Endif

Write (2,*)vegi,v

If (c.eq.3) then
      vegi='carrots'
elseif (c.eq.4) then
      vegi='brocolli'
elseif (c.eq.5) then
      vegi='snap beans'
elseif (c.eq.6) then
      vegi='asparagus'
elseif (c.eq.7) then
      vegi='pinto beans'
elseif (c.eq.8) then
      vegi='brussel sprouts'
elseif (c.eq.9) then
      vegi='lima beans'
elseif (c.eq.10) then
      vegi='green beats'
elseif (c.eq.11) then
      vegi='broad beans'
elseif (c.eq.12) then
      vegi='butterbur (fuki)'
elseif (c.eq.13) then
      vegi='cabbage'
elseif (c.eq.14) then
      vegi='sweet corn'
elseif (c.eq.15) then
      vegi='mushrooms'
elseif (c.eq.16) then
      vegi='okra'
elseif (c.eq.17) then
      vegi='onions'
elseif (c.eq.18) then
      vegi='peas'
elseif (c.eq.19) then
      vegi='potatoes'
Endif

Write (2,*)vegi,w

If (d.eq.4) then
      vegi='brocolli'
elseif (d.eq.5) then
      vegi='snap beans'
elseif (d.eq.6) then
      vegi='asparagus'
elseif (d.eq.7) then
      vegi='pinto beans'
elseif (d.eq.8) then
      vegi='brussel sprouts'
elseif (d.eq.9) then
      vegi='lima beans'
elseif (d.eq.10) then
      vegi='green beats'
```

```
        elseif (d.eq.11) then
              vegi='broad beans'
        elseif (d.eq.12) then
              vegi='butterbur (fuki)'
        elseif (d.eq.13) then
              vegi='cabbage'
        elseif (d.eq.14) then
              vegi='sweet corn'
        elseif (d.eq.15) then
              vegi='mushrooms'
        elseif (d.eq.16) then
              vegi='okra'
        elseif (d.eq.17) then
              vegi='onions'
        elseif (d.eq.18) then
              vegi='peas'
        elseif (d.eq.19) then
              vegi='potatoes'
        elseif (d.eq.20) then
              vegi='sweet potatoes'
        Endif

        Write (2,*)vegi,x

        Write (2,*)'----------------------------------------'
        Write (2,*)'  Nutrients       Weights       Percent(RDA)'
        Write (2,*)'  ---------       --------      --------------'
        Write (2,*)'Proteins                        'PRO,PRO3
        Write (2,*)'Vitamin A                       'VA,VA3
        Write (2,*)'Ascorbic acid '                 AA,AA3
        Write (2,*)'Thiamine                        'THI,THI3
        Write (2,*)'Riboflavin                      RI,RI3
        Write (2,*)'Niacin                          'NI,NI3
        Write (2,*)'Calcium                         'CA,CA3
        Write (2,*)'Iron                            'FE,FE3
        Write (2,*)'----------------------------------------'

          Endif
        Endif

110               Continue
100              Continue
90              Continue
80             Continue
50            Continue
40           Continue
30          Continue
20         Continue

        End
```

APPENDIX 2

Vegetables and Their Respective Nutrient Densities Used in the Fortran Program.

Vegetables	Protein (gm)	Vitamin A Value, (I.U)	Ascorbic Acid (mg)	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Calcium (mg)	Iron (mg)
Soybean	12.35	156	17.0	0.260	0.155	1.250	145	2.50
Spinach	3.15	7784	12.3	0.060	0.168	0.419	146	1.52
Carrot	1.19	17702	2.8	0.027	0.037	0.438	28	0.47
Brocolli	3.10	1892	40.1	0.055	0.081	0.458	51	0.61
Snap Bean	1.36	528	8.2	0.048	0.074	0.417	45	0.61
Asparagus	2.95	818	24.4	0.065	0.103	1.038	23	0.64
Pinto Bean	9.31	0	0.7	0.000	0.108	0.632	52	2.71
Brussel Sprout	3.64	589	45.7	0.103	0.113	0.537	24	0.74
Lima Bean	6.65	167	5.8	0.070	0.055	0.770	28	1.96
Green Bean	2.57	5100	24.9	0.117	0.289	0.499	114	1.90
Broad Bean	4.80	270	19.8	0.128	0.090	1.200	18	1.50
Butterbur	0.23	27	18.9	0.010	0.010	0.100	59	0.10
Cabbage	0.96	86	24.3	0.057	0.055	0.230	33	0.05
Sweet Corn	3.02	248	2.6	0.069	0.073	1.283	2	0.30
Mushroom	2.17	0	4.0	0.073	0.300	4.460	6	1.74
Okra	2.08	514	12.2	0.099	0.123	0.785	96	0.67
Onions	0.77	33	2.6	0.023	0.025	0.139	16	0.30
Peas, edible portion	3.50	167	22.0	0.064	0.119	0.563	59	2.40
Potato	1.71	0	7.4	0.098	0.019	1.312	8	0.31
Sweet potato	1.71	16410	9.1	0.066	0.056	0.555	35	0.54

APPENDIX 3

Nutrient Values of Yeast and Frozen Dough

A). Nutrient Density of yeast (100 gms)

Nutrients	% USRDA
Protein	10.5
Vitamin A value	0.00
Vitamin C	0.00
Thiamin	33.3
Riboflavin	20.6
Niacin	27.5
Calcium	00.0
Iron	1.4

B). Nutrient Density of Dough (100 gms)

Nutrients	% USRDA
Protein	24
Vitamin A	*
Vitamin C	*
Thiamin	40
Riboflavin	32
Niavin	32
Calcium	*
Iron	32

* Contain less than 2 % of the USRDA.

APPENDIX 4

Scorecard Used by Panel to Evaluate the Samples

Panelist - : ______
Sample - : ______

You will receive 4 samples of baked, breaded vegetables. Please taste each sample and describe how well you like the appearance, texture, and flavor. Please give us a rating of how well you like the product overall.

APPEARANCE : COLOR OF VEGETABLES	Like extremely	________
	Like very much	________
	Like moderately	________
	Like slightly	________
	Dislike slightly	________
	Dislike moderately	________
	Dislike very much	________
	Dislike extremely	________
TEXTURE : OVERALL	Like extremely	________
	Like very much	________
	Like moderately	________
	Like slightly	________
	Dislike slightly	________
	Dislike moderately	________
	Dislike very much	________
	Dislike extremely	________
MOISTNESS OF CRUST	Like extremely	________
	Like very much	________
	Like moderately	________
	Like slightly	________
	Dislike slightly	________
	Dislike moderately	________
	Dislike very much	________
	Dislike extremely	________
FLAVOR	Like extremely	________
	Like very much	________
	Like moderately	________
	Like slightly	________
	Dislike slightly	________
	Dislike moderately	________
	Dislike very much	________
	Dislike extremely	________
OVERALL ACCEPTABILITY	Like extremely	________
	Like very much	________
	Like moderately	________
	Like slightly	________
	Dislike slightly	________
	Dislike moderately	________
	Dislike very much	________
	Dislike extremely	________

COMMENTS :

APPENDIX 5

Comments by the Panelists Regarding the Samples

Product : Matrix 1. Conventional Oven.

- Best one of all 4
- Greatest beany flavor
- Tastes best
- Crust too soggy, flavor has a strong beany taste
- Slightly cooked off flavor
- How to keep the veggies from falling out ?
- Not enough salt & flavoring
- Need salts & flavorings
- Crust a little dark
- More flavor is needed
- Choice of vegetables is not appealling
- A little dry
- Too dry
- I'd like a thicker crust. Also, the filling is a little bit bland; it could use some cheese &/or a spiced or herbed source

Product : Matrix 1. Microwave Oven.

- Used no flavors - Too BLAND
- Crust soggy
- Crust has a nice golden color
- Not delicious. I like delicious food especially when it's veggies, not bad though
- Crust is too soggy - flavor is just average
- Need some salt & etc.
- You don't want to know
- Color - dull unappealing
- Vegetables fall out of crust
- Not enough salt
- Crust too moist
- Need salt and/or flavoring
- Very bland. Taste OLD
- Hard to handle
- There should be something to hold the vegetable together
- Some kind of seasoning is necessary

Product : Matrix 2. Conventional Oven.

- Need salt
- Peas are too yellow
- Crust more cohesive than previous samples
- Colorful mix of vegetables - best so far in color
- Slightly dry beans
- Need more of yellow and orange vegetables.
- Need more flavor
- Flavor of crust is a little too strong. Crust may be a little too dark
- Put some meat in this nasty thing and cut down on all the peas.
- Flavor & appearance poor
- Not enough color variation
- Preferred slightly saltish
- Needs salt & flavoring
- Crust too brown. Soybean leave a bad aftertaste
- Need salt

<u>Product : Matrix 2. Microwave Oven.</u>

- A little stronger than one before. But not enough
- Peas have a dry scaly appearance and are slightly yellow
- Crust very thin, friable, and soogy but has a nice golden color
- "Good" textures of vegetables, themselves in that they are not mushy
- Prefer softer texture of this one
- Seems the taste slightly better than the other
- Both fall apart too easily
- Crust is still soggy - veg. a little mushy
- More carrots
- Too much green in color, needs a mixture
- Preferred slightly saltish
- Needs salt and/or flavorings
- Did not taste good. Too dry

APPENDIX 6

Scorecard Used by the Panel to Rank the Samples for Color.

Panelist Number : ____________________

Tray number : ______________________

There are 4 samples of a baked vegetable product on the tray in front of you. Rank the 4 samples according to your preference for the color of the crust. Assign 1 to the sample that you like best and 4 to the sample that you like least. Record your response in the blank below.

Code	Rank	
________________	1	Color liked the most
________________	2	
________________	3	
________________	4	Color liked the least

When finished with this tray move to booth ________ to evaluate the tray there.

Tray number : ______________________

There are 4 samples of a baked vegetable product on the tray in front of you. Rank the 4 samples according to your preference for the color of the crust. Assign 1 to the sample that you like best and 4 to the sample that you like least. Record your response in the blank below.

Code	Rank	
________________	1	Color liked the most
________________	2	
________________	3	
________________	4	Color liked the least

When finished with this tray move to booth ________ to evaluate the tray there.

Tray number : ______________________

There are 4 samples of a baked vegetable product on the tray in front of you. Rank the 4 samples according to your preference for the color of the crust. Assign 1 to the sample that you like best and 4 to the sample that you like least. Record your response in the blank below.

Code	Rank	
________________	1	Color liked the most
________________	2	
________________	3	
________________	4	Color liked the least

VITA

Kamarudin bin Hasim was born on August 25, 1955, in Kuala Selangor, Selangor, Malaysia. He completed his high school at Sultan Abdul Aziz school in Kuala Selangor in 1973. He entered MARA Institute of Technology in 1974 and graduated with a Diploma in Food Technology in 1978. The same year he was employed with the Frazer & Neave (M) Sdn. Bhd. as Production Foreman. In March 1979, he was appointed Assistance Research Officer with Malaysian Agriculture and Research Development Institute (MARDI).

In August 1984, he received a federal scholarship from the Public Services Department, Malaysia, to futher his study. He entered the University of Tennessee, Knoxville, in September 1984, and received his Bachelor of Science in Agriculture (honors) with a major in Food Technology and Science.

He enrolled in the Graduate School of the University of Tennessee, Knoxville, in September 1986, and began work toward a Master of Science degree in Food Technology and Science.

He is a member of the Food Technology Club of the University of Tennessee and Gamma Sigma Delta, the Honor Society of Agriculture.

He is married to Khatijah binti Darus of Selama, Perak, and is blessed with two children, Kamal Aizuddin and Kama Aliyaa.