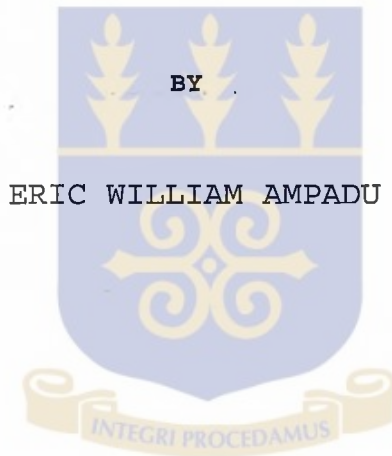


**SOYBEAN (GLYCINE MAX) PROCESSING AND PERFORMANCE  
IN FERMENTED MAIZE DOUGH SYSTEM**



ERIC WILLIAM AMPADU

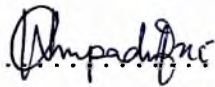
A Thesis submitted to the Department of Nutrition and Food Science, University of Ghana, Legon in partial Fulfilment of the requirements for the Award of a Master of Philosophy Degree in Food Science.

OCTOBER 1994

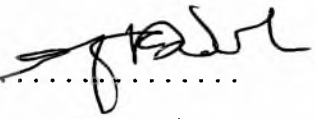
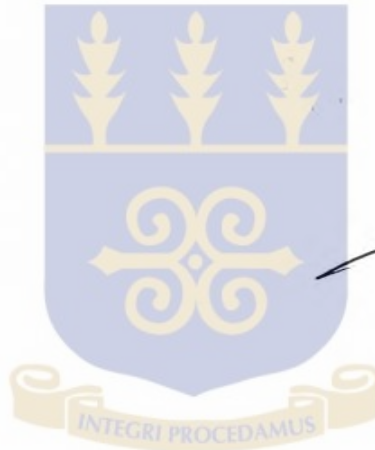


**DECLARATION**

This research project was done by me under the supervision of Professor S. Sefa-Dedeh, of the Department of Nutrition and Food Science, University of Ghana.



Candidate



Supervisor

ii

**DEDICATION**

To my Family.



**ABSTRACT**

The effect of addition of processed soybean flour on the physicochemical characteristics of fermented maize dough was studied.

Soybean flours; Full-fat, Extruded, and Defatted soy-flours were processed and added to maize dough before and after fermentation of the dough. The soy were added to the dough at 0,10, and 20 percent concentrations. The dough samples were also fermented at 0,6,24 and 48 hours respectively. Two traditional food products; Ga kenkey and Akasa (Porridge) were also prepared from the soy-maize dough samples and subjected to sensory evaluation to assess product performance. Physicochemical analysis indicated that pH of the soy-fortified dough was affected significantly by the method of addition of the soy flour, soy-flour concentration, and the fermentation time. Total titratable acidity of the soy-maize doughs were dependent on these factors. Generally pH of the dough decreased and total titratable acidity increased with increase fermentation time. Addition of Full fat soy flour to the maize dough before fermentation was found to promote fermentation resulting in higher acidity of dough. Hence increase in sourness of the dough. Regression models for pH and total titratable acidity were developed to predict various indices in the soy-maize dough systems. Water absorption characteristics of the samples were observed to be dependent on the temperature and

fermentation time. Water absorption at 70°C were generally higher than at 29°C.

Amylograph pasting properties indicate that addition of soy-flour to maize dough caused a reduction in viscosity. Viscosity characteristics generally increased with increase in fermentation time. The soy fortified maize dough showed lower viscosity characteristics compared to the maize dough (no soy) sample. Sensory analysis indicated the Ga-kenkey and Akasa prepared from soy-fortified maize dough generally showed lower mean scores hence lower consumer preference for colour, taste, flavour and texture compared with samples containing no soy flour. General acceptability scores indicated no significant difference between samples containing no soy flour and that containing Full fat soy flour in which soy was added after fermentation of the maize dough. The two samples were also most acceptable to the consumers. The incorporation of Full-fat soy flour to Ga-kenkey and Akasa is therefore promising. Difference test (Triangle test) also revealed significant differences in colour, taste, texture and flavour between the maize dough (no-soy) samples and the soy-fortified maize dough samples indicating the influence of soy-flours addition on sensory characteristics.

**ACKNOWLEDGEMENT**

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## 1.0

### INTRODUCTION

Economic, social and anthropological factors contribute to the incidence of protein malnutrition in developing countries. These factors, coupled with the present world food crisis particularly in the developing countries, calls for research into local food sources that can act as supplements to alleviate the problem of protein-energy malnutrition. Plant protein foods have important source of relatively good quality protein and they make substantial contribution to energy. The legumes are rich in the essential amino acid lysine but deficient in sulphur-containing amino acids such as cysteine and methionine (Bressani, 1974).

Among the legumes include soybean, cowpeas, groundnut, bambara beans, pigeon beans, mung beans, kidney bean.

## 1.1 COMPOSITION OF SOYBEAN

Soybean is a leguminous plant and the most prominent among the legumes. The economic value of soybeans lies in their protein and fat content. Nutritionally, soybean rank high on protein quality in relation to other plant proteins e.g. the cereals, maize, rice, millet. It however ranks below fish, beef muscle, whole milk and whole egg. The amino acid pattern of soybean protein approaches the optimum recommended by the Food and Agricultural Organisation (FAO). In addition soybeans appears to be a good source of required vitamins and minerals (Table 1). The lipid in soybean consists of a large proportion of polyunsaturated essential fatty acids and appreciable amount of carotene which is desirable (Table 1).

However, the proportion of unsaturated fatty acids depends on location, cultivar, environmental factors and the type of soil. (Fredler, 1971).

Soybean like many other legumes contains over 20 antinutritional factors such as Trypsin inhibitors, phytates, haemagglutinins, amino acid analogues and flatus factors which elicit adverse nutritional and physiological responses (Plahar, 1976; Rackis, 1972; Yoshida, 1988).

Identification of these antinutritive factors and development of methods to eliminate them have led to the increasing use of soybeans and its products.

## 1.2 SOYBEANS IN GHANA

The usage of soybeans is limited in Ghana as far as its cultivation and utilisation for human consumption is concerned.

As a new and minor crop, soybean has attracted only a limited breeding research attention in Ghana. Previous breeding efforts were restricted to introduction and extensive evaluation of exotic germ plasm after which promising varieties were recommended to farmers for cultivation (Asafo-Adjei and Atuahene Amankwa, 1991). The extent or scale of production of the crop however will depend among others on the extent of utilisation. In Ghana, widespread acceptance by consumers may only be a matter of time. Hence the promotion of soybean products or recipes which favour soybeans as part of normal Ghanaian food will be an important step towards increasing its utilisation.

Table 1. COMPOSITION OF SOYBEAN

| <u>Essential Amino acid</u> | <u>Amino acid content mg/g Protein</u> |
|-----------------------------|--|
| Isoleucine                  | 370                                    |
| Leucine                     | 430                                    |
| Lysine                      | 400                                    |
| Phenylamine                 | 310                                    |
| Tyrosine                    | 200                                    |
| Methionine                  | 80                                     |
| Cystine                     | 110                                    |
| Threonine                   | 250                                    |
| Tryptophane                 | 90                                     |
| Valine                      | 330                                    |

| <u>Fatty Acid composition</u> | <u>Range (%)</u> |
|-------------------------------|------------------|
| <u>(Saturated Acids)</u>      |                  |
| Lauric                        | 0.0 - 0.2        |
| Myristic                      | 0.1 - 0.4        |
| Palmitic                      | 0.5 - 9.8        |
| Stearic                       | 2.4 - 5.5        |
| Arachidic                     | 0.2 - 0.9        |
| Lignoceric                    | 0.0 - 0.1        |
| Total Saturated Acid          |                  |
| <u>Unsaturated Acids</u>      |                  |
| Decedenoic                    |                  |
| Tetradecenoic                 | 0.05 - 0.64      |
| Hexadecenoic & Palmitoleic    | 0.42 - 1.60      |
| Oleic                         | 10.9 - 60.0      |
| Linoleic                      | 25.0 - 64.8      |
| Linolenic                     | 0.3 - 12.1       |
| Arachidonic                   | Traces           |
| Total Unsaturated Acid        | 85.0             |

| <u>Mineral</u> | <u>Meal Percentage</u> |
|----------------|------------------------|
| Calcium        | 0.24 - 0.31            |
| Phosphorus     | 0.60                   |
| Magnesium      | 0.24 - 0.30            |
| Zinc (mg/kg)   | 55 - 77                |
| Iron           | 140                    |

| <u>Vitamins</u>  | <u>Meal Percentage</u> |
|------------------|------------------------|
| Thiamine         | 12.0 - 44.1            |
| Riboflavin       | 2.7 - 3.3              |
| Niacin           | 19.0 - 40.0            |
| Pyridoxine       | 8.8                    |
| Biotin           | 1.1 - 1.7              |
| Pantheothic acid | 13.3 - 16.0            |
| Folic Acid       | 3.7                    |
| Inositol         | 2500 - 390             |

Source: Ferrier L.K 1976 Simple Processing of whole Soybean as Food. Expanding use of Soybeans. Proceedings of a conference For Asia and Oceania INT SOY Publ. No. 10 p130.

### 1.3 FERMENTED MAIZE MEAL-AN INTERMEDIATE TRADITIONAL FOOD PRODUCT

Maize is eaten in many forms in Ghana such as fermented paste, porridge, roasted maize snacks, boiled and germinated and other preparations of the grain. The grains are generally milled and processed further into other products. Of all the processes used in preparation of the grain, fermentation is one of the most important process as fermented maize meal is used extensively in Ghana and other West African countries as part of their main diet and for various other food product (Plahar and Leung, 1983).

Among the traditionally known fermented maize products are namely:

- (i) Akasa or Koko :- which is fermented maize dough cooked into porridge.
- (ii) Kenkey :- fermented maize dough in which one-third of dough is cooked and mixed with the other uncooked portion and boiled.
- (iii) Maasa :- which is spiced and fried fermented maize dough.
- (iv) Kaffa :- fermented maize dough treated differently and cooked into solid pap.
- (v) Banku :- fermented maize dough mixed with or without fermented cassava dough (Agbelima) and cooked into solid dumpling. (Sefa-Dedeh, 1993)

In all these processed fermented maize products, fermented maize dough is the intermediate base product. The products are also important for several reasons which include increased shelf-life, attractive flavour, texture, improvement of palatability and nutritional value and reduction of bulk and required cooking time.

These fermented maize food products have low protein quality and therefore call for the development of high protein mixtures in Ghana. The solution lies in the use of intermediate cereal products with widespread utilisation (eg. fermented maize dough) as base material for the fortification or blending. Such blending or fortification can be achieved with the use of high protein seeds such as soybeans. However, there is the need to investigate the impact or effect of

incorporated soybeans on the sensory and functional properties requirements for the intended food uses. This may be an important step in the development and maintenance of the desired quality of the soy-fortified product. It is also essential that the criteria of quality applied to each traditional product be identified. This will require intimate and accurate knowledge of the nature (colour, texture, taste and flavour) of the traditional food and the behaviour (physical and chemical) of the processed soybean being used or incorporated into the traditional food product.

In order to derive maximum benefits and desired acceptability from the soy fortified maize dough product two or more of the under-listed factors must be considered or achieved.

- (i) The product must be low cost with easy method of preparation.
- (ii) The product must be designed to meet local acceptability requirements. Thus the product must be engineered or modified to resemble a traditionally acceptable product with respect to taste, texture, flavour and colour.
- (iii) The product should have a relatively long shelf-life at ambient conditions.
- (iv) The product must have easy handling and storage characteristics.

Thus, the challenge is not only in formulating a nutritious food but also in fabricating a protein rich food that has the identical intrinsic or more desirable colour, flavour, texture

and functional characteristics of the traditionally accepted food and at low cost.

#### 1.4 OBJECTIVES

The following objectives were set for this study.

##### 1. General Objective:

- (a) Determine the effect of processed soybeans on the physicochemical and sensory characteristics of soy flour-maize dough blends.

##### 2. Specific Objectives:

- (a) Evaluate the effects of :-

- (i) fermentation time
- (ii) soy-flour type
- (iii) soy-flour concentration
- (iv) method of addition of soy flour

on the physico-chemical and functional indices of soy-fermented maize dough mixtures.

- (b) Evaluate consumer perception or preference for soy-maize dough blends in selected Ghanaian foods; case study on Ga-kenkey and "Akasa" porridge.



**2.0****LITERATURE REVIEW****2.1 THE USE OF PLANT PROTEIN TO SOLVE THE PROTEIN PROBLEM**

The protein food crisis in the developing countries has led to research into promising under-exploited and non-conventional protein source that can act as supplements to available foods (Fulmer, 1989). The use of vegetable source of protein for dietary supplementation is highly relevant in developing countries (Lockmiller, 1973; Fulmer, 1989). The production of vegetable products requires lesser use of scarce resources than the production of animal products though wide variation exists according to the nature of individual products and the geographical location. Vegetable products as a class are generally cheaper than animal products. The protein nutritive value of some vegetable foods are comparable to meat and fish (Fulmer, 1989). Of the vegetable protein source the legumes are important protein source. Among the legumes, soybean which is easy to cultivate in most soils has been recommended for developing countries.

**2.2****WORLD TRENDS IN SOYBEAN PRODUCTION**

There has been unprecedented growth in the worldwide production and utilization of soybean due to the high concentration of excellent protein and a moderate content of oil useful for oil and industrial uses (Fredler, 1971).

This has resulted in the development of a worldwide marketing and processing technology covering the seeds and its main products. Soybeans and its products are the most

exported agricultural commodities running into billions of dollars annually (Fredler, 1971). It has also received the active attention of almost every facet of private and public agri-business. The meal and oil fractions are finding their way into more and more highly sophisticated applications for human use.

### 2.3 SOYBEAN IN GHANA

As at 1992 no official figures were available on soybean production in Ghana. Among some of the problems encountered in the introduction of soybeans in Ghana include the following:

- (a) low yielding ability of varieties of soybean grown by farmers.
- (b) lack of varieties resistant to shattering, disease and insect pests.
- (c) some processing techniques carried out domestically may be difficult to establish in areas to which they are not indigenous. Products made by these techniques may also have low acceptability outside the area or locality particularly where they have a characteristic flavour.
- (d) where soybean has been introduced as a cash crop its possibilities as a foodstuff are not recognised or exploited because the traditional methods of processing do not make the intended product acceptable to consumers.

Research and introduction of new processes can therefore be used to make soybean products which are bland in taste and which mix with a variety of dishes commonly found in the country.

Recently the Grain development Project of Ghana introduced a new high yielding soybean varieties named 'Bengbie' (wonderful bean). Compared to other soybean varieties in the country 'Bengbie' is

- (i) resistant to shattering
- (ii) nodulate freely with the indigenous cowpea/groundnut rhizobia in Ghana soils
- (iii) have seed storageability. Yield ranges from 1000kg/ha in the coastal savanna to about 2000kg/ha in the transitional and Guinea savanna zones (GGDP, 1993).

#### 2.4 SOYBEAN - NUTRITIONAL QUALITY

Soybean can produce the highest yield of protein per unit land area of any plant or animal food source (Arai et al., 1970). Compared with the other legume it provides the highest protein per gram.

Trace amount of starch has been reported in soybean. (Bressani, 1974). The protein in soybean is known to be a good source of all essential amino acid except methionine and tryptophan (Sosulski 1983). The protein also has high lysine and therefore can be used to complement low lysine level in cereal based products. This reciprocal enhancement can upgrade the nutrition of people who subsist on protein deficient diets

#### 2.4.1 ANTINUTRITIONAL FACTORS IN SOYBEAN

Despite its relatively good nutritional quality, soybean like other legumes contain various antinutritional factors which elicit adverse nutritional, biological and physiological responses (Holmes et al, 1982). The utilisation of soybeans has not paralleled production due to the presence of these antinutritional factors and toxic compounds which contribute to lower absorption rate and poor utilisation in the body (Grant, 1989). These factors include trypsin inhibitors, phytates, haemagglutinin, amino acid analogs, flatus factors and lipoxidase which affect overall nutritional value (Plahar, 1976).

Rackis (1972) reported that raw soybeans and underheated beans and their products may inhibit growth, depress metabolisable energy and fat absorption, reduce protein digestibility, cause pancreatic hypertrophy and reduce amino acid and mineral availability. In vitro evidence has shown that the human trypsin is weakly inhibited by soybean trypsin inhibitor (Grant, 1989). The haemagglutinin protein also has the unique property of being able to agglutinate red blood cells.

It has been shown that phytic acid in its natural form as phytate-mineral-protein complex in the seed decreases the availability of zinc, magnesium, phosphorus, calcium and iron (Spiller and Shipley, 1977).

Sosulski et al. (1982) reported the production of intestinal gas following ingestion of dry mature legumes. This has been attributed to the presence oligosaccharides;

raffinose and stachyose which pass into the large intestine where they are fermented anaerobically to produce gas.

The lipoxidase enzyme which causes the development of off flavour in soybean products has also attracted a lot of attention by researchers in recent times (Homma et al., 1985). The action of lipoxygenase during the rapturing of soybean results in the formation of compounds with objectionable beany flavour which are responsible for low acceptability of some soy-products. Investigation has identified a range of oxidation products of linoleic acid generated by lipoxygenase action which includes aldehydes, ketones and alcohol.

A raw green bean odour which is undesirable is produced by ethylvinyl ketone (an oxidation product) as reported by Wang and Toledo (1985). The identification of these antinutritive factors and development of methods to eliminate them have led to the increasing use of soybean and its products. Various methods that remove or inactivate the antinutritive factors have been reported (Ologhobo and Fetuga, 1982).

Many of these antinutritive factors can be eliminated or inactivated to a large degree by appropriate heat and processing during food preparation. The treatment may include dehulling, pre-soaking, steaming, cooking and germination, extrusion and fermentation. The various methods of heating include toasting (Gardiner, 1975), dry roasting (Johnson et al. 1980), heating in boiling water (Collins and Beaty, 1980) and micronisation (Hutton and Foxcroft, 1975). Wang and Toledo (1987) showed that lipoxygenase activity was greatly

reduced by microwave treatments. They reported that during microwave heating the time needed for enzymatic inactivation was shorter and the retention of protein solubility higher in comparison with other conventional methods. Pour et al. (1981) also indicate that dielectric heating at 42 MHz and 2450 MHz is also efficient in improving the biological properties of soybeans.

Chemam et al. (1989) also showed that the inactivation of lipoxygenase with acid was possible. They reported that inactivation of the enzyme was irreversible when treated at pH 3.0 and below irrespective of the acid used.

Fermentation has been shown to also reduce off-flavours and improve the sensory and nutritive value of soybeans (Parades-Lopez et al. 1989; Nishiya et al. 1990). Nishiya et al. (1990) used three microorganisms including *Saccharomyces cerevisiae* to improve the flavour of commercial soy protein isolates (CPI). They reported that the microorganisms decrease such typical bean flavour due to hexanal, hexanol and 1-octen-3-ol and increased preferable fermented flavour due to diacetyl and acetoin. The beany flavour has also been shown to be reduced by hydrating the soy product with a solution containing a water soluble primary yeast extract (from eg *Saccharomyces cerevisiae*) prior to incorporation the soy product into a food (Swartz et al. 1985).



## 2.5 SOYBEANS - PROCESSING AND UTILIZATION

Soybean utilisation and product quality are influenced by numerous factors including the beans characteristics (structural and chemical composition), specific soybean product types and processing (pH, processing time and temperature). Soybean has a wide range of uses. The various category of soybean products which have a number of food applications are: (a) whole soybeans (b) soy flours (c) soybean protein concentrate (70% protein) (d) soybean protein isolate (90% protein) (e) soy grits (f) extruded soy products. The food uses of the soybean products depend on a number of factors which must be recognised in considering soybean products for their functional properties such as enzyme activity, water soluble protein, fiber and carbohydrate content, flavour, particle size, presence or absence of lecithin and for their nutritional and economic value. Table 2 shows the typical percent composition of the soy products.

### 2.5.1 WHOLE SOYBEAN

The whole soybean may be dehulled or boiled or roasted. It may be eaten as snack or as an intermediate product for intended food application.

**Table 2 TYPICAL PERCENTAGE COMPOSITION OF SOY-PROTEIN PRODUCTS**

| ITEM                      | WHOLE<br>SOYBEANS | DEFATTED<br>SOYFLOUR | SOYPROTEIN<br>CONCENTRATES | SOYPROTEIN<br>ISOLATES |
|---------------------------|-------------------|----------------------|----------------------------|------------------------|
| MOISTURE                  | 10                | 7.0                  | 4.0                        | 4.0                    |
| PROTEIN                   | 30                | 52.0                 | 68.0                       | 92.0                   |
| FAT                       | 18                | 1.0                  | 1.0                        | 0.1                    |
| FIBER                     | 5                 | 3.5                  | 4.5                        | 0.1                    |
| ASH                       | 5                 | 6.0                  | 5.0                        | 3.5                    |
| SOLUBLE<br>CARBOHYDRATE   | 12                | 12.5                 | 2.0                        | 0                      |
| INSOLUBLE<br>CARBOHYDRATE | 12                | 18.5                 | 28.0                       | 0.1                    |

Source: Orr E. and Adair D (1967). The Production of Protein Foods and Concentrates from oil seeds. Tropical Products Inst Report G31.

### 2.5.2 SOYFLOURS

Soy flours are obtained by solvent extraction or variable heat treatments which yield soyflours with different functional properties and chemical characteristics. Some soy flour are white, cooked or toasted and others are full fat or fat free (Bressani, 1974). Soy flours are used in bakery products, soybean milk, high protein foods and protein supplements for cereal grain. The enzyme activity in full fat soy flour is taken advantage of to bleach wheat flour

during baking. The full fat soy flour is made by cleaning the beans, dehulling and grinding to a fine flour. The enzyme active is used at 0.5 to 0.75% based on wheat flour. The flour may have a beany bitter flavour but at the level used shows little difference in flavour.

The action of the lipoxygenase enzyme system which is taken advantage of is the bleaching effect it exerts on the wheat flour pigments. The lipoxygenase system results in the formation of hydroperoxides which in turn reacts to give a bleaching effect with improvement in crumb color, crumb softness, keeping quality and flavour.

### **2.5.3 SOYBEAN GRITS**

Soybean grits are obtained from defatted flakes and are similar to soybean flour with differing only in particle size. Soybean grits are coarser than soybean flour. The flour that passed through a 100 mesh US sieve or finer are referred to as flour products and those that are coarsely ground and screened referred to as grits. The soybean flour product are used for their functional characteristics such as water and fat absorption capacity which are influenced by the protein dispersion index (PDI) and particle size (Johnson, 1975).

### **2.5.4 SOYBEAN PROTEIN CONCENTRATE**

This is a soybean product with 70% protein in contrast to the flour or grits which contain 50% protein (Bressani, 1974).

It is obtained from defatted flakes after removal of the soluble carbohydrate fraction. In the process aqueous alcohol is used to extract the soluble carbohydrate, minerals and other components. The concentrate produced by the method has the least beany flavour. Such concentrate has the ability to absorb moisture and fat, hence are used in meat products, breakfast cereal bread, calf milk replacers etc. The soy protein produced by the acid leach process is neutralised at a pH of about 6.8 and spray dried. In the third process for producing concentrate the flakes or flour are heated to such a point to cause almost completely denatured proteins so that strong water wash remove solubles and give a product that has water and fat absorption.

#### 2.5.5 SOYBEAN PROTEIN ISOLATE

This is a soy-product with not less than 90% protein and is usually obtained from defatted flakes after alkaline extraction and isoelectric precipitation of the fraction (Visser et al. 1987) The products are high in protein, bland in flavour and have good functionality (Kim,1976).

Isolated soy proteins are essentially free of carbohydrates, fiber and fat. They have also a variety of properties different from concentrate and soyflours (Shiga et al., 1987). Among the important functional properties include emulsifying, fat binding, water absorption, adhesiveness, cohesiveness, film forming, thickening, stabilizing and foam. They have been used successfully in imitating dairy type products as binder or emulsifier in commuted meat products.

## 2.6. THE EFFECT OF PROCESSING ON SOYBEAN PRODUCT QUALITY

### 2.6.1 EFFECT OF HEATING

The nutritive value of soybean may be improved by heat treatment. The degree of nutritional improvement by heating depends among others on the temperature, duration of heating and pressure. The beneficial effects of heat treatment on the nutritive value is related to the inactivation of biologically active compounds (trypsin inhibitors and hemagglutinin which are thermolabile).

Boiling is essential to produce an acceptable texture and for practical purposes the desired texture dictate the boiling time required (Shiga *et al.* 1987). The use of softened water (pH about 7.5 to 7.9) or 0.5% sodium bicarbonate solution results in rapid tenderization and reduce the cooking time to about one-third required in tap water. The use of the sodium bicarbonate results in slightly different taste compared to that of tap water. A high pH will increase the loss of thiamine . Soaking and boiling also removes about one-third of the oligosaccharides in soybeans which are partly responsible for the production of intestinal gas or flatus. Steam blanched soybean results in products which are bland in taste, chewy to tender in texture. Water blanched soybean contains 50% to 70% moisture and steam blanched have between 20% to 30% moisture. Blanching simultaneously destroys the trypsin inhibitors, hemagglutinin and other known toxic factors present in the raw bean. The length of time required to destroy these components decreases with increased moisture content of the soybeans.

The effect of steam on soybean flavour is summarised in Table 3. The raw soybean meal is usually described as tasting beany, bitter and green. The green taste is reported to disappear after steaming for 3 mins at atmospheric pressure. The beany, bitter flavor, nutty sweet and toasted flavours varied in intensity with continued steaming. The data show that steaming longer than 20 mins which is approximately the time required for maximum nutritive value did not improve flavour score.

Table 3. Effect of Steaming on Flavour of Soybean

| Steaming time (mins) | Flavour Score | Flavour Description                     |
|----------------------|---------------|---|
| 0                    | 1.5           | beany, bitter, green                    |
| 3                    | 4.5           | beany, bitter,<br>nutty, toasted, sweet |
| 10                   | 6.0           | beany, nutty, bitter<br>toasted, sweet. |
| 20                   | 6.3           | beany, nutty, bitter<br>toasted, sweet. |
| 40                   | 6.1           | beany, nutty, bitter<br>toasted, sweet. |

1 = strong      10 = bland.

SOURCE: Smith and Circle (1972).

#### 2.6.2 EFFECT OF DEHULLING

Soy hull has been reported to affect physical and sensory characteristic of food system (Ashraf et al. 1988) Properties such as bulk volume, water holding capacity, oil holding capacity, ion exchange and particle size are affected (Ashraf et al. 1988). They reported that soy-hulls constitute approximately 8% of the whole soybean with a representative composition of soy hulls as follows: 9.0% protein, 0.9% fat, 86.2% total carbohydrate and 4.0% ash. The total carbohydrate may contain 29-34% hemicellulose, 42-49% cellulose and 1.4 to 2.7% lignin.

Dehulling of soybean have been reported to have little relative effect on the specific trypsin inhibitor activity since it is higher in the cotyledon than in the cuticle.

### 2.6.3 EFFECT OF FERMENTATION

Fermentation of soybean has been reported to improve digestibility. Ebine (1976) reported that during fermentation of koji, an oriental soybean product, digestibility is remarkably improved as a result of the enzyme in the koji and digestion of soybeans by salt-resistant microorganisms. He reported also that through fermentation of rice Miso, 60% of the protein is reduced to a water soluble form containing polypeptides and amino acids. Antinutritional factors and beany flavor which are problems affecting utilisation of soybean products have been reported to be reduced by fermentation.

### 2.6.4 EXTRUSION OF SOYBEANS

Extrusion cooking of soybean and soybeans product formulations is becoming an important and popular unit operation because of the versatility of the process. It is increasingly used in the manufacture of ready-to-eat (RTE) soy-cereal products. To maintain high quality of extrudate in a process that occurs at relatively short residence times, the flow of the dough and factors affecting it must be carefully controlled. The extruder die plays an important role in determining the texture characteristics of the finished product. In the developing countries the use of low cost extruder cookers (LCE's) in producing nutritious , precooked foods based on cereals and legumes is increasing (Brookwalter et al. 1971). The low cost extruders are single screw autogenous extruders that operate at low moisture (less

than 20%) and require minimal auxiliary equipment (Harper and Jansen, 1985). All cooking heat is developed by friction through viscous dissipation of mechanical energy applied to the shaft of the extruder. Important processing parameters for product quality include moisture content of the food material, residence time which is influenced by feeding rate, screw speed configuration, die geometry, temperature and pressure (Harper and Jansen, 1981).

The extrusion process has been reported to increase digestibility, palatability and reduces antinutritive component. Maga and Lorenz (1978) observed that the overall aroma, and flavour intensity increased with increased temperature in extruding blends of corn and soy. They reported that moisture content of the feed material in the extruder significantly affected the expansion and product breaking strength of extrudates.

Temperature and moisture have significant effect in raw flour aroma of extrudate (Chen et al., 1991; Molinna et al., 1983). Low temperature and high moisture results in high raw flour aroma. In addition high temperature and low moisture result in low raw flour aroma.

Several reasons have been advanced for the palatability of extrudates. During extrusion, starch is broken down into simpler components. Unpleasant volatile flavour components such as the beany taste of soybean are flashed off as the product is extruded from the barrels (Niele et al. 1980).

The cooking action of extruder increases the digestibility of protein and in some cases the availability

of amino acids by breaking down the secondary bonds of the protein molecules. The heat produced and short dwell time are not sufficient to destroy the amino acids. Extrusion also denatures antinutritive factors such as trypsin inhibitors and harmful enzymes.

The digestibility of starch is greatly improved by extrusion through a combination of gelatinisation and expansion. As the product passes through the extruder it gelatinises due to the effect of heat and moisture under pressure.

Extrusion affects fat in several ways:

- (i) the attrition and shear action cause walls of the oil bearing cells to rupture. This increases the availability of oil for digestion and hence the energy value of the raw material. In the extrusion of soybeans the bean is cooked and expand rapidly to deactivate the antimetabolites and rupture the oil cell. The liberated oil gives a product of liquid quality and as it flows across a shovel the extruded meal absorbed the oil (Brookwalter et al. 1971, Harper and Jansen,1985).
- (ii) Extrusion also results in improved stability of fat by destroying lipase which causes rancidity. The shear action and attrition also causes an increase in the proportion of digestible fibres.

## 2.7 MAIZE PROCESSING IN GHANA

Maize like other cereal provides a relatively good source of carbohydrate, protein and lipid which is essential to a balanced healthy diet.

Many varieties of maize are grown in Ghana. The varieties have different physical, chemical and functional characteristics which tend to affect their use in specific food product. The Proximate composition of some of the maize varieties are shown in Table 4. Ghana like most African countries has strong tradition associated with the type of food eaten and the processes applied for effective utilisation (Sefa-Dedeh, 1988).

Traditional food processing methods play an important role in the processing and utilisation of maize foods in Ghana (Sefa-Dedeh, 1993; Dovlo, 1970). Most of the maize products available on the market for direct use are ready to eat foods or the food ingredient is processed using simple traditional technologies. The method of preparation is deep rooted in tradition and among the techniques employed in processing is the method of fermentation.

Some of the fermented maize products are associated with some ethnic groups in Ghana. For example Ga kenkey (or komi) for the Gas and Fante kenkey for the fantes. Some of the products involving fermentation of maize during preparation include Ga kenkey, Fanti Kenkey, Hausa Koko, Maasa, etc. Spontaneous fermentation is used in the development of desired quality attributes (flavour, texture, taste, colour). e.g akasa (Fig.1).

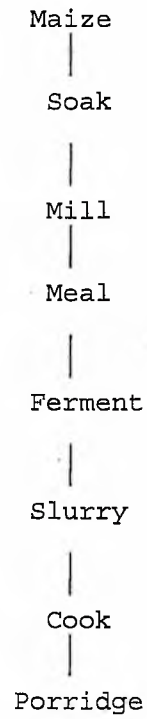
Table 4. PROXIMATE COMPOSITION OF SOME MAIZE VARIETIES IN  
GHANA

| VARIETY   | MOISTURE<br>CONTENTS | PERCENT<br>ASH | CRUDE<br>PROTEIN | FIBRE | FAT  |
|-----------|----------------------|----------------|------------------|-------|------|
| ABUROTIA  | 10.78                | 1.15           | 9.49             | 5.70  | 7.38 |
| COMPOSITE | 15.06                | 0.88           | 9.41             | 2.31  | 3.06 |
| DOBIDI    | 12.31                | 0.84           | 10.12            | 2.17  | 5.93 |
| HILYSINE  | 12.36                | 1.29           | 11.30            | 2.70  | 5.88 |
| LOCAL     | 10.42                | 1.19           | 10.37            | 2.30  | 2.66 |
| SAFITA    | 11.42                | 1.08           | 10.44            | 2.20  | 5.13 |

SOURCE: Sefa-Dedeh (1988)

Interim report research on maize varieties grown on  
Ghana. University of Ghana, Legon.

**FIGURE 1 AKASA (KOKO) PORRIDGE PREPARATION**



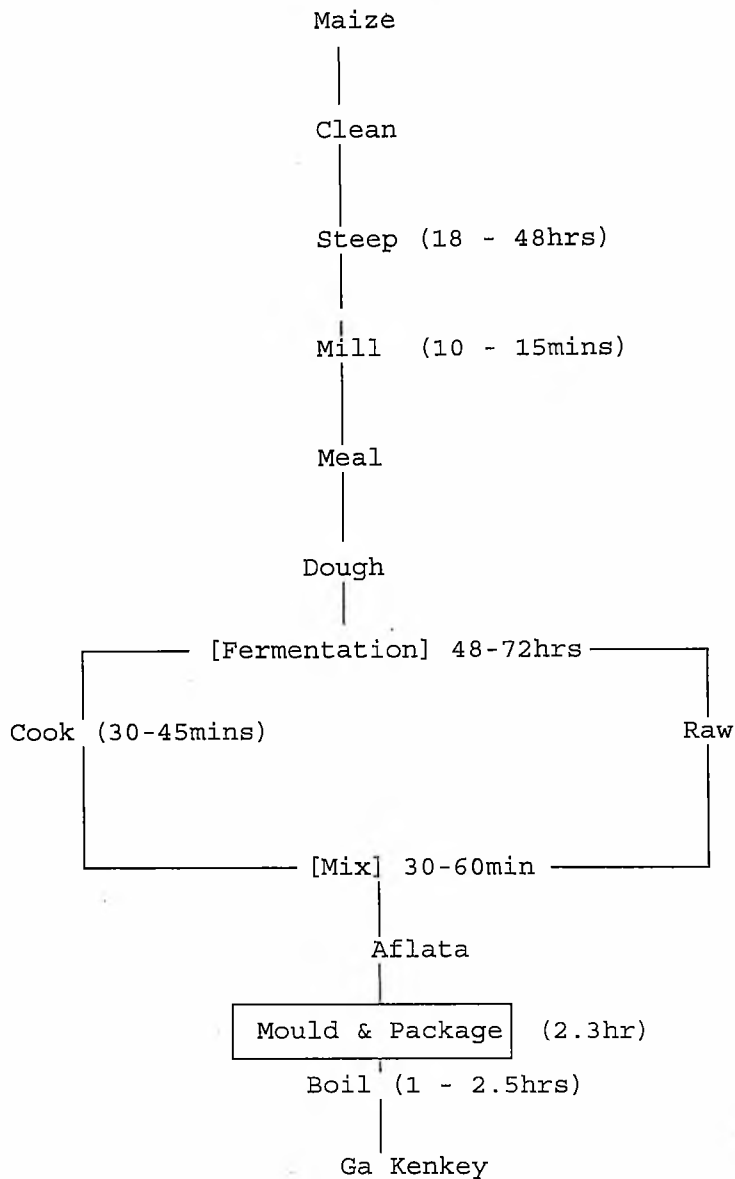
In Hausa koko preparation spices are added before fermentation. In addition combination of sorghum and corn can be used. In maasa processing spices are added before the fermentation stage and the milled maize dough obtained prepared into Aflata, fermented and fried.

#### **2.7.1 FERMENTATION OF MAIZE**

Methods of fermented dough preparation are not standard and wide variations exist in preparation and may depend on type of food product. Traditionally, maize dough preparation involves the general steps of steeping grains, milling, mixing into dough with water and spontaneous fermentation (1-3 days). Each of the stages in the maize dough preparation is important in achieving the desired characteristics, e.g. in Ga-kenkey processing (Fig. 2).

The soaking process softens the seed coat and the endosperm of the grain. Soaking also stimulates enzyme activity leading to breakdown of starch and increased proteolysis (Sefa-Dedeh, 1989) (Nyarko Mensah, 1972) The softening of the grain facilitates smooth milling and serves as first stage fermentation. Poor or inadequate softening results in chaffiness. Sefa-Dedeh, (1988) reported that the local variety of maize possesses good swelling characteristics compared to other high yielding varieties.

FIGURE 2 Ga kenkey processing



Source: Sefa-Dedeh, S. (1993)

Fanti kenkey production also follows the same process with difference only in the packaging material used.

Milling of the soaked grain serves several purposes such as to increase the surface area of maize grain to facilitate processes such as mixing, fermentation and cooking. The milling also helps develop desired sensory quality such as taste, colour and texture (Sefa-Dedeh, 1988). With increase in flour fineness, water absorption increased whereas properties such as bulk density and cooked paste viscosity decreased (Sefa-Dedeh, 1989). It was indicated that consumers preferred finely ground sample of fermented product.

Fermentation is an important step for development of flavour, texture, and aroma of food. The alteration of flavour and aroma is the result of microbial action which initiates a complex series of reactions involving namely carbohydrate, protein and fats.

The physicochemical, microbiological nutritional and sensory changes in fermented maize dough system has been documented by numerous researchers (Banigo and Muller, 1972; Plahar and Leung, 1982).

#### **2.7.2 PHYSICOCHEMICAL CHANGES DURING FERMENTATION**

Banigo and Muller (1972) identified eleven carboxylic acids in maize meal during fermentation of Ogi. The important acids they mentioned were lactic acid, acetic acid and butyric acid. Plahar and Leung (1982) working on the effects of moisture content on the development of carboxylic acids in traditional maize dough fermentation reported that the production of carboxylic acids during maize meal fermentation was influenced by the moisture content of dough. They

mentioned that high moisture content of 65% and 80% results in high concentration of acids. However the desired volatile to non volatile acids was achieved with 52% moisture level and at pH of 3.7.

Acetic acid, propionic acid and butyric acids are the major volatile acids they identified. The average maize dough has been reported to contain 49.3% moisture content, 37.5 starch, titrable acidity of 4.3mg/NaOH/g and pH of 3.76 (Plahar and Leung 1983).

The acid produced has several purposes according to Steinkrauss (1982):

- (i) it renders food resistant to spoilage by undesirable microorganism and development of food toxin.
- (ii) makes the food less likely to transfer pathogenic organism
- (iii) it modifies the flavour of original ingredient as in maize dough fermentation
- (iv) it enhances organoleptic and nutritional quality of the fermented product.

Associated with acid production is a corresponding decrease or fall in pH of maize dough during fermentation (Nketia 1979, Wayoe, 1987, Djokoto, 1982, Ackom-Quayson, 1993)

The lowering or reduction of pH of the dough which can be used to monitor the extent of fermentation is attributed to lactic acid and acetic acid production which are the end products of metabolism of sugar by glycolytic pathway. Functional properties such as water absorption capacity and swelling are affected by pH of the dough.

Plahar (1983) reported on storage stability of air-dried fermented maize dough. He observed that total soluble carbohydrate increase during storage when the dough was air dried. He also reported that changes in pasting properties occur during storage. Adeyemi et al. (1986) investigating into the storage stability of agidi, a Nigeria fermented maize product reported that the value of stability and index of gelatinisation were higher when the dough was prepared from dry milled flour than the wet milled.

### 2.7.3 MICROBIOLOGICAL, NUTRITIONAL AND SENSORY CHANGES IN MAIZE FERMENTATION

Microbiologically it has been reported that during fermentation of maize dough a mixed population of microflora develops in the dough. Dyer (1986) assessing the microflora and nutritional enhancement of corn meal during fermentation identified some of the microorganisms involve in fermentation as Lactobacillus brevis, Streptococcus faecalis, Aeromonas hydrophila, Enterobacter cloacae, Agrobacterium spp, Moraxella spp. These he mentioned produce vitamin B12 except Streptococcus faecalis which produces riboflavin. A mixed population of lactic acid bacteria and yeast in the dough has also been reported (Chompeeda et al., 1984; Djokoto, 1982)

Field et al. (1981) reported that natural lactic fermentation occurs when water is mixed with corn meal and incubated at 37°C. They isolated Lactobacillus fermentatum, Lactobacillus cellobiosus and Pediococcus acidilactic. They reported that viable coliforms, yeasts and molds disappear from the

fermentation by the second day.

Djokoto, (1982) indicated that Aspergillus penicillin and Rhizopus spp were involved in initial stage of maize dough fermentation. However at the start of the fermentation Lactic acid bacteria, Leuconostoc mesenteroides, Pediococcus cerevisiae were present. Aspergillus niger, Aspergillus flavus and Leuconostoc mesenteroides were all observed from the sixth hour and persisted and proliferated throughout the fermentation period.

Yeasts such as Endomycopsis , Saccharomyces candida, Torula and Saccharomycoides have been reported to be present during fermentation (Djokoto, 1982; Akinrele, 1970). Thus, the moisture content and storage temperature influence the growth and survival of the microorganism.

Frazier (1978) reported that bacteria and mold population decrease rapidly in corn meal with 13% moisture. Aspergillus niger and Aspergillus flavus were observed to be growing on the surface of the dough (Mensah et al., 1990).

Nutritionally the relative nutritive value (RNV) of fermented maize dough has been observed to increase during fermentation (Fields and Yao 1990; Lin et al., 1988) Field et al. (1990) reported on the nutritional improvement of maize meal by fermentation of Bacillus licheniformis and Enterobacter cloacae. The fermentation by the organism significantly increases the percent RNV. Amino acids such as methionine and Tryptophan content were reported to increase significantly. Enterobacter cloacae increased the lysine content and Total folacin significantly. Liu et al. (1988)

investigating the production of panthothenic acid by microorganism isolated from fermented corn meal observed that during fermentation panthothenic acid increased from 0.44mg/100g to 1.84 mg/100g samples after 3 days fermentation. Baccillus lincheniformis they indicate was partly responsible for the production of panthothenic acid. Fermentation by Baccillus lincheniformis and Enterobacter cloacae on corn meal results in the production of folic acid thus increase the percent relative nutritive value (Yao, 1989). Mixed culture of the two bacteria increased lysine, methionine, tryptophan and total folacin when compared to non-fermenting corn meal (Field et al., 1990).

Nanson et al. (1986) assessing the influence of pH on available amino acid concentration in fermented corn meal observed that the production of available amino acid and pH of the fermenting corn meal are related. They noticed that lysine is best produced at pH of 5.0-5.5. They also indicated that fermentation for 24 to 48hrs produces the highest concentration of available amino acids which decreases by the third or fourth day. Mold fermentation of maize gluten meal by Aspergillus oryzae and Rhizopus oligosporus has been mentioned to increase lysine content (Neuman et al., 1984)

Maize fermentation at 45°C also showed a high relative nutritive value and amino acid level (Nanson and Fields, 1984) Murdock et al. (1984) investigating the B-vitamin content of natural lactic and fermented corn meal observed that the maize fermentation results in increase in levels of vitamin B12, riboflavin and folacin. They also reported that fermentation

for 96hrs increased panthothenic acid. However no significant difference in niacin and biotin content was observed. The increase of riboflavin levels in fermenting maize meal was also confirmed by Dyer et al. (1986). Fluorometric measurement showed greater amount of riboflavin in the meal.

Adeyemi et al. (1986) investigating the effect of maize fermentation and souring on chemical properties and amylograph pasting viscosity of ogi reported that starch content decreases from 89.2% to 70.5%. Dry milling they observed increase starch damage. Amylograph stability, set back value or index of gelatinisation they observed decreases with fermentation.

Tongnual et al. (1981) also confirmed the increase in free amino acid and change in amino acid balance during natural fermentation of corn by proteolytic bacteria Pseudomonadaceae. The population of the bacteria decreased after 3 days of fermentation. Akobundu (1981) working on the development and evaluation of corn cowpea mixture as protein sources reported that fermentation has a marked effect on salt soluble protein of the mixture.

Fermentation by yeast he stated results in a significant reduction in the level of raffinose and stachyose. Little degradation of aflatoxin by fermentation of maize has been reported (Lillehoj, 1979).

The effect of addition of soyflour to fermented maize dough studied by Chompeeda et al. (1984) indicated that blends of autoclaved soybean meal and maize undergoing fermentation reduce raffinose and stachyose and increase lysine, methionine

and tryptophan in the blends. These increases in limiting amino acid result in increase in percent relative nutritive value. Addition of soybean meal to maize meal was found to decrease phosphorus (P) and Iron (Fe).

Plahar (1983) reported that consumer preference for maize dough fortified with 10% defatted soyflour was acceptable to Ghanaians. Soy fortification at 10% level he stated improved sensory preference and increase the protein quality of the blends.

### 3.0 MATERIALS AND METHODS

#### 3.1 MATERIALS

##### 3.1.1. MAIZE

Maize was obtained from the local market at Madina, a suburb of Accra. The local variety was purchased. This is the variety commonly used by the local food processors due to its desirable quality characteristics.

##### 3.1.2 SOYBEANS - VARIETY TGX 356<sup>D</sup>

Processed soybean flour were obtained from the Department of Nutrition and Food Science (University of Ghana). The soy flour were (a) Full-fat soy-flour (b) extruded soy-flour (c) Defatted soy-flour

###### (a) Full-fat Soy-flour

Soybeans were dehulled and milled in the laboratory hammer mill (CHRISTY AND NORRIS, ENGLAND) into fine flours and sieved.

###### (b) Extruded Soy-flour

Extruded soybean meal was prepared by passing partially defatted flour through a thermoplastic extruder.

###### (c) Defatted Soy-flour

Defatted soyflour was prepared by pressing oil from soybeans.

### 3.2 MAIZE DOUGH

Maize dough was prepared by adoption of traditional Ghanaian process described by Muller and Nyarko-Mensah (1972). Maize grains were washed and steeped in water for 18 hours and milled using the disc attrition mill (Straub Co. U.S.A., size 2A). The meal was kneaded in water (approximately 1:3 maize-water ratio) to form a dough of moisture content of about 50%. The dough was placed in plastic bowls and allowed to ferment at room temperature (29°C) for 0, 6, 24 and 48 hours.

### 3.3 SOY-FORTIFIED MAIZE DOUGH

The soy-flour was added at concentrations of 0%, 10% and 20% (dry matter basis) either (a) before, or (b) after fermentation of maize dough.

#### (a) ADDING SOY FLOUR BEFORE FERMENTATION

Soy flour (Full-fat, extruded and defatted) was added, each at concentrations of 10% and 20% (dry matter basis) to the maize dough. The mixture was thoroughly mixed and fermented for 0, 6, 24 and 48 hours respectively.

#### (b) ADDING SOY FLOUR AFTER FERMENTATION

Soy flour (Full-fat, extruded and defatted), was each mixed at concentration of 10% and 20% (DMB) with maize dough that was fermented at 0, 6, 24, and 48 hours.

### 3.4 EXPERIMENTAL METHODS

#### 3.4.1 CHEMICAL ANALYSIS

##### 3.4.1 (a) MOISTURE

The American Association of Cereal Chemists (AACC) method 44-40 was used. Approximately 2.0g of sample was used.

##### (b) PROTEIN

Protein content was determined using Macro-Kjeldahl method (Association of Official Analytical Chemists (AOAC) 1975 method 47-021).

##### (c) FAT

The (AOAC) method 7-066 (1975) was used.

##### (d) ASH

The (AOAC) method 2-049 was used.

##### (e) TOTAL TITRATABLE ACIDITY AND pH

Ten grams (dry matter basis) of sample was weighed and mixed with 100mL of carbon dioxide free distilled water. The slurry was stirred for 10 minutes using a magnetic stirrer. The pH of the slurry was measured using the pH meter at 25°C (TOA pH meter MODEL 30s). The slurry was allowed to settle and 5mL aliquots in triplicates pipetted in 250ml flasks. 50ml of distilled water was added and titrated against 0.1N NaOH to a phenolphthalein end point. The total acidity was calculated as percent lactic acid.

### 3.5 FUNCTIONAL PROPERTIES

#### 3.5.1 WATER ABSORPTION

Five grams of sample was mixed with 20mL of water in a centrifuge tube and left to stand for 30 mins at 29°C. The mixture was then centrifuged in a Denley BS 400 centrifuge (Page Scientific Inst., Hillside Berth, U.K.) at 3000 rpm for 30mins. The supernatant was poured out and the sample weighed. The amount of water retained in the sample was reported as water absorbed per 100g of sample (dry matter basis). Triplicate analysis was done. The measurement was repeated at 70°C.

The water absorption capacity was measured also at 70°C for comparison.

#### 3.5.2 VISCOSITY

The pasting properties of 10% (dmb) slurries of the samples were determined using the Brabender viscoamylograph (Brabender Instrument Co, Duisburg, Germany) equipped with a 700 cmg sensitivity cartridge. The sample was heated at 1.5°C/min from 25°C to 95°C, held at 95°C for 30mins and then cooled at the same rate to 50°C and held at 50°C for another 15mins.

### 3.6 FIELD SENSORY EVALUATION

Two Ga-kenkey processors were selected among six processors who were identified and interviewed. The two processors were selected based on their long experience in the

kenkey industry. Thirty one panellists were selected by preliminary compilation of names of consumers who patronise the kenkey processors product.

The selection was based on their level of education, frequency of consuming the product and their ability to read and understand a copy of the questionnaire used for the evaluation.

For fermented maize dough porridge , Akasa, 15 panellists were used. Soy-maize dough fortified with 20% soy-flour and fermented for 48hrs were used in the preparation of Ga kenkey and Akasa porridge.

The preference and difference tests were used in the evaluation. In the preference evaluation, panellists were asked to evaluate the coded sample by ranking the samples based on their degree of liking or preference on a 10 point scale for attributes of colour, texture, flavour, taste and acceptability.

In the difference test, ie. Triangle test, panellists were presented with three samples (two identical) in coded containers. Panellists were asked to select the different samples on the basis of colour, texture, flavour and taste.

The two processors were also asked to comment on the Soy Ga-kenkey.

### 3.7 STATISTICAL ANALYSIS

Data obtained was analyzed using STATGRAPHICS Version 4.2  
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## 4.0

## RESULTS AND DISCUSSION

## 4.1 Chemical Evaluation

The chemical composition of the soybean samples (Table 5) followed the known chemical characteristics of soybean which are high in protein and fat (Harper and Jansen, 1981; Ferrier, 1976; Lie *et al.*, 1974). The soy-maize dough (Table 6) had moisture content ranging from 49.01% to 54.24%. The protein content of the soy-maize dough also ranged from 16.72% to 23.27% which are high in contrast to that of maize dough without soy flour. Addition of soy-flour to maize dough can therefore be said to offer desired quality attributes such as the increase in protein contents.

Table 5. COMPOSITION OF PROCESSED SOYBEAN AND MAIZE FLOUR

|                      | MOISTURE<br>(%) | PROTEIN<br>N x 5.71 | FAT<br>(%) | ASH<br>(%) |
|----------------------|-----------------|---------------------|------------|------------|
| FULL-FAT<br>SOYFLOUR | 11.50           | 40.47±0.3           | 24.50±0.39 | 4.93±0.55  |
| EXTRUDED<br>SOYFLOUR | 7.16            | 43.15±0.17          | 15.89±0.07 | 5.49±0.71  |
| DEFATTED<br>SOYFLOUR | 7.59            | 50.36±0.22          | 8.44±0.13  | 6.14±0.04  |
| MAIZE<br>FLOUR       | 11.42           | * 9.83 ±0.47        | 5.71±0.03  | 1.07±0.09  |

Protein, Fat and Ash values on dry matter basis \* - N x 6.25

**Table 6. MOISTURE AND PROTEIN CONTENT OF MAIZE DOUGH CONTAINING DIFFERENT LEVELS OF SOYFLOUR**

| SOY TYPE | CONCENTRATION<br>(D.M.B) | MOISTURE<br>(%) | PROTEIN<br>N x 6.25 |
|----------|--------------------------|-----------------|---------------------|
| NO-SOY   | 0%                       | 54.24           | 10.2 ± 0.36         |
| FULL FAT | 10%                      | 52.29           | 16.72 ± 0.42        |
| FULL FAT | 20%                      | 50.21           | 20.54 ± 0.71        |
| EXTRUDED | 10%                      | 49.27           | 17.39 ± 0.66        |
| EXTRUDED | 20%                      | 49.01           | 21.56 ± 0.87        |
| DEFATTED | 10%                      | 50.31           | 20.71 ± 0.04        |
| DEFATTED | 20%                      | 49.77           | 23.27 ± 0.16        |

1 - Mean ± Standard Deviation

D.M.B. - dry matter basis

#### 4.2 pH Characteristics of Soy-fortified maize dough

One of the principal outcome of fermentation of maize dough is the production of acids and the concomitant changes in pH of the dough. Souring of fermented dough is a quality attribute affecting the flavour of fermented maize products.

The pH characteristics of soy-maize dough at 10% and 20% soy-level are shown in Figures 3 and 4.

Decrease in pH with increasing fermentation time was observed in all the samples irrespective of soy additions.

FIGURE 3.

EFFECT OF FERMENTATION TIME ON pH OF SOY-FORTIFIED MAIZE DOUGH  
(SOY ADDED BEFORE FERMENTATION OF MAIZE DOUGH)

A = 10% soy

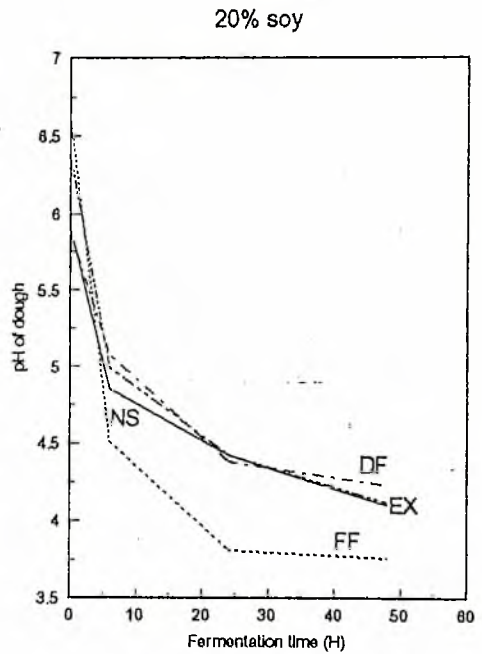
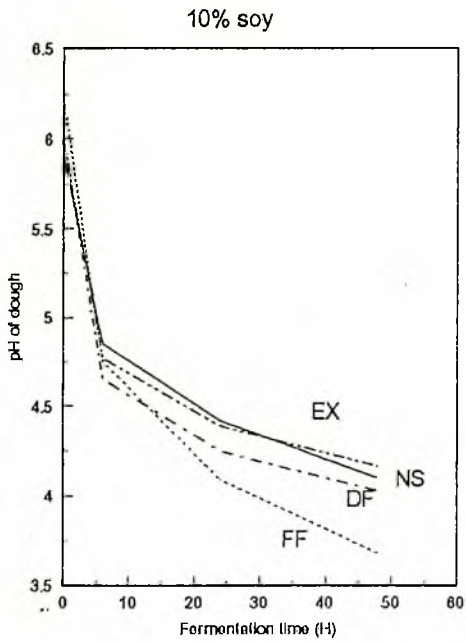
B = 20% soy

NS = No soy

EX = Extruded soy

DF = Defatted soy

FF = Full fat



NS = No soy  
EX = Extruded soy  
DF = Defatted soy  
FF = Full fat

FIGURE 4.

EFFECT OF FERMENTATION TIME ON pH OF SOY-FORTIFIED MAIZE DOUGH  
(SOY ADDED AFTER FERMENTATION OF MAIZE DOUGH)

A = 10% soy

B = 20% soy

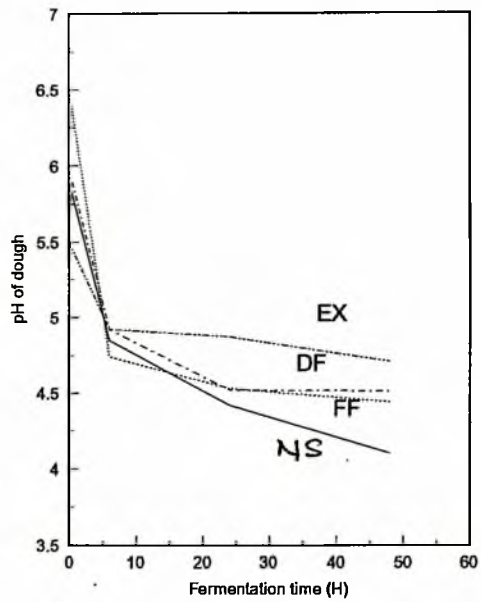
NS = No soy

EX = Extruded soy

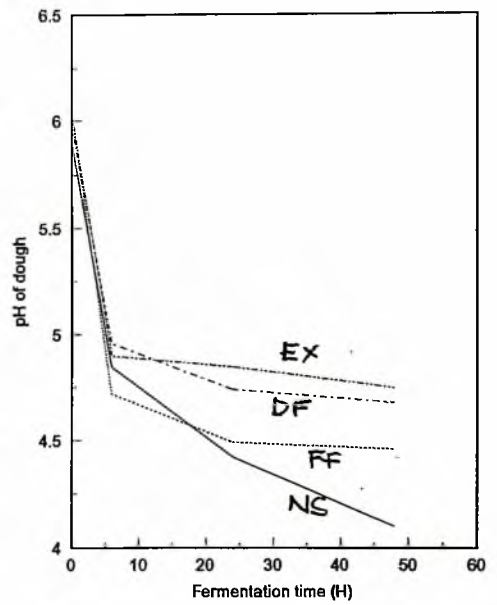
DF = Defatted soy

FF = Full fat

10% soy



20% soy



At 10% soy-level, extruded soy fortified dough showed similar trends as sample without the soy. This was observed when the soy-flour was added to the maize dough before fermentation. At 20% soy level, the defatted soy, extruded soy and the no-soy with no soybean dough respectively showed similar trends in pH characteristics.

The presence of full-fat soy flour in the dough may have stimulated acid production, with a concomitant lowering of the pH. This implies that addition of soybeans to maize dough prior to fermentation enhances the reduction in pH of the system. Except for the full-fat dough system all the dough with soybeans behaved close to the maize dough system.

Addition of soyflour to the dough after fermentation of the maize dough results in products with relatively high pH at all fermentation times. This was observed at different soy levels. The differences in pH in the effect due to different soy flours were more evident. This could result in reduction in sourness due to the soybean addition. Under the system, the dough without soy flour showed the lowest pH after 48 hours of fermentation followed by Full fat, defatted and Extruded samples respectively. Analysis of variance (ANOVA) on the data on pH (Table 7) shows that the method of addition of the soy, and fermentation time have significant effect ( $P < 0.05$ ) on dough pH. pH values in samples containing soyflour added before fermentation were lower than samples with soy added after fermentation.

The ANOVA also showed that the soyflour type added to the dough and concentration does not influence pH significantly. Further analysis from significant interaction shows that the pH

of dough at different fermentation time is affected by type of soy flour added and the method of addition.

**Table 7 ANALYSIS OF VARIANCE FOR SOY-MAIZE DOUGH pH**

| <u>Source of Variation</u> | <u>SS</u> | <u>df</u> | <u>MS</u> | <u>F</u> | <u>Sig Level</u> |
|----------------------------|-----------|-----------|-----------|----------|------------------|
| Main Effects               | 34.744    | 8         | 4.3430    | 134.32   | 0.000*           |
| Method of Addition         | 0.3886    | 1         | 0.3886    | 12.021   | 0.0013*          |
| Soy flour type             | 0.12457   | 2         | 0.6228    | 1.927    | 0.1589           |
| Soy-level                  | 0.20725   | 2         | 0.1036    | 3.205    | 0.0512           |
| Fermentation time          | 34.02367  | 3         | 11.3412   | 350.775  | 0.000*           |

\* = significant at  $p \leq 0.05$

**Multiple range analysis (LSD) for pH by Method of Addition**

| <u>Method of Addition</u> | <u>95 Percent Count</u> | <u>Confidence Average</u> | <u>Intervals Homogeneous Groups</u> |
|---------------------------|-------------------------|---------------------------|-------------------------------------|
| Before fermentation       | 36                      | 4.8025000                 | A                                   |
| After fermentation        | 36                      | 4.9494444                 | B                                   |

**Multiple range analysis for pH by Fermentation Time**

| <u>Fermentation time (H)</u> | <u>95 Percent Count</u> | <u>Confidence Average</u> | <u>Intervals Homogeneous Groups</u> |
|------------------------------|-------------------------|---------------------------|-------------------------------------|
| 48                           | 18                      | 4.2283333                 | A                                   |
| 24                           | 18                      | 4.4366667                 | B                                   |
| 6                            | 18                      | 4.8333333                 | C                                   |
| 0                            | 18                      | 6.0055556                 | D                                   |

#### 4.2.1 Regression Models for pH

A regression model was developed for pH of the dough for predictive evaluation of the dough (Table 8).

The model for the pH used is shown below:

$$Y_1 = a_1 + b_1X_1 + b_2X_2 + b_3X_1^2 + b_4X_2^2 + CX_1X_2 \dots$$

where

Y = pH of the dough

X<sub>1</sub> = Fermentation time

X<sub>2</sub> = Soy flour concentration or level

a<sub>1</sub>, b<sub>1</sub>, b<sub>2</sub>, b<sub>3</sub>, b<sub>4</sub>, C - coefficients.

The Regression equation for pH of the dough samples are shown in Table 8. For each of the Soy fortified maize dough, the relationship between pH, fermentation time and Soy level can be predicted based on the equation. The lowest pH attained for each sample in the system can be calculated. The response surface plots indicate the lowest pH for the models can be attained at a fermentation time of about 36 hours (Fig. 5-10). The pH of the dough did not change with increase in soy level for models of soy-fortified maize dough where full fat was added after fermentation (FFAF) or where extruded soy (EXBF) or defatted soy were added before fermentation (DFBF). The pH of the model containing full fat (FFBF), extruded (EXAF), defatted (DFAF) respectively changes with change in soy level in the dough. For each of the model therefore the pH of the dough can be predicted from the fermentation time and soy-level in the dough.



Table 8. REGRESSION MODEL FOR pH OF SOY-MAIZE DOUGH

| SOY MAIZE DOUGH TYPE | R <sup>2</sup> | REGRESSION EQUATION                                 |
|----------------------|----------------|---|
| FULL-FAT (FFBF)      | 0.7728         | $5.98 - 0.126 (x_1) + 0.007 (x_2) + (0.001x_1^2)$   |
| EXTRUDED (EXBF)      | 0.8169         | $5.74 - 0.0976 (x_1) - 0.008 (x_2) + (0.0013x_1^2)$ |
| DEFATTED (DFBF)      | 0.8447         | $5.67 - 0.093 (X_1) + 0.002 (X_2) + (0.0013X_1^2)$  |
| FULL-FAT (FFAF)      | 0.6828         | $5.76 - 0.099 (X_1) + 0.005 (X_2) + (0.001X_1^2)$   |
| EXTRUDED (EXAF)      | 0.6331         | $5.43 - 0.064 (X_1) + 0.016 (X_2) + (0.0008X_1^2)$  |
| DEFATTED (DFAF)      | 0.7837         | $5.496 - 0.076 (X_1) + 0.014 (X_2) + (0.001X_1^2)$  |

X<sub>1</sub> Fermentation time      X<sub>2</sub> Soy-level

FIGURE 5

RESPONSE SURFACE PLOT ON THE EFFECT OF FERMENTATION AND SOY CONCENTRATION ON pH OF DEFATTED SOY FORTIFIED MAIZE DOUGH (DFAF)

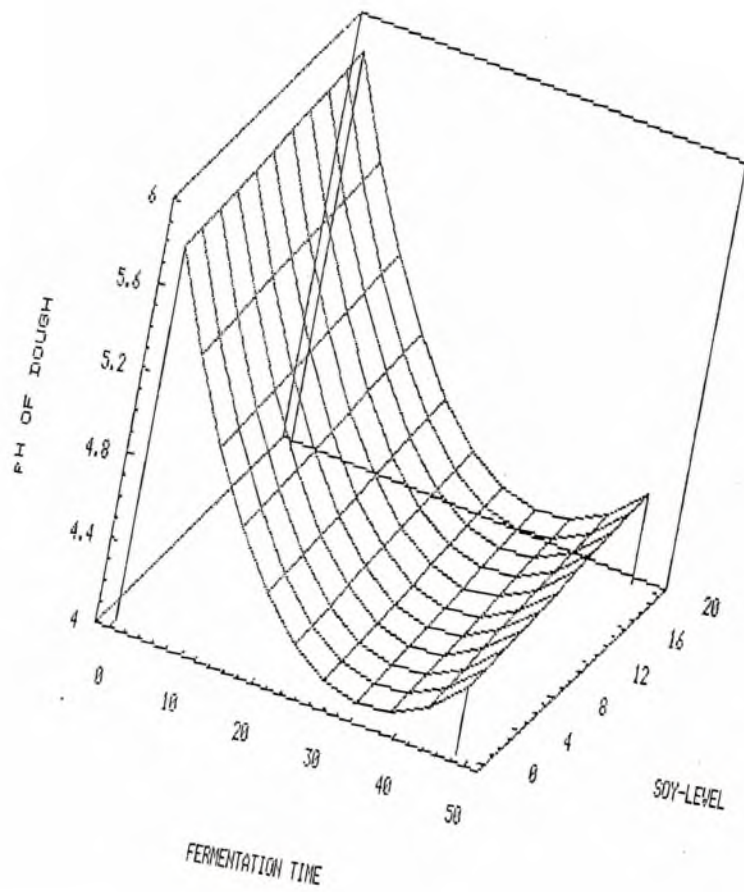


FIGURE 6

RESPONSE SURFACE PLOT ON THE EFFECT OF FERMENTATION AND SOY  
CONCENTRATION ON pH OF EXTRUDED SOY FORTIFIED MAIZE DOUGH (EXAF)

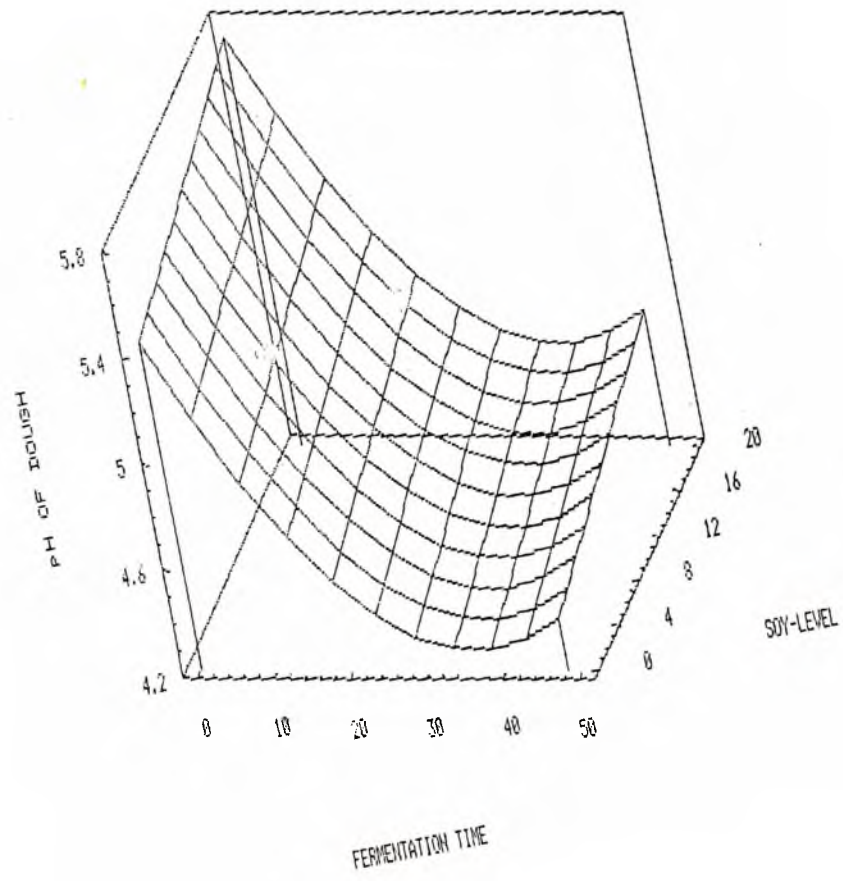
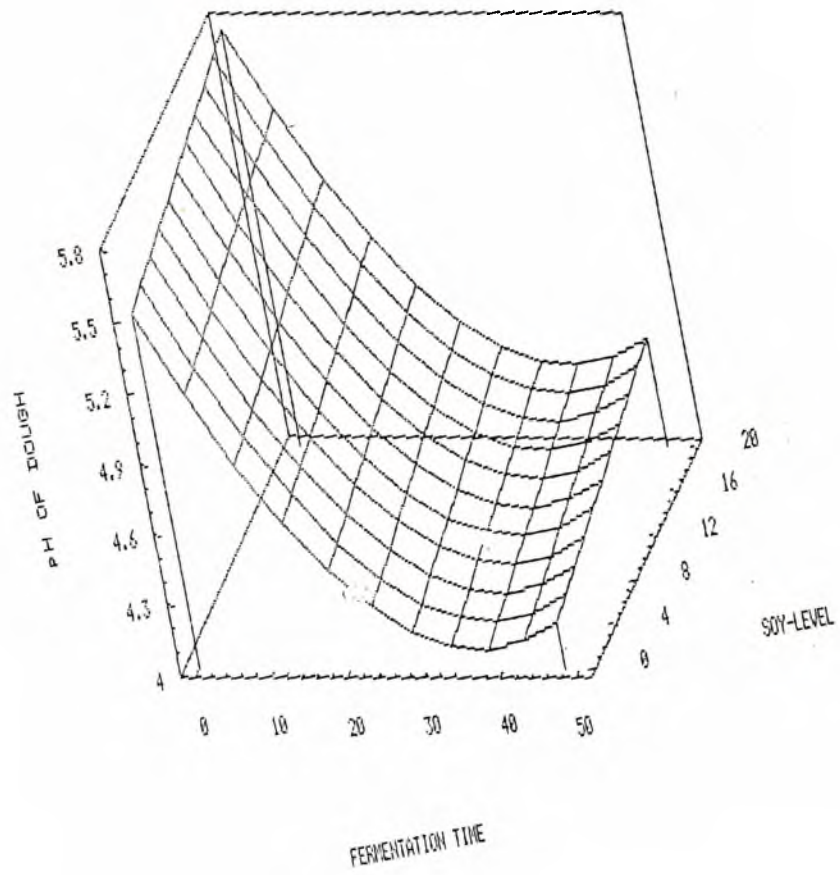
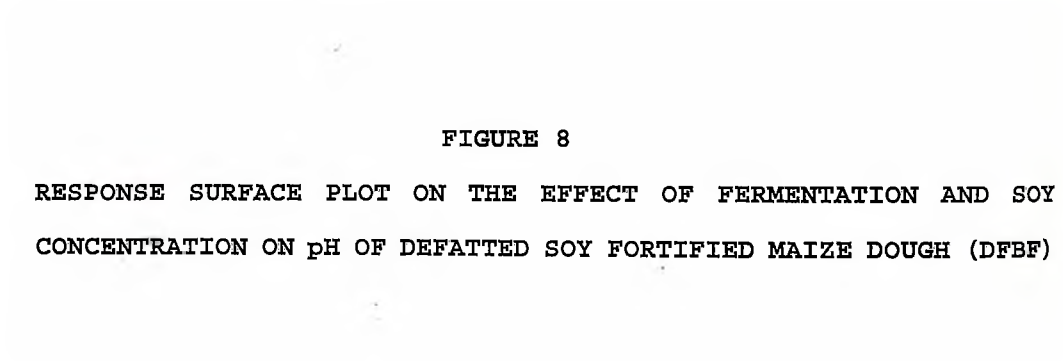


FIGURE 7

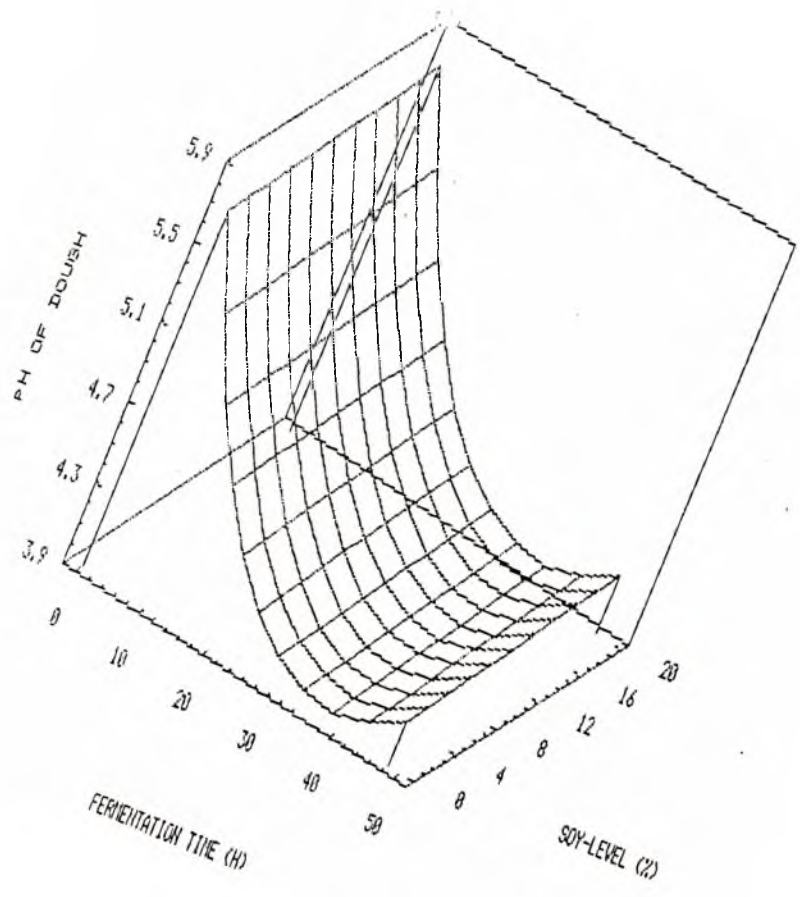
RESPONSE SURFACE PLOT ON THE EFFECT OF FERMENTATION AND SOY  
CONCENTRATION ON pH OF FULL FAT SOY FORTIFIED MAIZE DOUGH (FFAF)





**FIGURE 8**

**RESPONSE SURFACE PLOT ON THE EFFECT OF FERMENTATION AND SOY CONCENTRATION ON pH OF DEFATTED SOY FORTIFIED MAIZE DOUGH (DFBF)**



**FIGURE 9**  
**RESPONSE SURFACE PLOT ON THE EFFECT OF FERMENTATION AND SOY**  
**CONCENTRATION ON pH OF EXTRUDED SOY FORTIFIED MAIZE DOUGH (EXBF)**

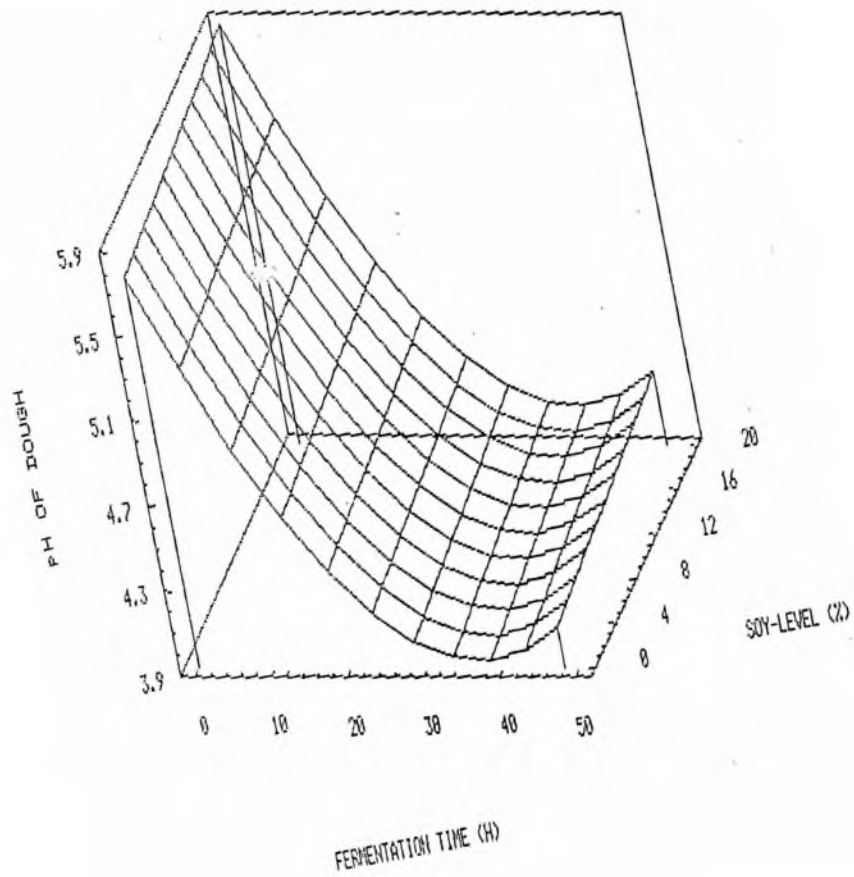
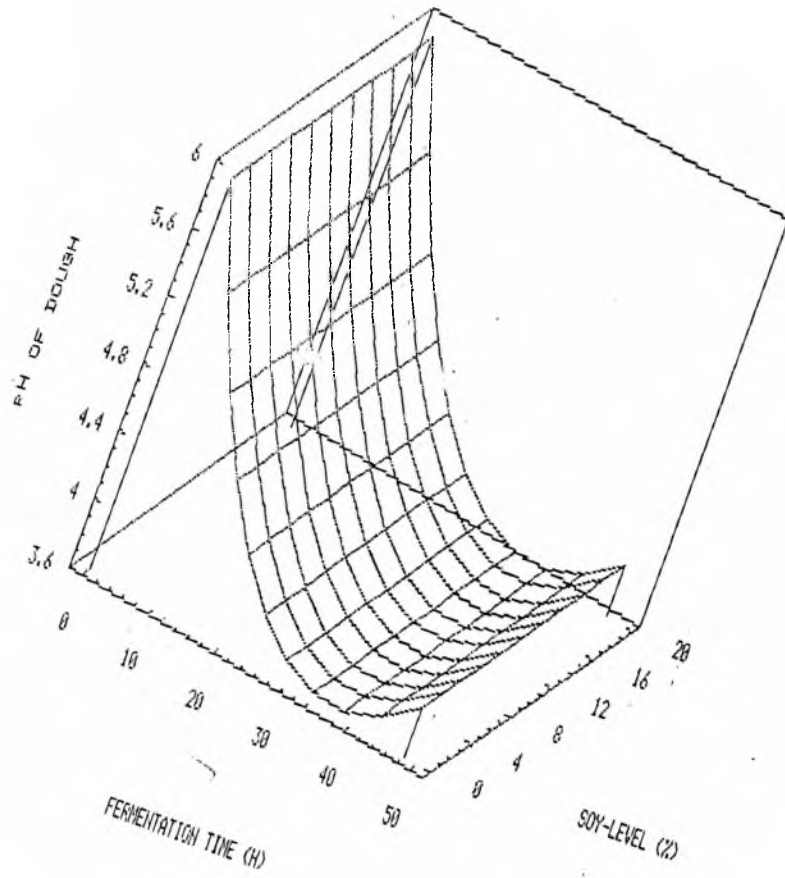


FIGURE 10

RESPONSE SURFACE PLOT ON THE EFFECT OF FERMENTATION AND SOY CONCENTRATION ON pH OF FULL-FAT SOY FORTIFIED MAIZE DOUGH (FFBF)



#### 4.3 ACIDITY CHARACTERISTICS OF-SOY MAIZE DOUGH

The acidity of fermented foods is very important because it affects the flavour and aroma. The effect of fermentation on acidity of soy-maize dough are shown in Figs. 11 and 12. The Acidity increases as fermentation proceeds. This was noted for all the dough sample irrespective of the method of addition of Soy and concentration of soy in the sample. However differences exist in the rates of acid development in the dough. For samples containing soyflour added before fermentation differences in sample acidity after 24 and 48 hours of fermentation was noted. By comparing the acidity results with the pH - fermentation time graph the differences in trends indicate that not all acids produced in the soy-dough samples may be easily ionizable to be detected by the pH meter. It can be indicated that even though the pH of the dough samples appear similar (Figs 9 & 10), the acidity measured through titration showed wide differences.

The dough containing the Full-fat soy showed the highest acid production at both 10% and 20% Soy-fortification level. This suggests that the full-fat soy seems to promote acid production. Addition of soyflour to the maize dough after fermentation generally leads to the reduction of the acid produced.

The extent of the dilution effect was greater with extruded soy, defatted soy and full fat soy respectively and in order of decreasing dilution effect. The dilution effect of the soy appears to increase with increasing soy concentration.

FIGURE 11

EFFECT OF FERMENTATION TIME ON ACIDITY OF SOY-FORTIFIED MAIZE DOUGH (SOY ADDED BEFORE FERMENTATION OF MAIZE DOUGH)

A = 10% soy  
B = 20% soy

NS = No soy  
EX = Extruded soy  
DF = Defatted soy  
FF = Full fat

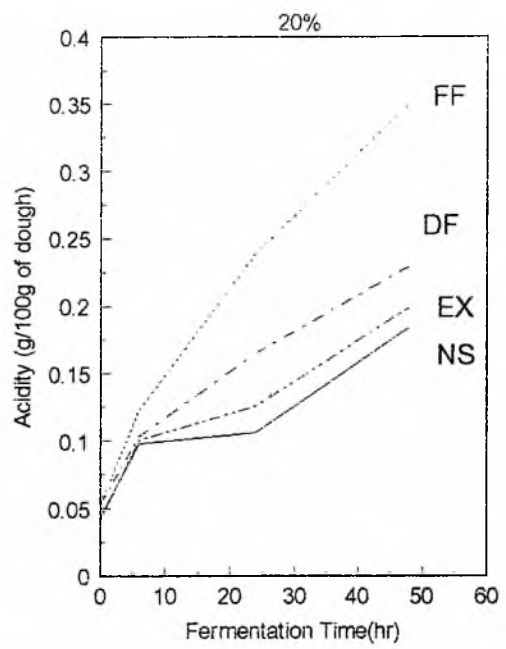
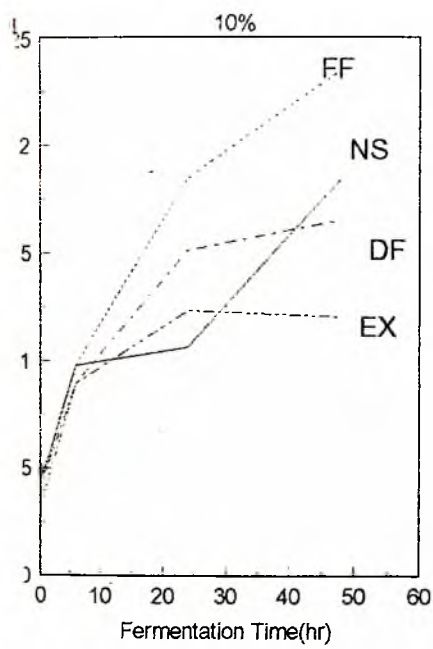


FIGURE 12

EFFECT OF FERMENTATION TIME ON ACIDITY OF SOY-FORTIFIED MAIZE DOUGH (SOY ADDED AFTER FERMENTATION OF MAIZE DOUGH)

A = 10% soy

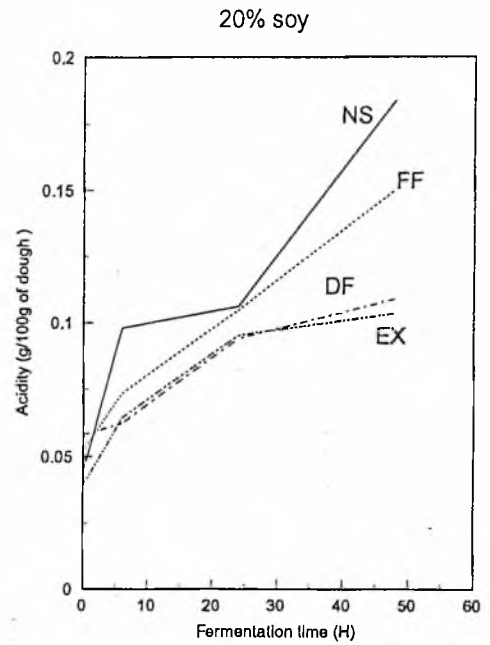
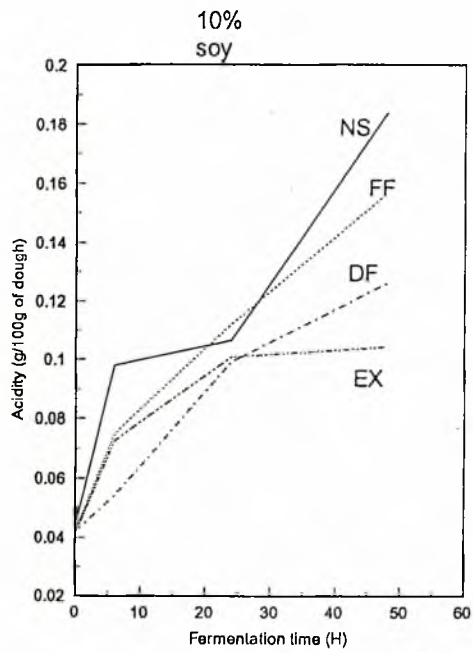
B = 20% soy

NS = No soy

EX = Extruded soy

DF = Defatted soy

FF = Full fat



- NS = No soy
- \*\* EX = Extruded soy
- DF = Defatted soy
- FF = Full fat soy

Analysis of Variance (ANOVA) Table 9 on Acidity indicate that the method of soy addition, the soy flour type and concentration in the dough and fermentation time influenced the acid production significantly. Generally, acid production was higher in the dough to which the soy was added before fermentation. In addition the acid production was even higher at 20% soy level irrespective of the soy flour type. Multiple Range analysis(LSD) also indicate there was no significant difference in Acidity between soy-fortified maize dough containing 0% and 10% soylevel respectively. Multiple range analysis also showed that total acidity values of soy-fortified maize dough prepared by adding soy to the maize dough before fermentation were generally higher than the dough in which the soy was added after fermentation.

**Table 9 ANALYSIS OF VARIANCE FOR SOY-MAIZE DOUGH ACIDITY**

| <u>Source of Variation</u> | <u>SS</u> | <u>df</u> | <u>MS</u> | <u>F</u> | <u>Sig Level</u> |
|----------------------------|-----------|-----------|-----------|----------|------------------|
| Main Effects               | 0.1948    | 8         | 0.024     | 56.61    | 0.000*           |
| Method of Addition         | 0.0177    | 1         | 0.017     | 41.05    | 0.000*           |
| Soy flour type             | 0.0088    | 2         | 0.004     | 10.33    | 0.002*           |
| Soy-level                  | 0.0032    | 2         | 0.0016    | 3.71     | 0.332            |
| Fermentation time          | 0.1650    | 3         | 0.055     | 127.91   | 0.000*           |

\* = significant at  $p \leq 0.05$

**MULTIPLE RANGE ANALYSIS FOR TOTAL ACIDITY**

**ACIDITY BY FERMENTATION TIME**

| <u>Fermentation Time (hrs)</u> | <u>95 Percent Count</u> | <u>Confidence Average</u> | <u>Intervals Homogeneous Groups</u> |
|--------------------------------|-------------------------|---------------------------|-------------------------------------|
| 0                              | 18                      | 0.045                     | A                                   |
| 6                              | 18                      | 0.088                     | B                                   |
| 24                             | 18                      | 0.124                     | C                                   |
| 48                             | 18                      | 0.175                     | D                                   |

## ACIDITY BY SOY-LEVEL

| Soy level | 95 Percent<br>Count | Confidence Intervals |                    |
|-----------|---------------------|----------------------|--------------------|
|           |                     | Average              | Homogeneous Groups |
| 10%       | 24                  | 0.100                | A                  |
| 0%        | 24                  | 0.108                | A                  |
| 20%       | 24                  | 0.116                | B                  |

## MULTIPLE RANGE ANALYSIS (LSD) FOR ACIDITY BY SOY FLOUR TYPE

| Soy flour<br>Type   | 95 Percent<br>Count | Confidence Intervals |                    |
|---------------------|---------------------|----------------------|--------------------|
|                     |                     | Average              | Homogeneous Groups |
| Extruded            | 24                  | 0.096                | A                  |
| Defatted            | 24                  | 0.104                | A                  |
| Full fat            | 24                  | 0.123                | B                  |
| Method of Addition  |                     |                      |                    |
| After fermentation  | 36                  | 0.092                | A                  |
| Before fermentation | 36                  | 0.123                | B                  |

## 4.3.1 Regression Model for Acidity

A regression model was also developed to predict the acidity at different soy level and fermentation time. From the model equation (Table 10) and corresponding plots acidity of the soy-maize dough system can be predicted. Response surface plot for acidity indicate the following (Figs. 13-18)

(i) In the products containing Full fat soy (FFAF), the model suggests that acidity does not change with change in soy-flour level.

(ii) In the products containing Extruded soy and Defatted soy the model suggests that the highest acidity was obtained at high fermentation time (48hrs) and lower soy concentration. At lower fermentation time, soy concentration can be increased without change in acidity.

(iii) In products containing defatted soy (DFBF), Full-fat (FFBF), respectively, higher acidity was achieved at long fermentation time and soy level in the dough.

Table 10 REGRESSION MODEL FOR ACIDITY

| SOY MAIZE<br>DOUGH TYPE | R <sup>2</sup> | REGRESSION<br>EQUATION   |
|-------------------------|----------------|--|
| FULL-FAT (FFBF)         | 0.9575         | $0.047 + 0.0047(X_1) +$<br>$0.0008(X_2) - 0.000048(X_1)^2$<br>$+ 0.000172(X_1X_2)$ |
| EXTRUDED (EXBF)         | 0.7304         | $0.056 + 0.002(X_1) + 0.0004(X_2)$   |
| DEFATTED (DFBF)         | 0.8616         | $0.058 + 0.002(X_1) + 0.0006(X_2)$<br>$+ 0.000047(X_1X_2)$                         |
| FULL-FAT (FFAF)         | 0.9179         | $0.062 + 0.0022(X_1) -$<br>$0.00065(X_2)$  |
| EXTRUDED (EXAF)         | 0.7720         | $0.059 + 0.002(X_1) -$<br>$0.0004(X_2) - 0.000064(X_1X_2)$                         |
| DEFATTED (DFAF)         | 0.8679         | $0.054 + 0.002(X_1)$<br>$+ 0.00002(X_2) -$<br>$(0.000071(X_1)^2)$                  |

$X_1$  = Fermentation time

$X_2$  = Soy flour level

FIGURE 13

RESPONSE SURFACE PLOT ON THE EFFECT OF FERMENTATION AND SOY CONCENTRATION ON ACIDITY OF DEFATTED SOY FORTIFIED MAIZE DOUGH (DFBF)

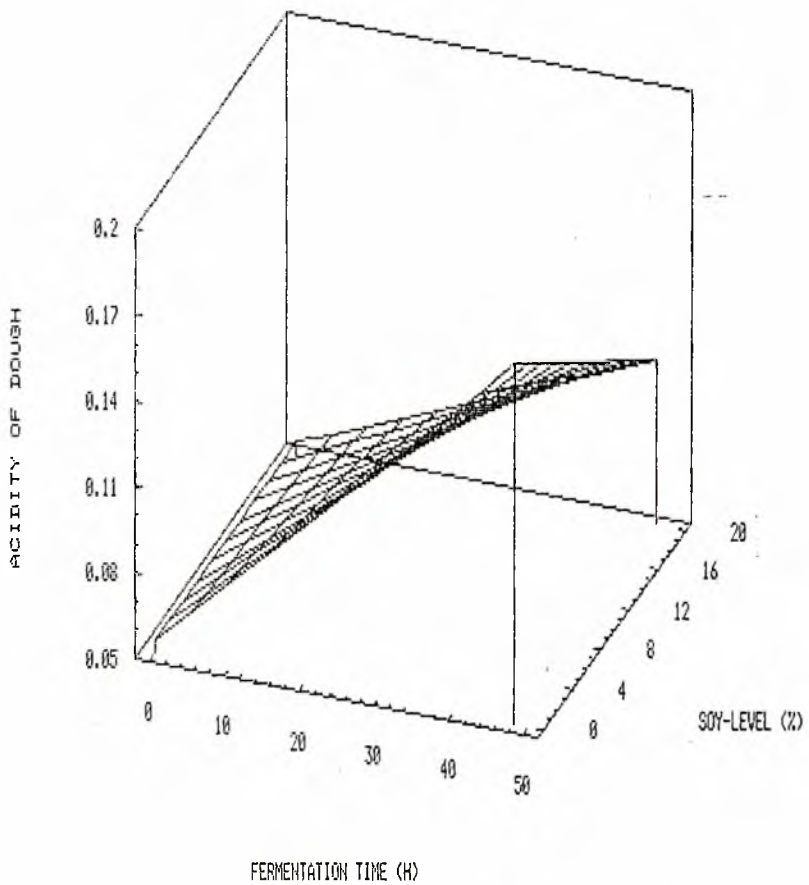


FIGURE 14

RESPONSE SURFACE PLOT ON THE EFFECT OF FERMENTATION AND SOY  
CONCENTRATION ON ACIDITY OF EXTRUDED SOY FORTIFIED MAIZE DOUGH  
(EXAF)

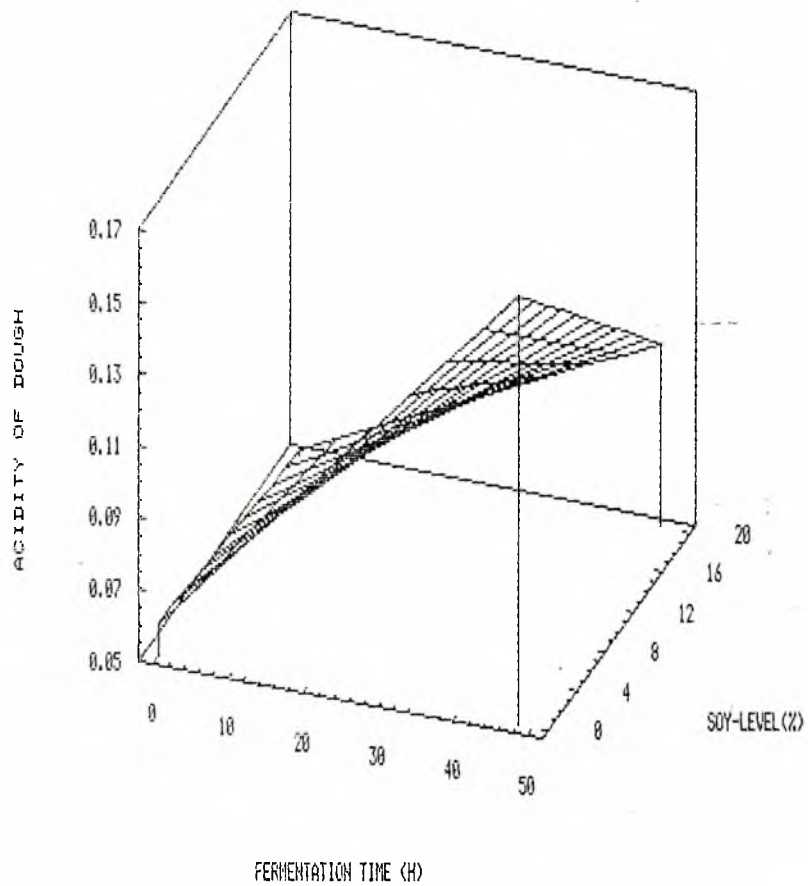
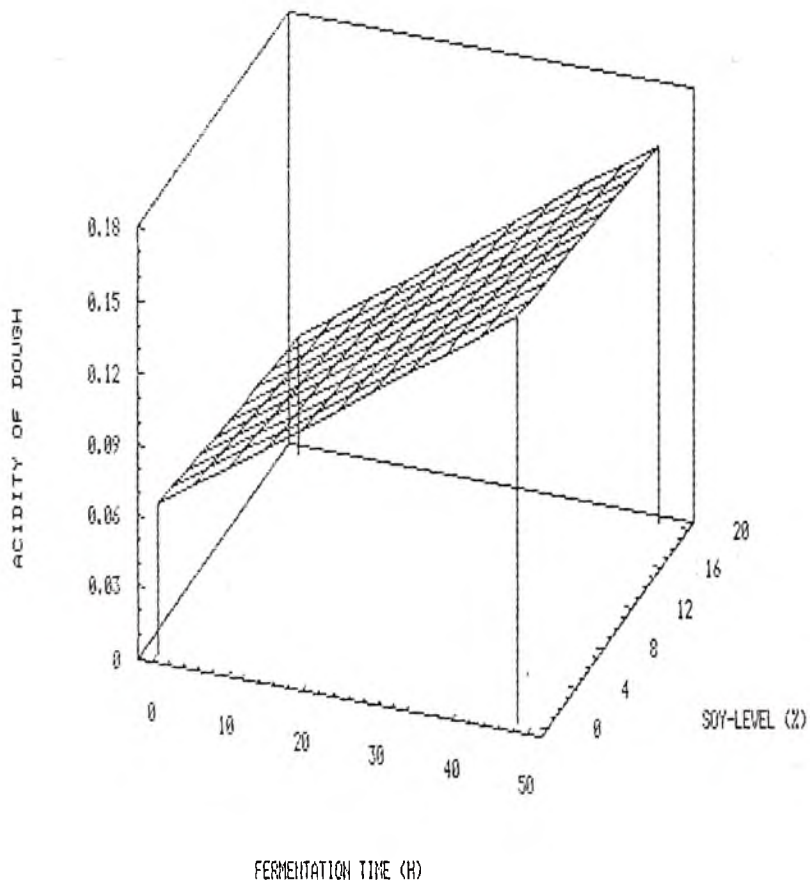


FIGURE 15

RESPONSE SURFACE PLOT ON THE EFFECT OF FERMENTATION AND SOY  
CONCENTRATION ON ACIDITY OF FULL-FAT SOY FORTIFIED MAIZE DOUGH  
(FFAF)



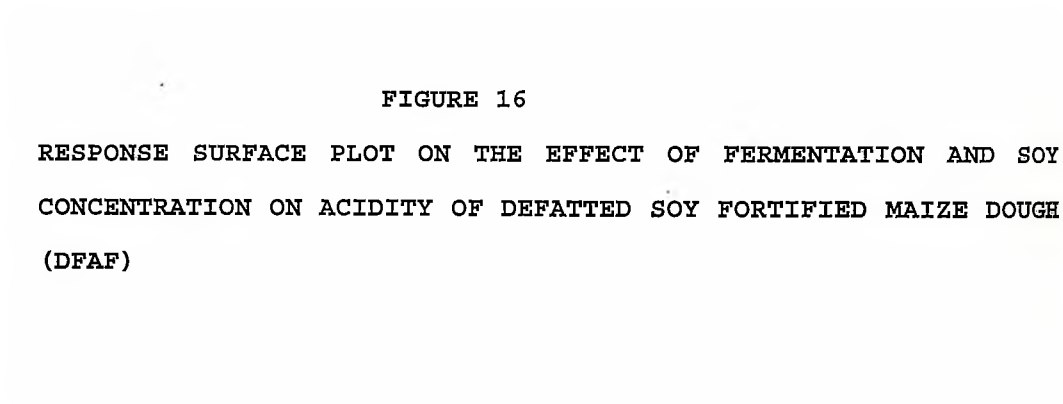


FIGURE 16

RESPONSE SURFACE PLOT ON THE EFFECT OF FERMENTATION AND SOY CONCENTRATION ON ACIDITY OF DEFATTED SOY FORTIFIED MAIZE DOUGH (DFAF)

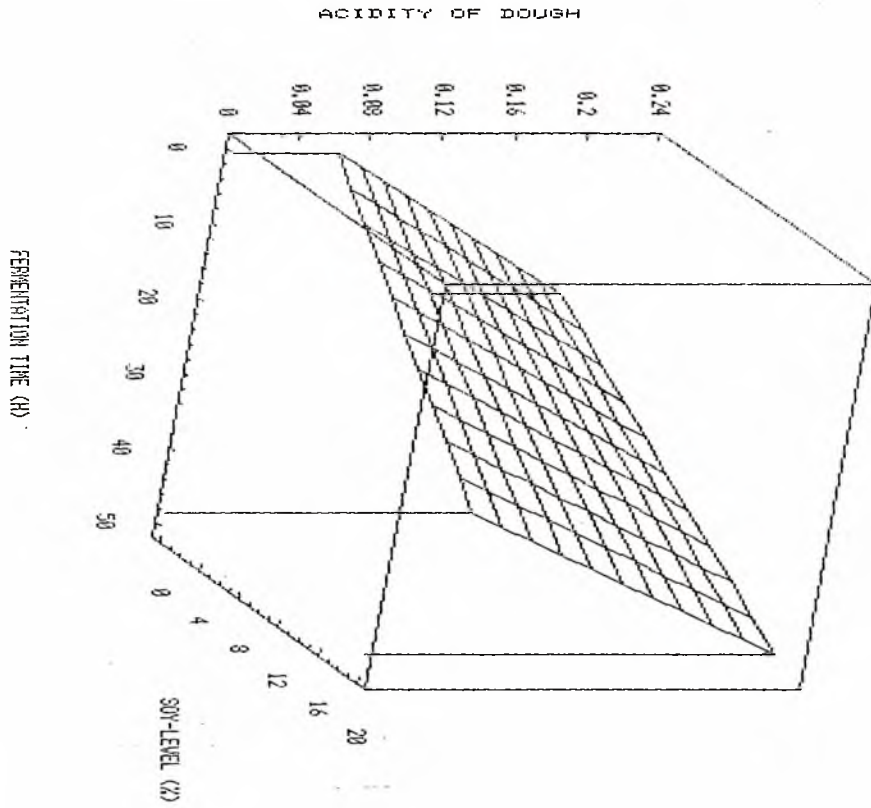
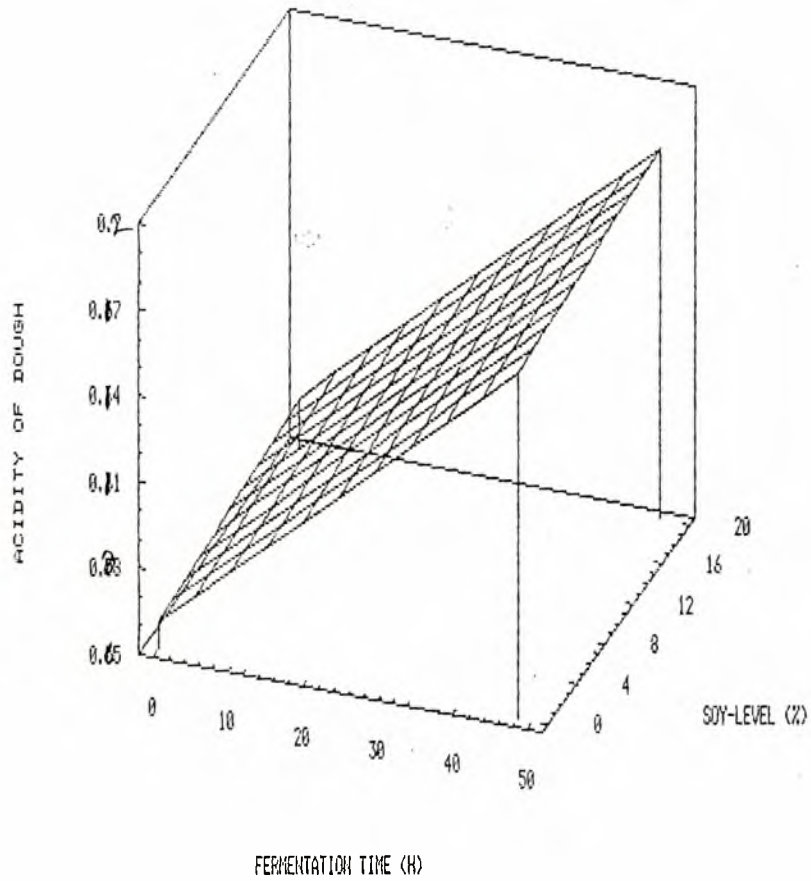
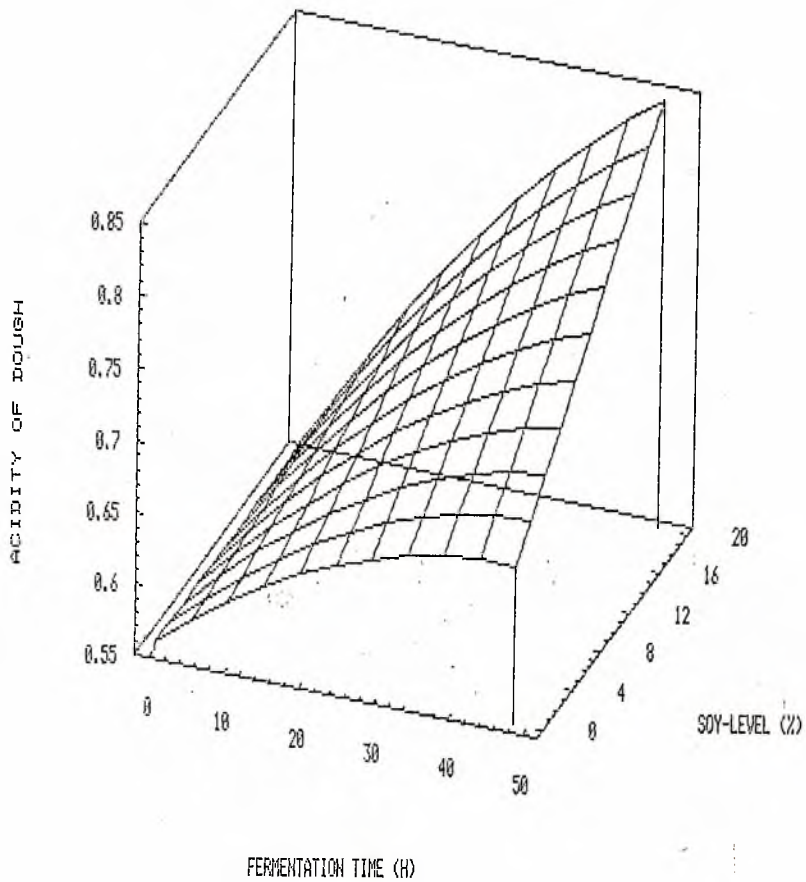


FIGURE 17  
RESPONSE SURFACE PLOT ON THE EFFECT OF FERMENTATION AND SOY  
CONCENTRATION ON ACIDITY OF EXTRUDED SOY FORTIFIED MAIZE DOUGH  
(EXBF)



**FIGURE 18**

**RESPONSE SURFACE PLOT ON THE EFFECT OF FERMENTATION AND SOY  
CONCENTRATION ON ACIDITY OF FULL-FAT SOY FORTIFIED MAIZE DOUGH  
(FFBF)**



#### 4.4 WATER ABSORPTION CHARACTERISTICS OF SOY-MAIZE DOUGH

Water absorption capacity changes in the Soy-maize samples as fermentation proceeds shows different trends and patterns which appear to have same relationship with the fermentation process and temperature (Fig.19-22). Generally water absorption at 70°C was higher than 29°C. Proteins are the primary sites for water absorption (Sefa-Dedeh, et al., 1988) and the binding sites become more exposed on application of mild heat treatment resulting in increased water absorption (Holmes et al., 1982), Philips et al., 1988).

Water absorption also appears to increase as fermentation proceeds especially in the samples in which the soyflour was added after fermentation of the dough. The water absorption of the Soy fortified-maize dough is generally higher when the soy flour was added to the maize dough after fermentation than before dough fermentation. The defatted soy fortified samples generally appear to show high water absorption perhaps due to higher increased binding sites. This may indicate the effect of soy processing on water absorption.

Increasing soy level from 10% to 20% has no significant change in the water absorption capacity. ANOVA (Table 11) indicates the temperature of dough and fermentation time are the only significant factors that influence water absorption. Thus the soyflour type, amount added or whether it is added before or after fermentation do not influence the water absorption capacity of the product at any given temperature.

Multiple range analysis indicated that water absorption after 48 hours was not significantly different from the 24 hours fermentation time but was significantly different from the samples fermented for 0 and 6 hours.

Table 11

## ANALYSIS OF VARIANCE FOR WATER ABSORPTION OF SOY-MAIZE DOUGH

| <u>Source of Variation</u> | <u>SS</u>      | <u>df</u> | <u>MS</u>      | <u>F</u>     | <u>Sig Level</u> |
|----------------------------|----------------|-----------|----------------|--------------|------------------|
| Main Effects               | 1289930.1      | 9         | 143325.6       | 33.078       | 0.000*           |
| Method of Addition         | 10392.8        | 1         | 10392.8        | 2.398        | 0.1241           |
| Temperature                | 1219835.4      | 1         | 1219835.4      | 281.479      | 0.000*           |
| Soyflour type              | 7915.6         | 2         | 3957.8         | 0.913        | 0.4040           |
| Soy flour level            | 5866.5         | 2         | 2933.2         | 0.677        | 0.5101           |
| <u>Fermentation time</u>   | <u>48249.8</u> | <u>3</u>  | <u>16083.3</u> | <u>3.711</u> | <u>0.0135</u>    |

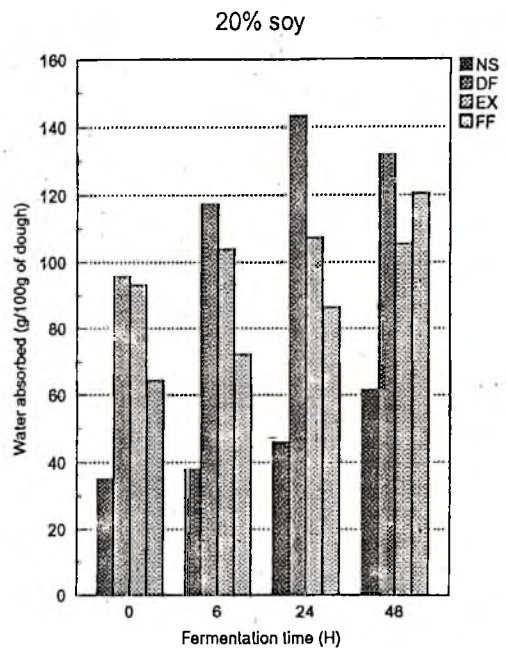
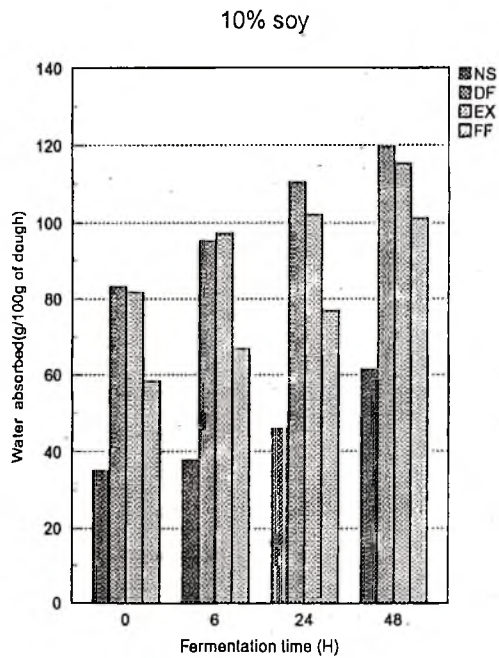
\* = significant at  $p \leq 0.05$

FIGURE 19.

EFFECT OF FERMENTATION TIME ON WATER ABSORPTION OF SOY-FORTIFIED  
MAIZE DOUGH AT 29°C (SOY ADDED AFTER FERMENTATION OF MAIZE DOUGH)

A = 10% soy  
B = 20% soy

NS = No soy  
EX = Extruded soy  
DF = Defatted soy  
FF = Full fat



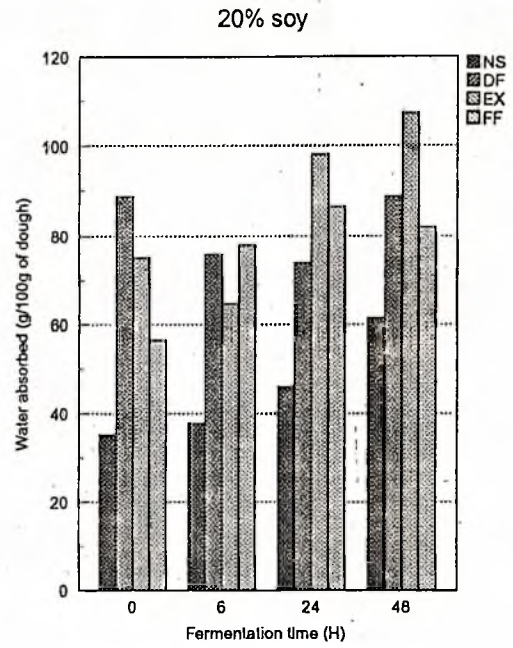
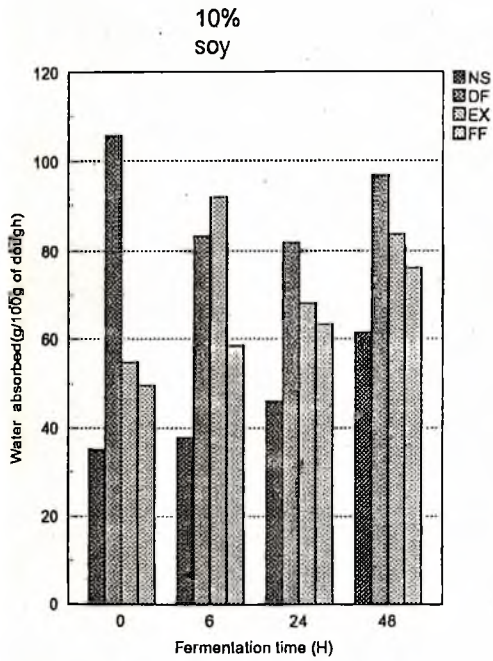
\*NS = No soy  
 DF = Defatted soy  
 EX = Extruded soy  
 FF = Full fat soy

FIGURE 20.

EFFECT OF FERMENTATION TIME ON WATER ABSORPTION OF SOY-FORTIFIED  
MAIZE DOUGH AT 29°C (SOY ADDED BEFORE FERMENTATION OF MAIZE  
DOUGH)

A = 10% soy  
B = 20% soy

NS = No soy  
EX = Extruded soy  
DF = Defatted soy  
FF = Full fat

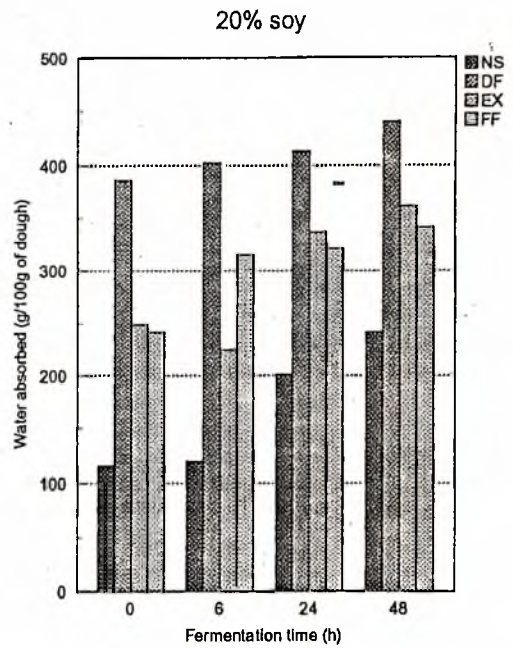
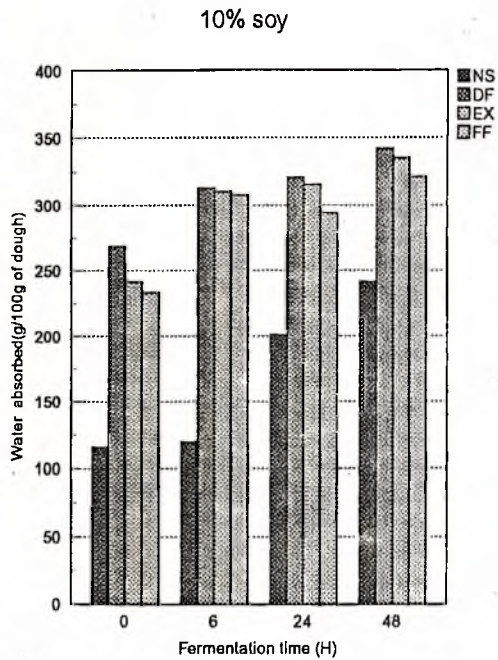


NS, No soy  
 DF = Defatted soy  
 EX = Extruded soy  
 FF = Full fat

FIGURE 21.  
EFFECT OF FERMENTATION TIME ON WATER ABSORPTION OF SOY-FORTIFIED  
MAIZE DOUGH AT 70°C  
(SOY ADDED AFTER FERMENTATION OF MAIZE DOUGH)

A = 10% soy  
B = 20% soy

NS = No soy  
EX = Extruded soy  
DF = Defatted soy  
FF = Full fat



NS = No soy  
 DF = Defatted soy  
 EX = Extruded soy  
 FF = Full fat

FIGURE 22.

EFFECT OF FERMENTATION TIME ON WATER ABSORPTION OF SOY-FORTIFIED  
MAIZE DOUGH AT 70°C  
(SOY ADDED BEFORE FERMENTATION OF MAIZE DOUGH)

A = 10% soy

B = 20% soy

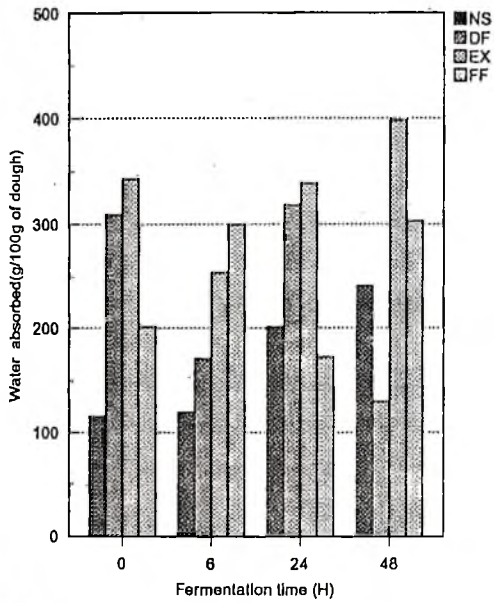
NS = No soy

EX = Extruded soy

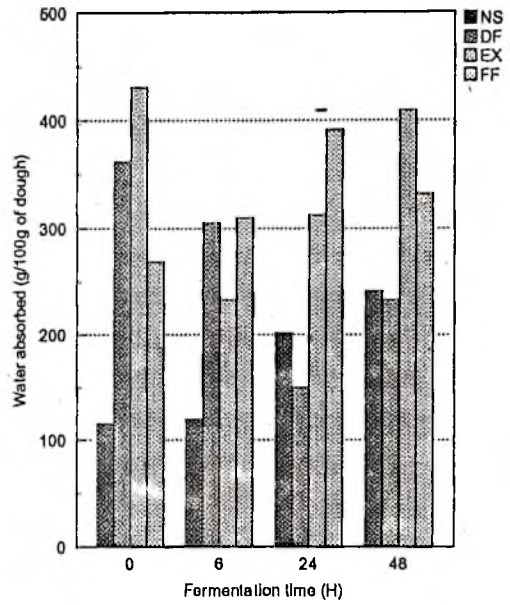
DF = Defatted soy

FF = Full fat

10% soy



20% soy



NS = Soy

DF = Defatted soy

EX = Extruded soy

FF = Full fat soy

#### 4.5 VISCOSITY CHARACTERISTICS OF SOY-MAIZE DOUGH

The cooked paste viscosity changes in texture when soy maize dough is cooked is measured by its viscosity characteristics. Tables 12 summarises key information or indices from the Brabender hot paste viscosity curves of maize dough.

Viscosity indices ( Peak vis, Vis 95°C, Vis 95°C Hold Vis 50°C Hold) increase with fermentation time and the Brabender viscosity curve obtained was characteristics of maize starch (Radley 1968).

An examination of the Brabender patterns (Figs 24-29) and viscosity indices (Tables 13-18) when soyflours were added to the maize dough showed interesting differences.

All the soy-maize dough also showed characteristics viscosity increase with increase in fermentation time irrespective of the method of addition of the soyflour. However their viscosity indices were lower than that of maize dough (no soy)

This suggests dough fermentation apart from flavour development also contributed to improve the rate and degree of starch gelatinisation and therefore promotes ease of cooking (Sefa-Dedeh, 1988). Addition of soyflour to the maize dough appears to decrease cooking properties but the degree of change depends on the soy-flour type and concentration. Increasing the soyflour concentration in dough reduces viscosity characteristics.

FIGURE 23

BRABENDER VISCOSITY CHARACTERISTICS OF MAIZE DOUGH  
(WITH NO SOY)

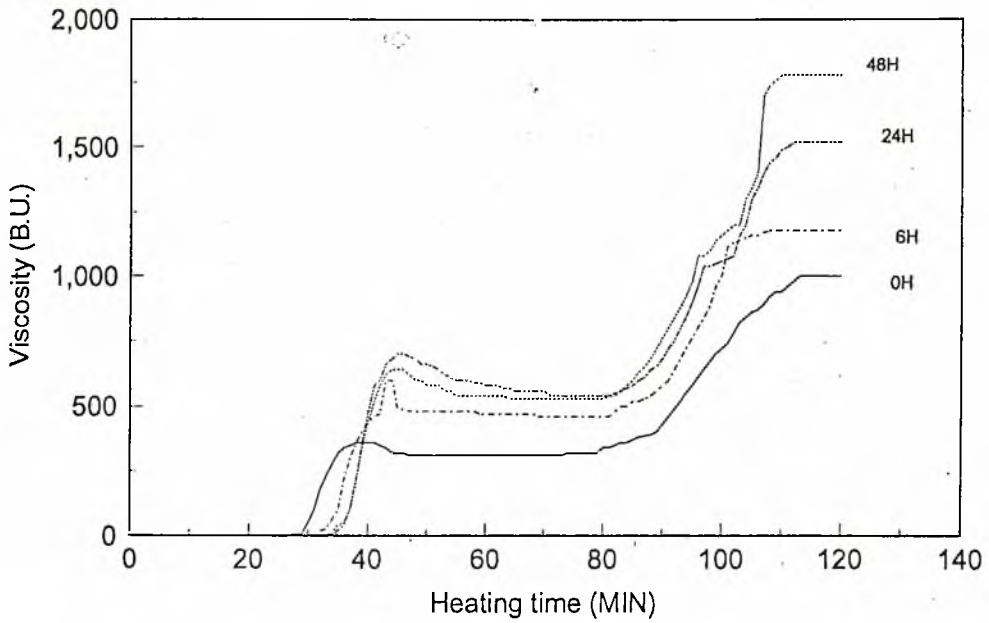
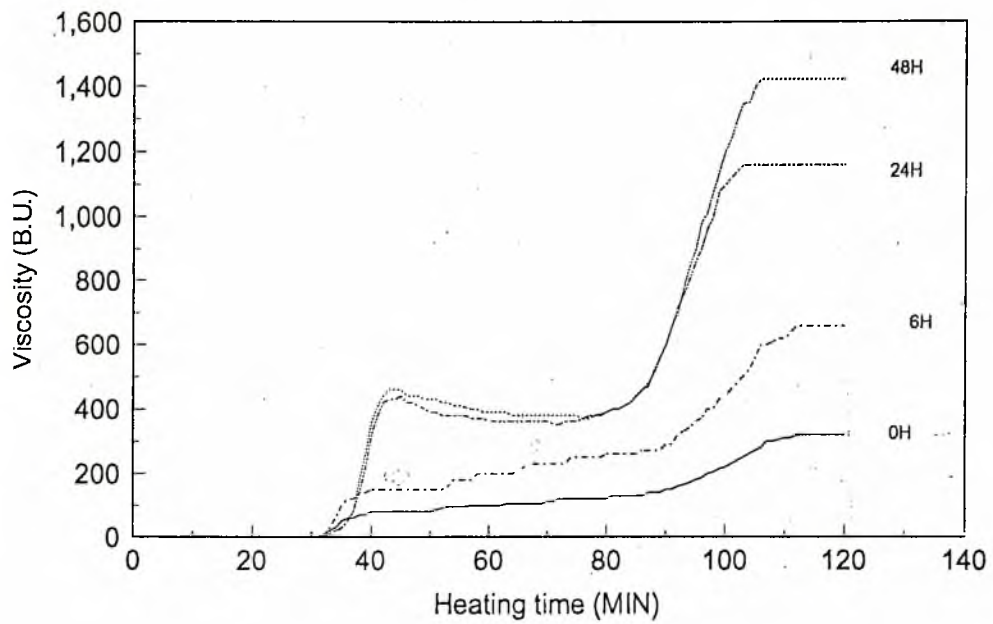


FIGURE 24

BRABENDER VISCOSITY CHARACTERISTICS OF SOY-FORTIFIED MAIZE  
DOUGH (WITH 10% FULL FAT SOY)

Soy added after dough fermentation

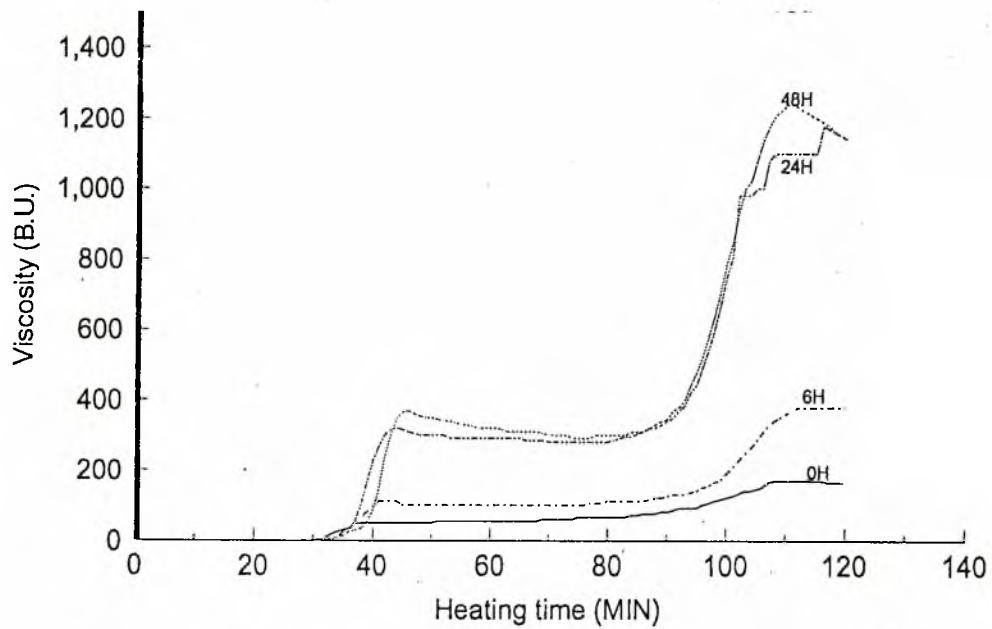


Soy added after dough fermentation.

FIGURE 25

BRABENDER VISCOSITY CHARACTERISTICS OF SOY-FORTIFIED MAIZE  
DOUGH (WITH 20% FULL FAT SOY)

Soy added before dough fermentation

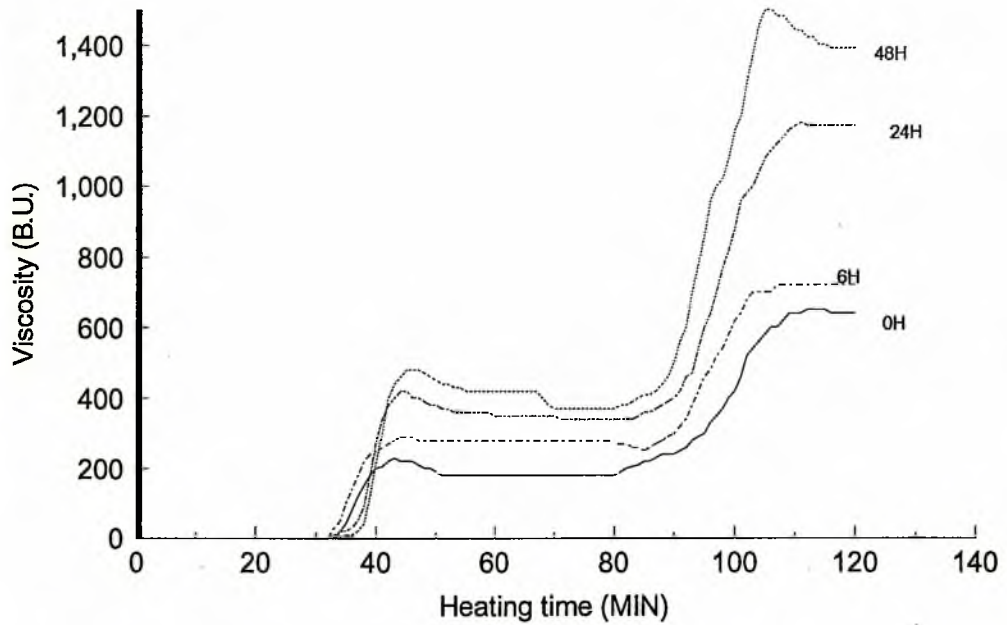


\* Soy added before dough fermentation

**FIGURE 26**

**BRABENDER VISCOSITY CHARACTERISTICS OF SOY-FORTIFIED MAIZE  
DOUGH (WITH 10% DEFATTED SOY)**

Soy added after dough fermentation

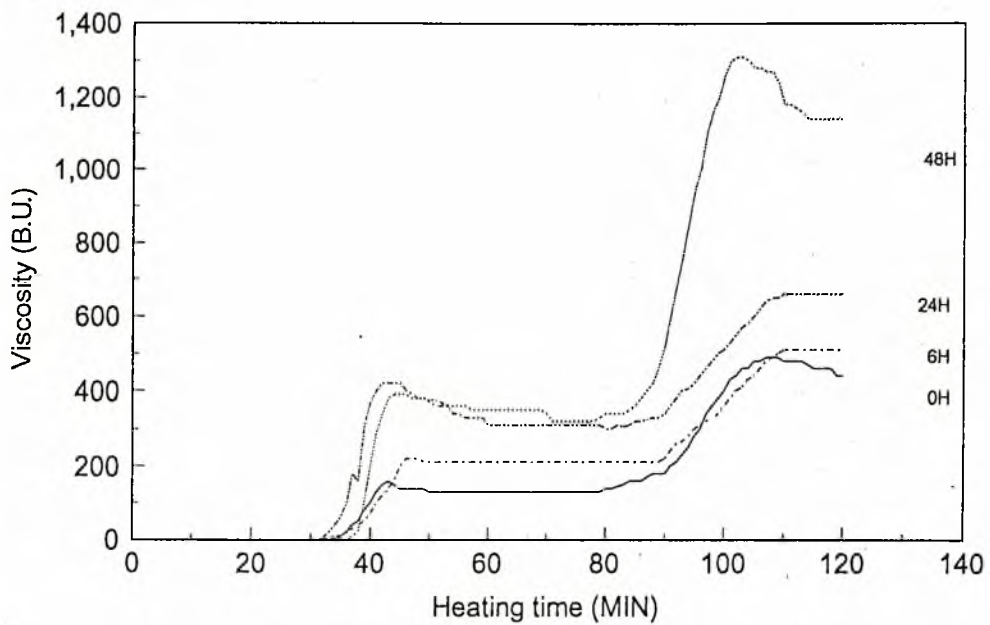


Soy added after dough fermentation

**FIGURE 27**

**BRABENDER VISCOSITY CHARACTERISTICS OF SOY-FORTIFIED MAIZE  
DOUGH (WITH 20% DEFATTED SOY)**

Soy added after dough fermentation

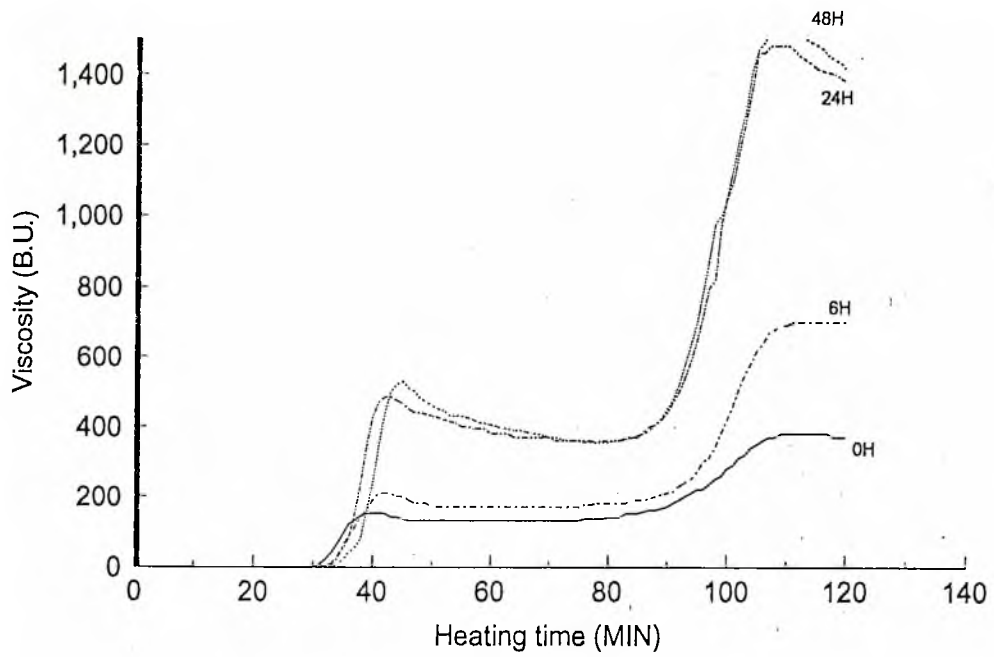


\* Soy added after fermentation of maize dough

FIGURE 28

BRABENDER VISCOSITY CHARACTERISTICS OF SOY-FORTIFIED MAIZE  
DOUGH (WITH 10% FULL-FAT SOY)

Soy added before dough fermentation

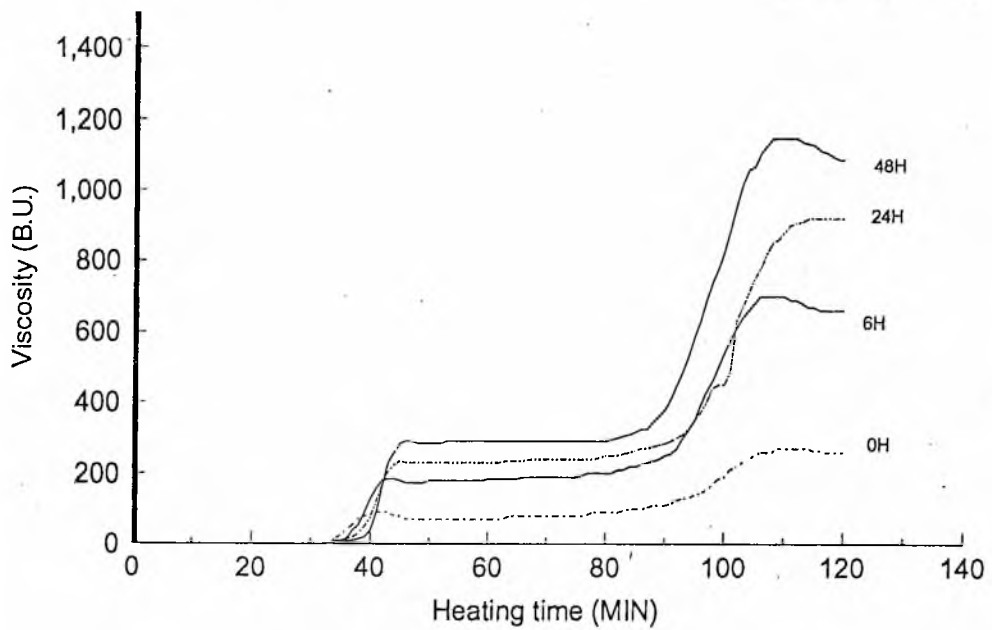


Soy added before dough fermentation

FIGURE 29

BRABENDER VISCOSITY CHARACTERISTICS OF SOY-FORTIFIED MAIZE  
DOUGH (WITH 20% EXTRUDED SOY)

Soy added before dough fermentation



\* Soy added before dough fermentation

Table 12 Viscosity characteristics of Maize dough (with no soy)

| Fermentation Time (Hrs) | Pasting Temp. °C | Peak (BU) | 95°C (BU) | 95H (BU) | 50°C | 50H (BU) |
|-------------------------|------------------|-----------|-----------|----------|------|----------|
| 0                       | 72.1             | 360       | 330       | 320      | 820  | 1000     |
| 6                       | 76.6             | 500       | 490       | 460      | 1140 | 1180     |
| 24                      | 79.8             | 700       | 630       | 540      | 1200 | 1500     |
| 48                      | 80.1             | 600       | 660       | 520      | 1340 | 1780     |

Table 13 Viscosity Characteristics of Maize dough fortified with Full fat soyflour (AFF)  
(10% & 20% soylevel)

| Fermentation Time (Hrs) | PASTING TEMP. °C |      | PEAK (BU) |     | 95°C (BU) |     | 95H (BU) |     | 50°C (BU) |      | 50°C (BU) |      |
|-------------------------|------------------|------|-----------|-----|-----------|-----|----------|-----|-----------|------|-----------|------|
|                         | 10%              | 20%  | 10%       | 20% | 10%       | 20% | 10%      | 20% | 10%       | 20%  | 10%       | 20%  |
| 0                       | 73.9             | 74.9 | 80        | 15  | 80        | 15  | 120      | 60  | 280       | 160  | 300       | 160  |
| 6                       | 74.1             | 75.0 | 120       | 80  | 120       | 80  | 110      | 70  | 630       | 400  | 650       | 420  |
| 24                      | 74.5             | 75.1 | 440       | 320 | 440       | 300 | 350      | 280 | 980       | 740  | 1160      | 840  |
| 48                      | 77.4             | 75.5 | 460       | 340 | 460       | 310 | 380      | 290 | 1350      | 1000 | 1400      | 1020 |

Table 14 Viscosity Characteristics of Maize dough fortified with Extuded soyflour (AFF)  
(10% & 20% soylevel)

| Fermentation Time (Hrs)) | Pasting Temp. °C |      | Peak (BU) |     | 95°C (BU) |     | 95H (BU) |     | 50°C (BU) |      | 50H (BU) |      |
|--------------------------|------------------|------|-----------|-----|-----------|-----|----------|-----|-----------|------|----------|------|
|                          | 10%              | 20%  | 10%       | 20% | 10%       | 20% | 10%      | 20% | 10%       | 20%  | 10%      | 20%  |
| 0                        | 74.9             | 75.2 | 280       | 230 | 270       | 230 | 260      | 230 | 760       | 800  | 820      | 780  |
| 6                        | 75.3             | 75.7 | 320       | 250 | 300       | 250 | 290      | 240 | 850       | 820  | 900      | 800  |
| 24                       | 77.7             | 76.2 | 430       | 310 | 420       | 300 | 350      | 280 | 960       | 750  | 1020     | 820  |
| 48                       | 77.6             | 77.6 | 500       | 390 | 490       | 380 | 390      | 340 | 1360      | 1120 | 1400     | 1140 |

Table 15 Viscosity characteristics of Maize dough fortified with Defatted soyflour (AFF)  
(10% & 20% soylevel)

| Fermentation Time (Hrs) | Pasting Temp °C |      | Peak (BU) |     | 95° C (BU) |     | 95H (BU) |     | 50°C (BU) |      | 50H (BU) |      |
|-------------------------|-----------------|------|-----------|-----|------------|-----|----------|-----|-----------|------|----------|------|
|                         | 10%             | 20%  | 10%       | 20% | 10%        | 20% | 10%      | 20% | 10%       | 20%  | 10%      | 20%  |
| 0                       | 72.3            | 75.4 | 230       | 160 | 220        | 150 | 200      | 120 | 560       | 480  | 640      | 490  |
| 6                       | 73.2            | 75.9 | 290       | 220 | 290        | 200 | 280      | 210 | 700       | 500  | 720      | 510  |
| 24                      | 77.5            | 76.1 | 420       | 410 | 420        | 400 | 330      | 300 | 1080      | 600  | 1180     | 860  |
| 48                      | 78.4            | 78.7 | 480       | 390 | 480        | 380 | 380      | 320 | 1000      | 1320 | 1400     | 1160 |

Table 16 Viscosity characteristics of Maize dough fortified with Full fat (BFF)  
(10% & 20% soylevel)

| Fermentation Time (Hrs) | Pasting Temp °C |      | Peak (BU) |     | 95°C (BU) |     | 95H (BU) |     | 50°C (BU) |      | 50H (BU) |      |
|-------------------------|-----------------|------|-----------|-----|-----------|-----|----------|-----|-----------|------|----------|------|
|                         | 10%             | 20%  | 10%       | 20% | 10%       | 20% | 10%      | 20% | 10%       | 20%  | 10%      | 20%  |
| 0                       | 70.6            | 73.0 | 150       | 50  | 140       | 60  | 140      | 60  | 360       | 120  | 380      | 160  |
| 6                       | 73.0            | 73.7 | 210       | 110 | 180       | 110 | 180      | 100 | 630       | 280  | 700      | 380  |
| 24                      | 73.6            | 74.5 | 480       | 320 | 480       | 320 | 360      | 280 | 1440      | 960  | 1410     | 1140 |
| 48                      | 73.9            | 75.2 | 530       | 370 | 530       | 360 | 360      | 300 | 1500      | 1080 | 1400     | 1120 |

Table 17 Viscosity characteristics of Maize dough fortified with Extuded soyflour (BFF)  
(10% & 20% soylevel)

| Fermentation Time (HRS) | Pasting Temp. °C |      | Peak (BU) |     | 95°C (BU) |     | 95H (BU) |     | 50°C (BU) |      | 50H (BU) |      |
|-------------------------|------------------|------|-----------|-----|-----------|-----|----------|-----|-----------|------|----------|------|
|                         | 10%              | 20%  | 10%       | 20% | 10%       | 20% | 10%      | 20% | 10%       | 20%  | 10%      | 20%  |
| 0                       | 72.1             | 73.2 | 150       | 180 | 120       | 190 | 130      | 200 | 400       | 670  | 400      | 660  |
| 6                       | 73.0             | 73.6 | 220       | 90  | 200       | 80  | 200      | 80  | 580       | 250  | 660      | 260  |
| 24                      | 74.9             | 75.4 | 370       | 230 | 360       | 230 | 350      | 240 | 1020      | 700  | 1180     | 900  |
| 48                      | 75.3             | 76.0 | 430       | 290 | 420       | 290 | 370      | 290 | 1360      | 1080 | 1400     | 1100 |

Table 18 Viscosity Characteristics of Maize dough fortified with Defatted Soyflour (BFF)  
(10% & 20% soylevel)

| Fermentation Time (Hrs) | Pasting Temp. °C |      | Peak (BU) |     | 95° (BU) |     | 95H (BU) |     | 50°C (BU) |      | 50H (BU) |      |
|-------------------------|------------------|------|-----------|-----|----------|-----|----------|-----|-----------|------|----------|------|
|                         | 10%              | 20%  | 10%       | 20% | 10%      | 20% | 10%      | 20% | 10%       | 20%  | 10%      | 20%  |
| 0                       | 76.7             | 74.4 | 160       | 140 | 150      | 130 | 160      | 120 | 500       | 400  | 540      | 400  |
| 6                       | 76.5             | 75.7 | 160       | 100 | 160      | 90  | 160      | 90  | 540       | 390  | 580      | 300  |
| 24                      | 74.8             | 77.9 | 420       | 260 | 330      | 240 | 370      | 240 | 1440      | 1020 | 1380     | 990  |
| 48                      | 74.3             | 78.2 | 500       | 340 | 500      | 340 | 380      | 290 | 1300      | 1150 | 1440     | 1100 |

#### 4.5.1 Peak Viscosity

Peak viscosity indicates the maximum or highest viscosity encountered during the preparation or cooking of the paste irrespective of the temperature. The peak viscosity decreases with increase in soyflour concentration in the dough. The reduction effect was more pronounced when the maize dough was fortified with Fullfat soy flour after fermentation.

ANOVA (Table 19) suggests method of addition, soyflour type, soyflour level and fermentation time significantly affect the peak viscosity of the soy-maize paste.

Table 19. ANALYSIS OF VARIANCE FOR PEAK VISCOSITY

| Source of Variation | SS        | df | MS        | F ratio | Sig.Level |
|---------------------|-----------|----|-----------|---------|-----------|
| Main Effects        | 2379455.6 | 8  | 297431.94 | 238.1   | 0.000*    |
| Method of addition  | 12933.7   | 1  | 12933.7   | 10.35   | 0.0026*   |
| Soyflour type       | 9127.1    | 2  | 4563.5    | 3.65    | 0.035*    |
| Soyflour level      | 1294893.7 | 2  | 647446.9  | 518.3   | 0.000*    |
| Fermentation time   | 1062501.0 | 3  | 354167.0  | 283.5   | 0.000*    |

\* = significant at  $p \leq 0.05$

#### 4.5.2 Viscosity at 95°C and 95°C Hold

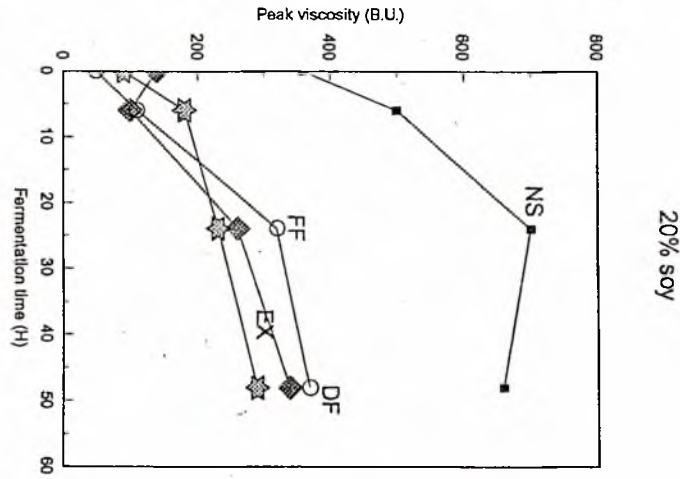
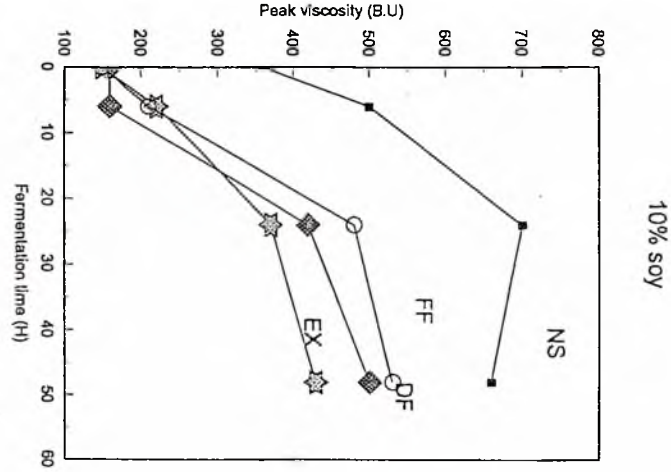
The viscosity of the paste at 95°C reflects the ease of cooking the starch and the viscosity at 95°C Hold indicates the stability breakdown of the paste. The doughs with high viscosity at 95°C are therefore easy to cook.

FIGURE 30

EFFECT OF SOY FORTIFICATION AND FERMENTATION ON PEAK VISCOSITY  
OF MAIZE DOUGH (SOY ADDED BEFORE FERMENTATION OF DOUGH)

A = 10% soy  
B = 20% soy

NS = No soy  
EX = Extruded soy  
DF = Defatted soy  
FF = Full fat

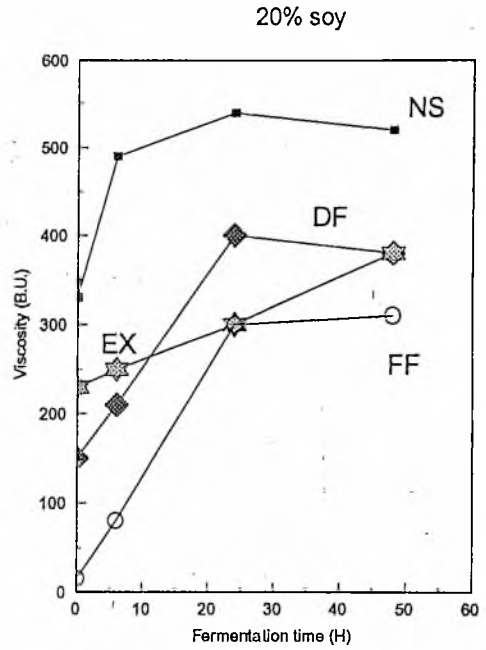
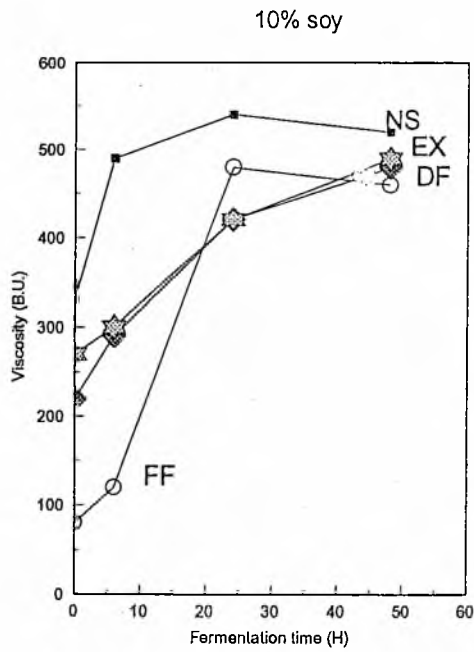


**FIGURE 31**

**EFFECT OF SOY FORTIFICATION AND FERMENTATION ON PEAK VISCOSITY  
OF MAIZE DOUGH (SOY ADDED AFTER FERMENTATION OF DOUGH)**

**A = 10% soy  
B = 20% soy**

**NS = No soy  
EX = Extruded soy  
DF = Defatted soy  
FF = Full fat**



NS =No soy  
EX=Extruded soy  
DF=Defatted soy  
FF=Full fat soy

The fullfat soy fortified dough sample appears to show difficulty in cooking than the samples containing extruded and defatted soy. Analysis of variance (ANOVA Table 20 & 21) shows that viscosity at 95°C and 95°C Hold respectively were influenced by the method of addition of soyflour, soyflour type, soy level and the fermentation time.

**Table 20. ANALYSIS OF VARIANCE FOR VISCOSITY AT 95°C**

| <u>Source of Variation</u> | <u>SS</u>       | <u>df</u> | <u>MS</u>       | <u>F ratio</u> | <u>Sig.Level</u> |
|----------------------------|-----------------|-----------|-----------------|----------------|------------------|
| Main Effects               | 1463988.9       | 8         | 182998.6        | 149.760        | 0.000*           |
| Method of addition         | 11628.1         | 1         | 11628.1         | 9.516          | 0.0037*          |
| Soyflour type              | 9027.1          | 2         | 4513.54         | 3.694          | 0.0337*          |
| Soyflour level             | 725893.9        | 2         | 362946.9        | 297.02         | 0.000*           |
| <u>Fermentation time</u>   | <u>717439.9</u> | <u>3</u>  | <u>239146.6</u> | <u>195.71</u>  | <u>0.000*</u>    |

\* = significant at  $p \leq 0.05$

**Table 21. ANALYSIS OF VARIANCE FOR VISCOSITY AT 95°C HOLD**

| <u>Source of Variation</u> | <u>SS</u>       | <u>df</u> | <u>MS</u>       | <u>F ratio</u> | <u>Sig.Level</u> |
|----------------------------|-----------------|-----------|-----------------|----------------|------------------|
| Main Effects               | 132866.7        | 8         | 166033.3        | 197.63         | 0.000*           |
| Method of addition         | 7401.4          | 1         | 7401.39         | 8.81           | 0.005*           |
| Soy flour type             | 13669.4         | 2         | 6834.72         | 8.13           | 0.0011*          |
| Soy flour level            | 809702.8        | 2         | 404851.4        | 481.88         | 0.000*           |
| <u>Fermentation time</u>   | <u>497493.1</u> | <u>3</u>  | <u>165831.0</u> | <u>197.384</u> | <u>0.000*</u>    |

\* = significant at  $p \leq 0.05$

FIGURE 32

EFFECT OF SOY FORTIFICATION AND FERMENTATION ON VISCOSITY AT 95°C  
OF MAIZE DOUGH (SOY ADDED BEFORE FERMENTATION OF DOUGH)

A = 10% soy

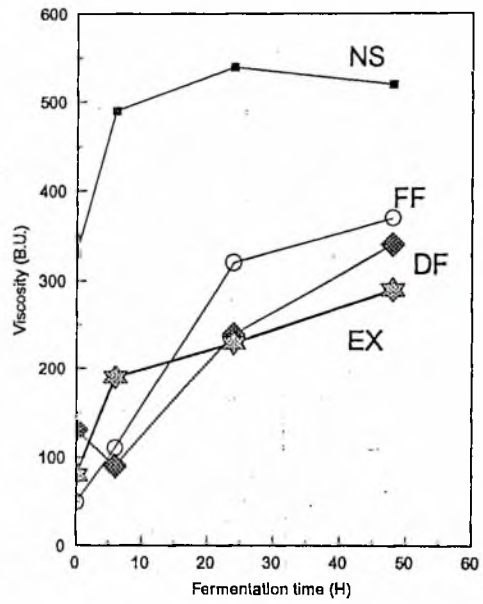
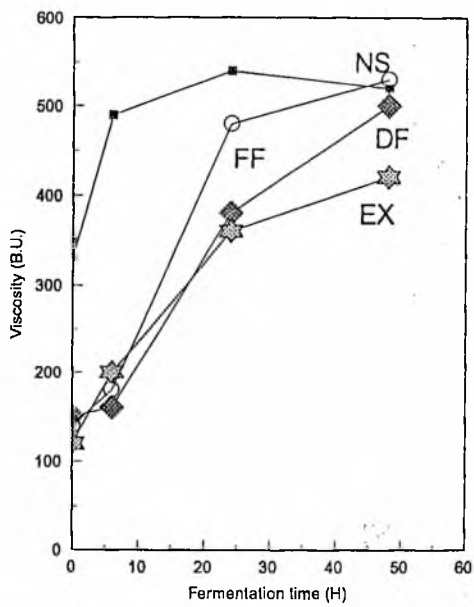
B = 20% soy

NS = No soy

EX = Extruded soy

DF = Defatted soy

FF = Full fat



NS = No soy  
 EX = Extruded soy  
 DF = Defatted soy  
 FF = Full fat

FIGURE 33

EFFECT OF SOY FORTIFICATION AND FERMENTATION ON VISCOSITY AT 95°C  
OF MAIZE DOUGH (SOY ADDED AFTER FERMENTATION OF DOUGH)

A = 10% soy

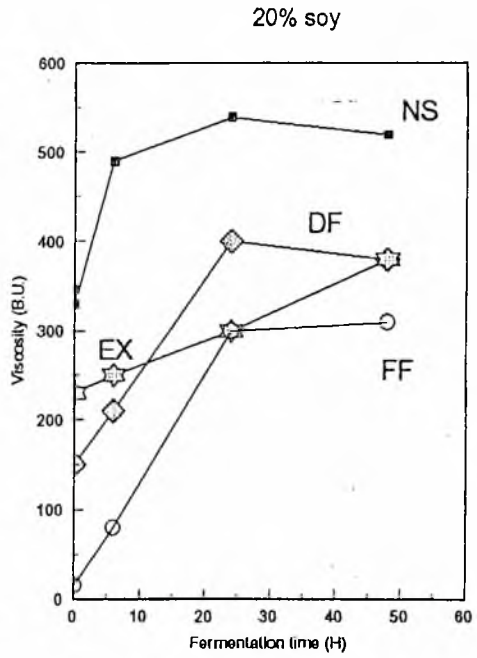
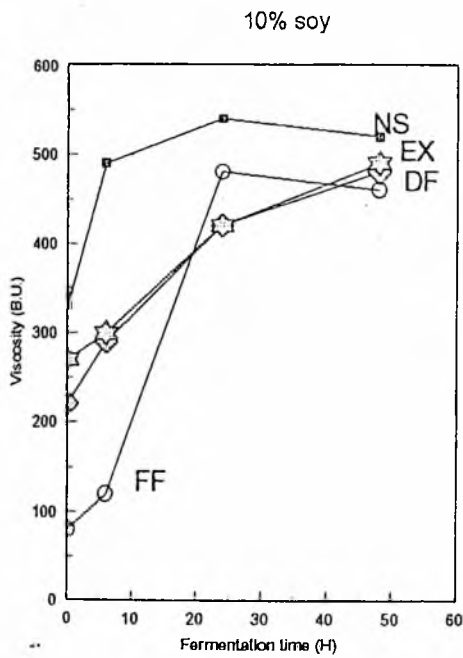
B = 20% soy

NS = No soy

EX = Extruded soy

DF = Defatted soy

FF = Full fat



NS =No soy  
 EX= Extruded soy  
 DF=Defatted soy  
 FF=Full fat soy

The dough containing fullfat and defatted soy flour respectively showed easier cooking when the soyflour was added before fermentation than after. It may be indicated that extruded soy dough sample appears to show easier cooking when the soyflour was added after fermentation of the dough. Increasing the soy flour concentration in the dough significantly reduces its ease of cooking and therefore lowers viscosity characteristics.

On holding the samples at 95°C for 30 minutes slight reduction in viscosity occurs in dough samples containing Fullfat soy and Defatted soy respectively indicating little breakdown of the paste. No change in viscosity was observed in the dough containing extruded soy flour (EXBF).

#### 4.5.3 Viscosity at 50°C and 50°C Hold

The increase in viscosity of paste when the paste is cooked from 95°C to 50°C is an indication of retrogradation or set back. Brabender viscosity at 50°C and 50°C Hold were found to increase with fermentation time for all the samples irrespective of the method of addition of the soyflour. Dough samples with low viscosity at 50°C may therefore exhibit soft texture on cooling and in addition its acceptability will depend on the intended food uses. Hence maize dough containing Fullfat soyflour and Extruded soy (BFF) respectively may have relatively softer texture compared to the samples containing defatted soyflour.

ANOVA results (Table 22 & 23) indicate that viscosity at 50°C and 50°C hold respectively were affected significantly by the soy level and fermentation time.

**Table 22. ANALYSIS OF VARIANCE FOR VISCOSITY AT 50°C**

| <u>Source of Variation</u> | <u>SS</u>        | <u>df</u> | <u>MS</u>        | <u>F ratio</u> | <u>Sig.Level</u> |
|----------------------------|------------------|-----------|------------------|----------------|------------------|
| Main Effects               | 3873480.6        | 8         | 484185.1         | 33.749         | 0.000*           |
| Method of addition         | 138.9            | 1         | 138.89           | 0.010          | 0.9232           |
| Soy flour type             | 52636.1          | 2         | 26318.1          | 1.834          | 0.1729           |
| Soy flour level            | 1217411.1        | 2         | 608705.56        | 42.43          | 0.0000*          |
| <u>Fermentation time</u>   | <u>2603294.4</u> | <u>3</u>  | <u>867764.31</u> | <u>60.485</u>  | <u>0.0000</u>    |

\* = significant at  $p \leq 0.05$

**Table 23 ANALYSIS OF VARIANCE FOR VISCOSITY AT 50°C HOLD**

| <u>Source of Variation</u> | <u>SS</u>      | <u>df</u> | <u>MS</u>        | <u>F ratio</u> | <u>Sig.Level</u> |
|----------------------------|----------------|-----------|------------------|----------------|------------------|
| Main Effects               | 12272906       | 8         | 1534113.2        | 170.41         | 0.000*           |
| Method of addition         | 5168           | 1         | 5168.1           | 0.574          | 0.4611           |
| Soy flour type             | 55069          | 2         | 27534.7          | 3.059          | 0.0570           |
| Soy flour level            | 4964653        | 2         | 2482326.4        | 275.79         | 0.000*           |
| <u>Fermentation time</u>   | <u>7248015</u> | <u>3</u>  | <u>2416005.1</u> | <u>268.4</u>   | <u>0.000</u>     |

\* = significant at  $p \leq 0.05$

The method of addition of soy flour and soyflour type had no significant effect on the viscosity at 50°C and 50°C Hold respectively. Results indicate viscosity characteristics decreased with increase in soy level due to dilution effect by the soy flour. The viscosity at 50°C hold which indicate the stability of the cooked paste due to mechanical treatment follows the same pattern as viscosity at 50°C. Maize dough containing no soy flour appears to show good textural characteristics than the soy fortified doughs.

#### 4.5.4 Pasting Temperature

The beginning of swelling of starch as indicated or measured by the pasting temperature increases with fermentation time.

ANOVA results (Table 24) indicate the method of addition of soy-flour, soy-type, soy-level and fermentation time significantly affect the pasting temperature. Pasting temperature also increases with increase in soy-level in the dough. It appears the addition of soyflour tends to restrict or delay swelling of the starch granules in the dough.

**Table 24. ANALYSIS OF VARIANCE FOR PASTING TEMPERATURE**

| <u>Source of Variation</u> | <u>SS</u>      | <u>df</u> | <u>MS</u>    | <u>F ratio</u> | <u>Sig.Level</u> |
|----------------------------|----------------|-----------|--------------|----------------|------------------|
| Main Effects               | 311.56         | 8         | 38.94        | 37.13          | 0.000*           |
| Method of addition         | 12.168         | 1         | 12.16        | 11.60          | 0.0015*          |
| Soy flour type             | 15.44          | 2         | 7.72         | 7.3            | 0.0019*          |
| Soy flour level            | 69.87          | 2         | 34.93        | 33.319         | 0.000*           |
| <u>Fermentation time</u>   | <u>214.078</u> | <u>3</u>  | <u>71.35</u> | <u>68.04</u>   | <u>0.000</u>     |

\* = significant at  $p \leq 0.05$

#### **4.6 CONSUMER PERCEPTION OF SOY-FORTIFIED MAIZE DOUGH IN GA-KENKEY AND AKASA**

The sensory evaluation was conducted to evaluate acceptance of Ga-kenkey and Akasa Porridge prepared from Soy-fortified maize doughs.

##### **4.6.1 Consumer Preference for Ga-Kenkey**

The sensory evaluation or perception of Ga-Kenkey from soy-maize dough shows wide variation in consumer responses to the color taste, flavor, texture and general acceptability of the product.

##### **4.6.2 COLOUR**

The colour of a food product is a very important attribute. For most foods, changes in the colour can be recognised by the

consumer. Such changes may be due to raw materials, ingredients additions or processing techniques. Based on the mean scores (Table 26) the colour of the maize dough with no soy was most preferred with mean score of (8.3) compared with the soy-fortified Ga kenkey with mean scores ranging from (3.5) to (6.2). This indicated that addition of soyflour produces differences in consumer preferences for colour. Among the soy-fortified Ga-kenkey, the colour of the product containing full fat (FFAF) was the most preferred with a mean score of 6.2 followed by the extruded (EXBF); 4.87, full fat (FFBF); (4.5) and Defatted soy; (3.5) respectively.

Results of ANOVA (Table 25) shows that the preference of Soy-fortified Ga-kenkey were significantly different with respect to colour. This suggests that incorporating processed soybeans into Ga-kenkey produced significant changes in colour. Further analysis using LSD (Table 26) showed that Ga-kenkey containing defatted soy was not significantly different in colour from that containing full-fat (FFBF). This suggests that defatted soy and Full-fat (FFBF) seem to have the same effect on colour when incorporated into Ga-kenkey.

**Table 25 ANOVA SUMMARY TABLE FOR COLOUR**

| <u>Source of Variation</u> | <u>SS</u>      | <u>df</u>  | <u>MS</u> | <u>F ratio</u> | <u>Sig.Level</u> |
|----------------------------|----------------|------------|-----------|----------------|------------------|
| Main Effects               | 575.4          | 33         | 17.436    | 2.923          | 0.000*           |
| Panelist                   | 174.53         | 29         | 6.0183    | 1.009          | 0.4645           |
| Sample                     | 400.866        | 4          | 100.216   | 16.801         | 0.0000*          |
| Residual                   | 691.933        | 116        | 5.9649    |                |                  |
| <u>Total corr</u>          | <u>1267.33</u> | <u>149</u> |           |                |                  |

\* = significant at  $p \leq 0.05$

**Table 26 MULTIPLE RANGE ANALYSIS FOR COLOUR OF GA KENKEY**

| SAMPLE                               | MEAN SCORE | LSD INTERVALS<br>(Homogenous gps) |
|--------------------------------------|------------|-----------------------------------|
| Maize dough + Defatted Soy<br>(DFBF) | 3.533      | A                                 |
| Maize dough + Full fat (FFBF)        | 4.500      | A                                 |
| Maize dough + Extruded (EXBF)        | 4.866      | B                                 |
| Maize dough + Full fat (FFAF)        | 6.167      | C                                 |
| Maize dough + 0% Soy                 | 3.267      | D                                 |

Similarly it can be said that extruded soy (EXBF) and the full fat (FFBF) showed no significant difference in colour preference when added to Ga-kenkey.

However, there was relatively good preference for Soy-fortified Ga kenkey containing Full fat when the soy was added after fermentation of the dough (FFAF)

Thus adding full fat soyflour to the maize dough after fermentation produced more preferred colour characteristics than when the soy was added before fermentation of the maize dough.

#### 4.6.3. TEXTURE

The texture of Ga-kenkey is important or critical in the Ga-kenkey industry. It determines to a greater extent the marketability of the processors' product.

Mean scores for texture (Table 28) shows that the Ga-kenkey with no soy had the most preferred texture (6.87), followed by soy-fortified Ga-kenkey containing extruded (EXBF), Full fat (FFAF)

Defatted (DFBF) and Full fat (FFBF) respectively. Analysis of variance (Table 27) shows that the texture of Ga-kenkey was influenced by the sample types. Further analysis(LSD) indicated the preference for texture of Ga kenkey containing no soy was significantly different from all the soy-fortified products with the exception of extruded soy-fortified Ga-kenkey.

**Table 27 ANOVA SUMMARY TABLE FOR TEXTURE OF GA KENKEY**

| Source of Variation | SS      | df  | MS       | F ratio | Sig.Level |
|---------------------|---------|-----|----------|---------|-----------|
| Main Effects        | 372.700 | 33  | 11.29392 | 1.530   | 0.0517    |
| Panelist            | 291.233 | 29  | 10.0425  | 1.361   | 0.1282    |
| Sample              | 81.466  | 4   | 20.366   | 2.760   | 0.0310*   |
| Residual            | 856.133 | 116 | 7.380    |         |           |
| Total corr          | 1228.83 | 149 |          |         |           |

\* = significant at  $p \leq 0.05$

**Table 28 MULTIPLE RANGE ANALYSIS FOR TEXTURE OF GA KENKEY**

| SAMPLE                        | MEAN SCORE | LSD INTERVALS<br>(Homogenous gps) |
|-------------------------------|------------|-----------------------------------|
| Maize dough + Full fat (FFBF) | 4.933      | A                                 |
| Maize dough + Defatted (DFBF) | 5.400      | B                                 |
| Maize dough + Full fat (FFAF) | 5.433      | B                                 |
| Maize dough + Extruded (EXBF) | 6.533      | C                                 |
| Maize dough + 0% Soy          | 6.867      | C                                 |

This suggests that extruded soyflour (EXBF) when added to Ga-kenkey exhibits textural characteristics similar to the product from 100% maize dough. Soy-fortified Ga-kenkey containing Full

fat (FFBF), defatted Soy (DFBF) and Full fat (FFAF) appears to show no significant differences in texture.

An interesting observation made during the processing of Ga-kenkey, the product containing the defatted soyflour showed high flow characteristic or "watery texture" during the aflata preparation making it difficult for the dough to hold in the corn sheath or husk. However upon cooking, a very hard texture was obtained which consequently had lower consumer preference for texture.

#### 4.6.4 TASTE

The taste of Ga-kenkey is also an important quality index which is used by consumers to assess the acceptability of the product. To many consumers, taste provides the criteria for preferring a processors product to another.

Based on Mean score (Table 30) the most preferred Ga-kenkey was the one that contained no soyflour which had the highest mean score (8.133) followed by the soy fortified Ga-kenkey containing Full fat (FFAF), Extruded soy (EXBF), Defatted (DFBF) and Full fat (FFBF) respectively

Anova results (Table 29) indicated significant differences in the consumer preferences for taste of the samples.

Table 29. ANOVA SUMMARY TABLE FOR TASTE OF GA KENKEY

| <u>Source of Variation</u> | <u>SS</u>      | <u>df</u>  | <u>MS</u> | <u>F ratio</u> | <u>Sig. Level</u> |
|----------------------------|----------------|------------|-----------|----------------|-------------------|
| Main Effects               | 596.546        | 33         | 18.077    | 3.271          | 0.000*            |
| Panelist                   | 176.373        | 29         | 6.0818    | 1.101          | 0.3494            |
| Sample                     | 420.173        | 4          | 105.043   | 19.009         | 0.000*            |
| Residual                   | 641.026        | 116        | 5.5260    |                |                   |
| <u>Total corr</u>          | <u>1237.57</u> | <u>149</u> |           |                |                   |

\* = significant at  $p \leq 0.05$

Table 30 MULTIPLE RANGE ANALYSIS FOR TASTE OF GA KENKEY

| SAMPLE                        | MEAN SCORE | LSD INTERVALS<br>(Homogenous gps) |
|-------------------------------|------------|-----------------------------------|
| Maize dough + Full fat (FFBF) | 3.467      | A                                 |
| Maize dough + Defatted (DFBF) | 4.700      | B                                 |
| Maize dough + Extruded (EXBF) | 4.867      | B                                 |
| Maize dough + Full fat (FFAF) | 6.900      | C                                 |
| Maize dough + 0% Soy          | 8.133      | D                                 |

Further analysis showed that Ga kenkey containing no soy flour was significantly different in taste from all the soy-fortified samples. Even among the soy-fortified samples differences in taste exist indicating the effect of soy processing on the taste. There was no differences in taste of soy-fortified Ga-Kenkey containing extruded and defatted soy respectively.

The characteristic taste of Ga-kenkey is partly due to the sourness developed during the fermentation process. The low preference for taste of Ga-kenkey with Full fat soy (FFBF) may be related to the high acidity developed as a result of the fermentation. Some of the panellists commented on the high sourness in the product.

#### 4.6.5. FLAVOR

Results on the mean scores (Table 32) indicated Ga-kenkey with no soy had the most preferred flavor (7.8) followed by the

product containing defatted Soy (DFBF), Full fat (FFAF), Extruded (EXBF) and Full Fat (FFBF) respectively.

Anova (Table 31) shows there was differences in flavor of the samples.

**Table 31 ANOVA SUMMARY TABLE FOR FLAVOUR OF GA KENKEY**

| Source of Variation | SS       | df  | MS     | F ratio | Sig. Level |
|---------------------|----------|-----|--------|---------|------------|
| Main Effects        | 500.413  | 33  | 15.164 | 2.396   | 0.003*     |
| Panelist            | 224.240  | 29  | 7.732  | 1.222   | 0.2263     |
| Sample              | 276.173  | 4   | 69.043 | 10.908  | 0.000*     |
| Residual            | 734.226  | 116 | 6.329  |         |            |
| Total corr          | 1234.640 | 149 |        |         |            |

\* = significant at  $p \leq 0.05$

**Table 32 MULTIPLE RANGE ANALYSIS FOR FLAVOUR OF GA KENKEY**

| SAMPLE                        | MEAN SCORE | LSD INTERVALS<br>(Homogenous gps) |
|-------------------------------|------------|-----------------------------------|
| Maize dough + Full fat (FFBF) | 3.733      | A                                 |
| Maize dough + Extruded (EXBF) | 4.633      | A                                 |
| Maize dough + Full fat (FFAF) | 5.667      | B                                 |
| Maize dough + Defatted (DFBF) | 5.367      | B                                 |
| Maize dough + 0% Soy          | 7.800      | C                                 |

However further analysis LSD (Table 32) shows that among soy-fortified Ga-kenkey no differences in flavor exist between

the product containing defatted (DFBF), full fat (FFAF), extruded (EXBF) respectively.

#### 4.6.6. ACCEPTABILITY

Acceptability is the sum of preferences for colour, texture, taste and flavor as judged by the taste panelists.

Based on the mean scores (Table 34) for acceptability Ga-kenkey containing no soy flour was most acceptable to the panellists followed by the products with Fullfat soy (FFAF) (7.17), Extruded soy (EXBF) (5.27), Defatted soy (5.10) and Full fat (FFBF), (4.17) respectively. It appears from the mean scores that acceptability was affected by the method of addition of full-fat flour to Ga-kenkey.

**Table 33. ANOVA SUMMARY TABLE FOR ACCEPTABILITY OF GA KENKEY**

| <u>Source of Variation</u> | <u>SS</u>      | <u>df</u>  | <u>MS</u> | <u>F ratio</u> | <u>Sig. Level</u> |
|----------------------------|----------------|------------|-----------|----------------|-------------------|
| Main Effects               | 540.10         | 33         | 16.366    | 2.592          | 0.001*            |
| Panelist                   | 221.63         | 29         | 7.642     | 1.210          | 0.2366            |
| Sample                     | 318.46         | 4          | 79.616    | 12.604         | 0.000*            |
| Residual                   | 732.73         | 116        | 6.316     |                |                   |
| <u>Total corr</u>          | <u>1272.83</u> | <u>149</u> |           |                |                   |

\* = significant at  $p \leq 0.05$



Table 34 MULTIPLE RANGE ANALYSIS FOR ACCEPTABILITY OF GA KENKEY

| SAMPLE                            | MEAN SCORE | LSD INTERVALS<br>(Homogenous gps) |
|-----------------------------------|------------|-----------------------------------|
| Maize dough + Full fat (FFBF)     | 4.167      | A                                 |
| Maize dough + Defatted Soy (DFBF) | 5.100      | A                                 |
| Maize dough + Extruded (EXBF)     | 5.267      | A                                 |
| Maize dough + Full fat (FFAF)     | 7.167      | B                                 |
| Maize dough + 0% Soy              | 8.133      | B                                 |

Thus Ga-kenkey containing full-fat soy was more acceptable when the soy was added after fermentation of the dough. Anova (Table 33) indicates differences in acceptability of Ga-kenkey containing no soy was not significantly different from the product containing Full-fat when soy was added after fermentation of the maize dough.

There was also no significant difference in acceptability in soy-fortified Ga-kenkey containing extruded soy, defatted soy and the Full fat soy (FFBF) respectively. This indicated that where acceptability or performance was concerned addition of the three processed soy-flours showed no significant differences.

The Full-fat Soy-flour is the easiest of all the soybean flour processed and can be prepared using simple traditional methods especially in the rural communities.

The soybean can be dehulled by steaming in traditional steamers and cracked to dehull in the disc attrition mill which is commonly used in the rural areas.

#### 4.6.7. Processors' Evaluation of Ga Kenkey

Following the evaluation two Ga-kenkey processors were asked to examine the products, evaluate and comment on the products with respect to their acceptability and marketability in the Ga-kenkey industry. Their observation are summarised in Table 35. From the evaluation the following deductions were made;

- (a) that the colour of the products were generally acceptable. Thus the colour differences observed were in their view not significant.
- (b) that maize dough containing no soy is the most acceptable with respect to taste, flavour and texture which can therefore be considered as a standard.
- (c) that Ga-kenkey containing full fat soy (FFAF) was more acceptable among the soy fortified Ga -Kenkey especially its flavour.
- (d) that Ga-Kenkey containing Full-fat Soy (FFBF) had the strongest flavor which was unacceptable for Ga-Kenkey (the results of taste panel support this observations)

**TABLE 35 PROCESSORS EVALUATION OF GA-KENKEY**

| SAMPLE                                  | COLOUR                                    | TEXTURE                               | TASTE   | FLAVOR  |
|---|---|---------------------------------------|---|---|
| Maize Dough<br>+<br>0% Soy              | (i)Acceptable and appealing (good)        | (i)Elastic and acceptable             | Sweet (which is acceptable (normal taste                            | (i)Acceptable for kenkey  |
| Maize dough<br>+<br>20% Full fat (FFBF) | (i)Okay.(not much different from normal.) | (i)Elastic and quite acceptable       | (i) Too sweet (not so good for kenkey but good for Porridge. (Koko) | (i)Quite good but strong compared to other samples (not better than others) |
| Maize dough<br>+<br>20% Full fat (FFAF) | (i) Okay and acceptable.                  | (i)Elastic and acceptable for kenkey. | (i)Okay-but too sweet.<br>(ii) better than (BFF)                    | (i)Acceptable and better than all the soy-maize samples                     |
| Maize dough<br>+<br>20% Extruded (EXBF) | (i)Acceptable as normal.                  | (i)Elastic and good                   | (i)Not sweet-very low sweet taste.                                  | (i) Okay  |
| Maize dough<br>+<br>20% Defatted (DFBF) | (i) Okay                                  | (i)Quite acceptable and very hard.    | (i)Sweet and acceptable.  | (i) Strong but quite acceptable.  |

#### 4.7. DIFFERENCE TEST ANALYSIS ON GA-KENKEY

The difference test was performed to determine whether two samples of Ga-kenkey could be distinguished from each other by sensory analysis. The difference were evaluated based on the samples appearance in colour, taste, texture and flavour. The analysis of data was done using One-tailed binomial test for significance. (Table 36).

**TABLE 36. RESULTS OF DIFFERENCE TEST FOR GA-KENKEY  
SOY FORTIFIED MAIZE DOUGH SAMPLES**

| SRT | NO<br>SOY | FULL<br>FAT<br>(FFAF) | FULL<br>FAT<br>(FFBF) | EXTRUDED<br>(EXEF) | DEFATTED<br>(DFBF) | COLOUR | TEXTURE | TASTE | FLAVOUR |
|-----|-----------|-----------------------|-----------------------|--------------------|--------------------|--------|---------|-------|---------|
| A   | X         |                       | X                     |                    |                    | +      | +       | +     | +       |
| B   |           | X                     | X                     |                    |                    | +      | +       | +     | +       |
| C   | X         |                       |                       |                    | X                  | +      | -       | -     | +       |
| D   | X         |                       |                       | X                  |                    | +      | -       | +     | +       |
| E   |           |                       | X                     |                    | X                  | +      | -       | +     | -       |
| F   |           |                       |                       | X                  | X                  | -      | -       | -     | -       |

+ — Significant difference  
 - — No significant difference  
 X = TEST SAMPLE

##### 4.7.1. Set A

Analysis of data showed that there were significant differences in colour, taste, texture and flavour between. Ga-kenkey containing no soy and that containing Full fat (FFBF) Soy.  
 For colour; 87% of panellist detected differences  
 For texture; 58% of panellist detected differences  
 For flavour; 70% of panellist detected differences  
 For taste; 70% of panellist detected differences

It is therefore apparent that addition of Full-fat soy to kenkey before fermentation of the maize dough may contribute to change in the colour, texture, flavour and taste of Ga-kenkey.

#### 4.7.2. Set B

This evaluation was conducted to ascertain how the method of addition of soy affect sensory properties of Ga-kenkey. Test for differences indicated significant differences in colour, texture, taste and flavour of Ga kenkey containing Full-fat (FFBF) and Full-fat soy (FFAF) respectively.

For colour: 71% of panellist detected differences.

For texture: 52% of panellist detected differences

For taste: 64% of panellist detected differences.

For flavour: 68% of panellist detected differences.



This suggests that the method of addition of soyflour produces significant changes in colour, texture, taste and flavour of the soy-fortified Ga-kenkey. It appears majority of panellists were able to detect differences in colour followed by flavour of the products.

#### 4.7.3 Set C

Results of test on Set C was quite different from sets A and B. Significant differences in colour and flavour were detected by the taste panel on Ga-kenkey containing no soy and that containing defatted soyflour (FFBF).

For colour: 90% of panellist detected difference

For flavour: 54% of panellist detected difference

For texture; 35% of panellist detected difference

For taste: 38% of panellist detected difference

Thus no significant differences in texture and taste of the two products were detected.

#### 4.7.4 Set D

Results on different test shows that significant difference exist between Ga-kenkey containing no soy and that containing extruded soyflour on the basis of colour, taste and flavour. No significant difference was detected in the texture of the products. This indicate that extruded soy imparted textural characteristics similar to the maize dough.

For colour: 100% of panellist were able to detect differences in colour.

For texture, 48% of panellist detected difference.

For taste, 64% of panellist detected difference.

For Flavour: 84% of panellist detected difference.

The effect of addition of extruded soyflour to Ga-kenkey on colour, taste and flavour was very pronounce.

#### 4.7.5 Set E

Difference test results shows that significant difference in colour and taste of Ga-kenkey containing Full-fat soy (FFBF), and defatted soy (DFBF). No differences were detected in the texture and flavour of the products.

For colour: 77% of panellist detected difference

For texture: 32% of panellist detected difference

For taste: 61% of panellist detected difference

For flavour: 48% of panellist detected difference

With respect of texture it appears Full-fat soy behaves similar to defatted soy when incorporated into Ga-kenkey.

#### 4.7.6 Set F

Results indicated no significant differences in colour, texture, taste and flavour of Ga-kenkey containing extruded soy (EXBF) and defatted soy (DFBF) respectively.

For colour: 29% of panellist detected differences

For texture: 45% of panellist detected differences

For taste: 48% of panellist detected differences

For flavour: 38% of panellist detected differences

The extruded soyflour and defatted soy can therefore be said to exhibit similarity in colour, flavour, texture and taste when added to Ga-kenkey.

#### 4.8 SENSORY EVALUATION OF AKASA PORRIDGE

Akasa is the most common weaning food in Ghana and is also common breakfast food. Sensory analysis of the products showed differences in consumer preferences for the akasa samples.

##### 4.8.1 COLOUR:

Mean score results (Table 38) indicated Akasa from maize dough containing no soy had the most appealing colour (6.79) followed by soy-fortified dough containing extruded soy (6.43) Full-fat (FFAF) (5.37), Full-fat (FFBF) and defatted soy (4.64).

Consumer preference for colour differed with the type of sample. ANOVA (Table 37) showed that there were significant differences in consumer preference for colour of the Akasa samples. Further analysis using multiple range tests (LSD), showed that the preference for colour of the Akasa samples containing soy (whether defatted or fullfat, added before or after fermentation) were significantly different from those containing extruded soy. There were however, no significant

differences between the colour of unfortified maize dough, and that of the maize dough fortified with extruded soy.

**Table 37. ANOVA SUMMARY TABLE FOR COLOUR OF AKASA**

| Source of Variation | SS       | df | MS     | F ratio | Sig. Level |
|---------------------|----------|----|--------|---------|------------|
| Main Effects        | 189.4154 | 18 | 10.523 | 1.444   | 0.1518     |
| Panelist            | 135.581  | 14 | 9.678  | 1.328   | 0.2242     |
| Sample              | 59.179   | 4  | 14.794 | 1.031   | 0.000*     |
| Residual            | 371.57   | 51 | 7.728  |         |            |
| Total corr          | 560.985  | 69 |        |         |            |

\* = significant at  $p \leq 0.05$

**Table 38 MULTIPLE RANGE ANALYSIS FOR COLOUR OF AKASA**

| SAMPLE                        | MEAN SCORE | LSD INTERVALS<br>(Homogenous gps) |
|-------------------------------|------------|-----------------------------------|
| Maize dough + Defatted        | 4.643      | A                                 |
| Maize dough + Full fat (FFBF) | 4.714      | A                                 |
| Maize dough + Full fat (FFAF) | 5.357      | A                                 |
| Maize dough + Extruded (EXBF) | 6.428      | B                                 |
| Maize dough + 0% Soy          | 6.785      | B                                 |

The observations suggest that soybean can impart colour to the fermented maize system. Consumer acceptability of the colour however depends upon the process treatment given to the soy.

#### 4.8.2 TEXTURE

Akasa containing Full-fat soy (FFAF) indicated the highest mean score for texture followed by extruded soy, no soy, Full-fat (FFBF) and Defatted soy respectively. Anova showed no difference in texture of the samples. (Table 39 & 40)

**Table 39. ANOVA SUMMARY TABLE FOR TEXTURE OF AKASA**

| Source of Variation | SS      | df | MS     | F ratio | Sig. Level |
|---------------------|---------|----|--------|---------|------------|
| Main Effects        | 166.299 | 18 | 9.238  | 1.412   | 0.1665     |
| Panelist            | 117.499 | 14 | 8.392  | 1.283   | 0.2504     |
| Sample              | 48.956  | 4  | 12.239 | 1.371   | 0.1293     |
| Residual            | 333.643 | 51 | 6.542  |         |            |
| Total corr          | 499.942 | 69 |        |         |            |

**Table 40 MULTIPLE RANGE ANALYSIS FOR TEXTURE OF AKASA**

| SAMPLE                        | MEAN SCORE | LSD INTERVALS<br>(Homogenous gps) |
|-------------------------------|------------|-----------------------------------|
| Maize dough + Defatted (DFBF) | 4.643      | A                                 |
| Maize dough + Full fat (FFBF) | 5.214      | A                                 |
| Maize dough + 0% Soy          | 5.786      | A                                 |
| Maize dough + Extruded (EXBF) | 6.714      | B                                 |
| Maize dough + Full fat (FFAF) | 6.786      | B                                 |

#### 4.8.3 TASTE

Based on mean score Akasa containing no soy had the highest score for taste (6.5) followed by that containing Full-fat FFAF (6.43), extruded soy (EXBF) (5.14), defatted soy (DFBF) (5.07) and Full-fat (FFBF) (4.5).

Anova results (Table 41) indicated no significant differences in consumer preference for taste. This implies addition of soyflour and method of addition does not significantly affect taste of Akasa. This may be of significance in weaning food preparation based on Akasa. Full-fat soy flour can be added to the maize dough to enhance nutritional quality without change in taste. (Table 42).

**Table 41. ANOVA SUMMARY TABLE FOR TASTE OF AKASA**

| Source of Variation | SS      | df | MS     | F ratio | Sig. Level |
|---------------------|---------|----|--------|---------|------------|
| Main Effects        | 201.345 | 18 | 11.185 | 1.794   | 0.0526     |
| Panelist            | 158.973 | 14 | 11.355 | 1.821   | 0.0608     |
| Sample              | 41.123  | 4  | 10.280 | 1.649   | 0.1764     |
| Residual            | 318.026 | 51 | 6.235  |         |            |
| Total corr          | 519.371 | 69 |        |         |            |

**Table 42 MULTIPLE RANGE ANALYSIS FOR TASTE OF AKASA**

| SAMPLE                            | MEAN SCORE | LSD INTERVALS<br>(Homogenous gps) |
|-----------------------------------|------------|-----------------------------------|
| Maize dough + Full fat (FFBF)     | 4.571      | A                                 |
| Maize dough + Defatted Soy (DFBF) | 5.071      | A                                 |
| Maize dough + Extruded Soy (EXBF) | 5.143      | A                                 |
| Maize dough + Full fat (FFAF)     | 6.428      | B                                 |
| Maize dough + 0% Soy              | 6.500      | B                                 |

#### 4.8.4 FLAVOUR

With respect to flavour, Akasa containing extruded soy (FFBF) appears to have the most appealing flavour (8.428) based on the mean score. This was followed by Akasa containing Full-fat (FFAF), no soy, Full-fat (FFBF) and defatted (DFBF). (Table 44) The low mean score for the product containing defatted soy can be attributed to the strong beany flavour as a result of the defatting process. Analysis of variance (Table 43) indicates no significant difference in flavour of the samples.

**Table 43. ANOVA SUMMARY TABLE FOR FLAVOUR OF AKASA**

| <u>Source of Variation</u> | <u>SS</u> | <u>df</u> | <u>MS</u> | <u>F ratio</u> | <u>Sig. Level</u> |
|----------------------------|-----------|-----------|-----------|----------------|-------------------|
| Main Effects               | 509.031   | 18        | 28.279    | 1.670          | 0.0774            |
| Panelist                   | 378.089   | 14        | 27.006    | 1.594          | 0.1130            |
| Sample                     | 31.960    | 4         | 32.990    | 1.948          | 0.1167            |
| Residual                   | 863.839   | 51        | 16.938    |                |                   |
| Total corr                 | 1372.871  | 69        |           |                |                   |

**Table 44 MULTIPLE RANGE ANALYSIS FOR FLAVOUR OF AKASA**

| SAMPLE                        | MEAN SCORE | LSD INTERVALS<br>(Homogenous gps) |
|-------------------------------|------------|-----------------------------------|
| Maize dough + Defatted (DFBF) | 4.357      | A                                 |
| Maize dough + Full fat (FFBF) | 5.357      | A                                 |
| Maize dough + 0% Soy          | 6.357      | A                                 |
| Maize dough + Full fat (FFAF) | 6.714      | B                                 |
| Maize dough + Extruded (EFAF) | 8.428      | B                                 |

#### 4.8.5 ACCEPTABILITY

Akasa from maize dough containing no soy was most acceptable to consumers from the mean scores. This was also followed by Akasa containing Full-fat soy (FFAF) (6.79), extruded soy (EFAF) (6.43), Full-fat (FFBF) and defatted soy (DFBF) (3.64). (Table 45 & 46) The Akasa containing the defatted soy was least accepted perhaps on the basis of the strong beany flavour developed during defatting. Anova

acceptability of the products.

Akasa from the maize dough with no soy was not significantly different from that containing Full-fat soy (FFAF) and the extruded soy (FFBF) on the basis of acceptability. These three sample can thus be said to be the most acceptable for preparation of Akasa.

**Table 45. ANOVA SUMMARY TABLE FOR ACCEPTABILITY OF AKASA**

| <u>Source of Variation</u> | <u>SS</u>      | <u>df</u> | <u>MS</u> | <u>F ratio</u> | <u>Sig. Level</u> |
|----------------------------|----------------|-----------|-----------|----------------|-------------------|
| Main Effects               | 218.301        | 18        | 12.127    | 1.589          | 0.089             |
| Panelist                   | 71.243         | 14        | 5.088     | 0.667          | 0.794             |
| Sample                     | 145.965        | 4         | 36.491    | 4.782          | 0.0024*           |
| Residual                   | 389.184        | 51        | 7.631     |                |                   |
| <u>Total corr</u>          | <u>607.485</u> | <u>69</u> |           |                |                   |

\* = significant at  $p \leq 0.05$

**Table 46. MULTIPLE RANGE ANALYSIS FOR ACCEPTABILITY OF AKASA**

| SAMPLE                        | MEAN SCORE | LSD INTERVALS<br>(Homogenous gps) |
|-------------------------------|------------|-----------------------------------|
| Maize dough + Defatted (DFBF) | 3.643      | A                                 |
| Maize dough + Full fat (FFBF) | 3.857      | A                                 |
| Maize dough + Extruded (EXBF) | 6.428      | A                                 |
| Maize dough + Full fat (FFAF) | 6.786      | B                                 |
| Maize dough + 0% Soy          | 6.857      | B                                 |

#### 4.9 DIFFERENCE TEST ON AKASA

Results on the difference test for soy fortified Akasa are presented in Table 47.

**TABLE 47 RESULTS ON DIFFERENCE TEST ON AKASA**

| SET | NO SOY | FULL FAT (FFAF) | FULL FAT (FFBF) | EXTRUDED (EXBF) | DEFATTED (DFBF) | COLOUR | TEXTURE | FLAVOR | TASTE |
|-----|--------|-----------------|-----------------|-----------------|-----------------|--------|---------|--------|-------|
| A   | X      |                 | X               |                 |                 | +      | +       | +      | -     |
| B   |        | X               | X               |                 |                 | +      | -       | +      | +     |
| C   | X      |                 |                 |                 | X               | +      | +       | +      | -     |
| D   | X      |                 |                 | X               |                 | +      | -       | +      | -     |
| E   |        |                 | X               |                 | X               | +      | +       | +      | +     |
| F   |        |                 |                 | X               | X               | +      | +       | -      | -     |

+ - SIGNIFICANT DIFFERENCE  
 - - NO. SIGNIFICANT DIFFERENCE  
 X = TEST SAMPLE

##### 4.9.1. Set A:

Results indicated there was significant difference in the colour, texture and taste of Akasa containing no soy and that containing Full-fat soy (BFF).

For colour; 80% of panellist detected difference

For texture; 67% of panellist detected difference

For taste; 67% of panellist detected difference

For flavour; 53% of panellist detected difference

No significance difference in flavour was detected by the panellist.

##### 4.9.2. Set B

Results indicated significant difference in colour, taste and flavour of Akasa containing Full-fat (AFF) and Full-fat soy (BFF) respectively. No significant differences was observed in the texture of the products.

93.3% of panellist detected difference in colour

For taste; 73% of panellist detected difference

For flavour; 60% of panellist detected difference

For texture; 53% of panellist detected difference

#### 4.9.3 Set C

Results showed significant difference in the colour, taste and texture of Akasa containing no soyflour and that containing defatted soy (BFF).

For colour; 93% of panellist detected difference

For texture; 73% of panellist detected difference

For taste; 53% of panellist detected difference

For flavour; 73% of panellist detected difference

Thus the ability of panellist to detect difference between samples was greater for colour, flavour and taste.

#### 4.9.4 Set D

Significant difference was found in only the colour and flavour of Akasa containing no soy and that containing defatted soy respectively.

No significant differences were detected in the texture and taste of the Akasa samples.

The panellist scores were:

For colour; 67% detected difference

For texture; 40% detected difference

For taste: 47% detected difference

For flavour; 67% detected difference

#### 4.9.5 Set E

Resulting difference test indicated significant differences in colour, texture, flavour and taste of the Akasa containing

Full-fat (FFBF) and defatted soy (DFBF)

73% of panellist detected difference in colour

For texture 66% of panellist detected difference

For flavour 80% of panellist detected difference

For taste 73% of panellist detect difference

#### 4.9.6 Set F

Akasa containing extruded and defatted soy showed difference in colour and texture. No significant differences was observed in the flavour and taste of the two products.

In order of panellist ability to detect differences

80% of panellist detected difference in texture

60% of " " " in colour

46% of " " " in flavour

40% of " " " in taste

Thus panellist could easily detect difference in texture of the products.

#### 4.10. Summary of Comment by Taste Panellists

##### A) Ga- Kenkey

1. Ga-kenkey containing no soy is the best because the colour, texture, and flavour is good. This comment was passed by majority of the panellist.
2. Ga-kenkey containing Full-fat (FFAF) is also good for its taste and flavour.
3. Some of products are not comparable to 'original' kenkey because of their flavour and colour.
4. Some of the soybean products have strong flavour
5. Ga-kenkey containing Full-fat (FFBF) should be improved.

## B) AKASA

1. Akasa containing no soy was most acceptable
2. Most of the soy-fortified Akasa were found to be good except for some which had 'bad' taste and flavour.

## 5.0

### CONCLUSION

A. The processing of Soybean and its incorporation into fermented maize dough not only enhanced the nutritional quality but also influenced the characteristics of the dough and therefore the product quality of the intended food uses.

B. The method of addition of the soyflour affected physicochemical characteristics such as pH, total acidity, water absorption and pasting properties of the dough.

C. Sourness of dough is an important taste index for consumers , and it is measured by the pH and acidity. It changed as fermentation proceeded as was indicated by the increase in acidity and lowering of pH of the fermenting dough system. Addition of soyflours to the maize dough further lowered pH and increased acidity of the dough. Addition of Full fat soy to maize dough before fermentation of the maize dough enhanced the development of sourness in the soy-fortified maize dough. This was indicated by high titratable acidity values. Lower pH and higher acidity in soy fortified maize dough can therefore be achieved when soyflour was added before fermentation than after fermentation of the maize dough.

D. Temperature and fermentation influence water absorption of soy-fortified maize dough significantly. Water absorption at 70°C was generally higher than at 29°C. Water absorption

affect dough formation.

**E.** Addition of soyflour to maize dough also affected cooking properties significantly. Viscosity indices (Peak viscosity, vis 95°C, vis 95°C Hold Vis 50°C and Vis 50°C Hold) decreased on the addition of soyflour to the maize dough. The viscosity indices increased with fermentation time irrespective of method of addition. The full fat soy product (Soy fortified dough) showed the lowest viscosity characteristics. Maize dough with no soy showed better cooking properties than the soy-fortified samples.

Soy-fortified maize dough in which the soy was added after fermentation had better cooking properties than those in which the soy was added before fermentation of the maize dough.

Increasing the soy level also decreased the ease of cooking of the soy-fortified maize dough. Among the soy-fortified maize dough samples, the doughs containing Full-fat soy flour showed more difficulty in cooking.

Viscosity at 50°C indicates increasing the soy flour level in the dough from 0% to 20% reduces the thickness of the cooked paste on cooling. This is important in foods such as Ga kenkey in which acceptability is partly determined by texture after cooking.

**F.** As far as sensory analysis of the soy fortified dough prepared into Ga kenkey and Akasa (Porridge) is concerned, the products from maize dough with no soy and Full fat soy fortified maize dough in which the soy was added after

fermentation were most acceptable to consumers. The full fat soy product (soy added after fermentation of maize dough had preference for colour, texture, taste and flavour similar to the unfortified maize dough. The defatted soy fortified product was least preferred for its 'hard' texture and flavour.

**G.** The full fat soy fortified product (soy added before fermentation) was also the least preferred for its strong and objectionable flavour and increased sourness in the product. Thus on adding soyflour to maize dough before fermentation, the duration of fermentation and the development of sourness should be considered.

**H.** On the difference test on Ga kenkey panelist were able to detect differences in colour, texture, taste and flavour between Ga kenkey from maize dough (no soy) and full fat soy products (FFBF). For texture and taste no difference were detected between Ga kenkey product from maize dough (no soy) and the defatted soy product.

**I.** The method of addition of full-fat soyflour to maize dough also affected responses. Differences, were detected by panelists in colour, texture taste and flavour between the products (Ga kenkey) containing full fat soy flour added before fermentation and after fermentation respectively. Difference test also showed no significant differences in responses between the product containing Extruded soy and Defatted soy respectively. Difference test on Akasa showed

that panelists detected differences in the colour between samples presented. For Akasa samples containing full-fat soyflour added before and after fermentation differences in colour flavour and taste were noticed.

J. The method of addition of soyflour to maize dough is therefore an important factor to be considered in fortifying maize dough with soyflour. Hence 20% Full-fat soyflour added to maize dough fermented for 48 hours may be convenient for Ga-kenkey and Akasa preparation.

## 6.0

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## APPENDIX I

pH Characteristics of Soy-maize dough  
(Soy-flour added before fermentation of Maize dough)

| Soy-Maize Sample               | FERMENTATION TIME<br>(HOUR) |      |      |      |
|--------------------------------|-----------------------------|------|------|------|
|                                | 0                           | 6    | 24   | 48   |
| Maize dough (No soyflour)      | 5.90                        | 4.85 | 4.42 | 4.10 |
| Maize dough + 10 Full fat Soy  | 6.21                        | 4.75 | 4.09 | 3.68 |
| Maize dough + 20% Full fat     | 6.60                        | 4.51 | 3.81 | 3.76 |
| Maize dough + 10% Extruded Soy | 5.99                        | 4.77 | 4.39 | 4.17 |
| Maize dough 20% Extruded Soy   | 6.63                        | 4.99 | 4.42 | 4.12 |
| Maize dough + 10% Defatted Soy | 5.98                        | 4.65 | 4.25 | 4.03 |
| Maize dough + 20% Defatted Soy | 5.87                        | 5.07 | 4.38 | 4.23 |

## APPENDIX II

## pH Characteristics of Soy-maize dough

(Soy flour added after fermentation of maize dough)

| Soy-Maize sample               | 0    | 6    | 24   | 48   |
|--------------------------------|------|------|------|------|
| Maize dough (No Soy)           | 5.90 | 4.85 | 4.42 | 4.10 |
| Maize dough + 10% Full fat Soy | 6.51 | 4.74 | 4.53 | 4.44 |
| Maize dough + 20% Full fat Soy | 6.04 | 4.72 | 4.49 | 4.46 |
| Maize dough + 10% Extruded Soy | 5.50 | 4.92 | 4.87 | 4.71 |
| Maize dough + 20% Extruded Soy | 6.04 | 4.90 | 4.85 | 4.75 |
| Maize dough + 10% Defatted Soy | 5.62 | 4.92 | 4.52 | 4.51 |
| Maize dough + 20% Defatted Soy | 5.98 | 4.96 | 4.74 | 4.68 |

**APPENDIX III****Acidity Characteristics of Soy-maize dough**

(Soyflour added after fermentation of Maize dough)

| Soy-Maize Sample             | 0      | 6      | 24     | 48     |
|------------------------------|--------|--------|--------|--------|
| Maize dough (No Soy)         | 0.0440 | 0.0980 | 0.1064 | 0.1842 |
| Maize dough+10% Full fat Soy | 0.0420 | 0.0748 | 0.1120 | 0.1568 |
| Maize dough+20% Full fat Soy | 0.0521 | 0.0732 | 0.1049 | 0.1504 |
| Maize dough+10% Extruded Soy | 0.0411 | 0.0726 | 0.1008 | 0.1043 |
| Maize dough+20% Extruded Soy | 0.0392 | 0.0643 | 0.0952 | 0.1036 |
| Maize dough+10% Defatted Soy | 0.0420 | 0.0542 | 0.0991 | 0.1260 |
| Maize dough+20% Defatted Soy | 0.0580 | 0.0621 | 0.0941 | 0.1092 |

**APPENDIX IV****Acidity Characteristics of Soy-maize dough**

(Soyflour added before fermentation of Maize dough)

| Soy-Maize Sample             | 0      | 6      | 24     | 48     |
|------------------------------|--------|--------|--------|--------|
| Maize dough (No Soy)         | 0.0440 | 0.0980 | 0.1064 | 0.1842 |
| Maize dough+10% Full fat Soy | 0.0420 | 0.0980 | 0.1848 | 0.2352 |
| Maize dough+20% Full fat Soy | 0.0532 | 0.1232 | 0.2394 | 0.3500 |
| Maize dough+10% Extruded Soy | 0.0336 | 0.0896 | 0.1232 | 0.1204 |
| Maize dough+20% Extruded Soy | 0.0420 | 0.1008 | 0.1260 | 0.1988 |
| Maize dough+10% Defatted Soy | 0.0420 | 0.0896 | 0.1512 | 0.1652 |
| Maize dough+20% Defatted Soy | 0.0580 | 0.1038 | 0.1652 | 0.2296 |

TOTAL TITRABLE ACIDITY (g per 100g sample (dry matter basis))

## APPENDIX V      SENSORY EVALUATION OF AKASA "PORRIDGE"

|    | COLOUR |     |     |     |     | TEXTURE |     |     |     |     | TASTE |     |     |     |     |
|----|--------|-----|-----|-----|-----|---------|-----|-----|-----|-----|-------|-----|-----|-----|-----|
|    | 075    | 238 | 313 | 675 | 790 | 075     | 238 | 313 | 675 | 790 | 075   | 238 | 313 | 675 | 790 |
| 1  | 5      | 10  | 7   | 9   | 8   | 5       | 9   | 6   | 8   | 7   | 4     | 9   | 5   | 6   | 7   |
| 2  | 5      | 2   | 4   | 1   | 3   | 5       | 1   | 4   | 2   | 3   | 5     | 4   | 1   | 3   | 2   |
| 3  | 1      | 10  | 3   | 2   | 7   | 8       | 1   | 2   | 6   | 9   | 5     | 4   | 1   | 3   | 2   |
| 4  | 3      | 9   | 2   | 7   | 6   | 2       | 7   | 3   | 5   | 6   | 2     | 7   | 3   | 4   | 5   |
| 5  | 3      | 8   | 2   | 9   | 7   | 2       | 9   | 6   | 10  | 8   | 8     | 7   | 4   | 10  | 9   |
| 6  | 9      | 3   | 5   | 1   | 7   | 8       | 2   | 6   | 3   | 5   | 7     | 3   | 10  | 2   | 5   |
| 7  | 10     | 3   | 7   | 1   | 5   | 10      | 1   | 7   | 3   | 5   | 3     | 10  | 5   | 1   | 7   |
| 8  | 2      | 10  | 6   | 9   | 7   | 4       | 9   | 7   | 10  | 8   | 6     | 9   | 4   | 10  | 7   |
| 9  | 3      | 10  | 6   | 9   | 8   | 3       | 9   | 8   | 10  | 6   | 3     | 10  | 5   | 9   | 7   |
| 10 | 1      | 3   | 2   | 6   | 5   | 1       | 6   | 2   | 7   | 8   | 4     | 2   | 3   | 10  | 1   |
| 11 | 2      | 10  | 4   | 6   | 8   | 2       | 10  | 7   | 8   | 6   | 7     | 10  | 4   | 10  | 6   |
| 12 | 10     | 2   | 6   | 5   | 9   | 5       | 3   | 8   | 6   | 9   | 8     | 3   | 6   | 5   | 9   |
| 13 | 7      | 9   | 6   | 8   | 5   | 5       | 8   | 6   | 9   | 7   | 5     | 7   | 8   | 9   | 4   |
| 14 | 4      | 6   | 6   | 2   | 5   | 5       | 6   | 1   | 3   | 7   | 4     | 6   | 5   | 8   | 1   |

## SENSORY EVALUATION OF ANASA "PORRIDGE" (Contd.)

|    | F L A V O U R |     |     |     |     | A C C E P T A B I L I T Y |     |     |     |     |
|----|---------------|-----|-----|-----|-----|---------------------------|-----|-----|-----|-----|
|    | 075           | 238 | 313 | 675 | 790 | 075                       | 238 | 313 | 675 | 790 |
| 1  | 6             | 10  | 8   | 9   | 7   | 3                         | 9   | 4   | 7   | 5   |
| 2  | 5             | 1   | 4   | 2   | 3   | 5                         | 4   | 2   | 1   | 3   |
| 3  | 2             | 8   | 7   | 9   | 1   | 5                         | 4   | 2   | 1   | 9   |
| 4  | 6             | 8   | 2   | 7   | 5   | 2                         | 7   | 3   | 8   | 7   |
| 5  | 8             | 3   | 7   | 5   | 5   | 2                         | 6   | 4   | 9   | 8   |
| 6  | 3             | 6   | 9   | 4   | 8   | 9                         | 5   | 7   | 2   | 3   |
| 7  | 5             | 1   | 3   | 7   | 10  | 5                         | 7   | 3   | 10  | 1   |
| 8  | 3             | 10  | 8   | 9   | 5   | 2                         | 10  | 6   | 4   | 8   |
| 9  | 3             | 10  | 6   | 9   | 8   | 1                         | 10  | 3   | 8   | 5   |
| 10 | 3             | 5   | 1   | 2   | 8   | 2                         | 3   | 1   | 10  | 9   |
| 11 | 7             | 10  | 4   | 9   | 6   | 1                         | 10  | 3   | 10  | 7   |
| 12 | 2             | 3   | 5   | 6   | 8   | 8                         | 3   | 6   | 5   | 9   |
| 13 | 4             | 9   | 5   | 8   | 7   | 3                         | 9   | 5   | 10  | 8   |
| 14 | 4             | 5   | 6   | 8   | 7   | 3                         | 9   | 5   | 10  | 8   |

APPENDIX VI  
SET A

## DATA ON DIFFERENCE TEST FOR AKASA

| PANELLIST | COLOUR | TEXTURE | FLAVOUR | TASTE |         |
|-----------|--------|---------|---------|-------|---------|
| 1         | +      | +       | +       | +     |         |
| 2         | +      | +       | +       | +     |         |
| 3         | -      | +       | -       | +     | Colour  |
| 4         | +      | +       | +       | +     | x = 12  |
| 5         | +      | +       | +       | -     |         |
| 6         | +      | +       | -       | +     | Texture |
| 7         | -      | -       | +       | -     | x = 10  |
| 8         | +      | -       | -       | -     |         |
| 9         | +      | +       | +       | +     | Flavour |
| 10        | -      | -       | -       | -     | x = 8   |
| 11        | +      | +       | -       | -     |         |
| 12        | +      | -       | +       | +     | Taste   |
| 13        | +      | +       | +       | +     | x = 10  |
| 14        | +      | +       | -       | +     |         |
| 15        | +      | -       | -       | +     |         |

## SET B

| PANELLIST | COLOUR | TEXTURE | FLAVOUR | TASTE |  |
|-----------|--------|---------|---------|-------|--|
| 1         | +      | +       | +       | +     |  |
| 2         | +      | +       | +       | +     |  |
| 3         | +      | -       | -       | +     |  |
| 4         | +      | +       | +       | +     |  |
| 5         | +      | -       | -       | +     |  |
| 6         | +      | +       | +       | -     |  |
| 7         | -      | -       | -       | -     |  |
| 8         | +      | -       | -       | -     |  |
| 9         | +      | +       | +       | +     |  |
| 10        | +      | -       | -       | +     |  |
| 11        | +      | +       | +       | +     |  |
| 12        | +      | -       | +       | +     |  |
| 13        | +      | +       | +       | +     |  |
| 14        | +      | +       | +       | -     |  |
| 15        | +      | -       | -       | -     |  |
|           | 14     | 8       | 9       | 11    |  |

## SET C

| PANELLIST | COLOUR | TEXTURE | FLAVOUR | TASTE |          |
|-----------|--------|---------|---------|-------|----------|
| 1         | +      | +       | +       | +     |          |
| 2         | +      | +       | +       | +     |          |
| 3         | -      | -       | +       | +     | Colour   |
| 4         | +      | +       | +       | +     | (+) = 14 |
| 5         | +      | +       | +       | -     |          |
| 6         | +      | -       | +       | -     | Texture  |
| 7         | +      | -       | -       | -     | (+) = 11 |
| 8         | +      | +       | -       | -     |          |
| 9         | +      | +       | +       | +     | Flavour  |
| 10        | +      | +       | -       | -     | (+) = 11 |
| 11        | +      | +       | -       | -     |          |
| 12        | +      | +       | +       | -     | Taste    |
| 13        | +      | +       | +       | +     | (+) = 8  |
| 14        | +      | +       | +       | +     |          |
| 15        | +      | -       | +       | +     |          |



## SET D

| PANELLIST | COLOUR | TEXTURE | FLAVOR | TASTE |          |
|-----------|--------|---------|--------|-------|----------|
| 1         | +      | +       | +      | -     |          |
| 2         | +      | +       | +      | +     | Colour   |
| 3         | -      | -       | +      | -     | (+) = 10 |
| 4         | +      | +       | +      | +     |          |
| 5         | +      | +       | -      | +     | Texture  |
| 6         | +      | -       | +      | -     | (+) = 6  |
| 7         | -      | -       | +      | -     |          |
| 8         | +      | -       | -      | -     | Flavour  |
| 9         | +      | +       | +      | +     | (+) = 10 |
| 10        | -      | -       | -      | -     |          |
| 11        | +      | -       | +      | -     | Taste    |
| 12        | +      | -       | +      | +     | (+) = 7  |
| 13        | +      | +       | +      | +     |          |
| 14        | -      | -       | -      | +     |          |
| 15        | -      | -       | -      | -     |          |

## SET E

| Panellist | Colour | Texture | Flavour | Taste |          |
|-----------|--------|---------|---------|-------|----------|
| 1         | +      | +       | +       | -     |          |
| 2         | +      | +       | +       | +     |          |
| 3         | -      | +       | +       | -     | Colour   |
| 4         | +      | +       | +       | +     | (+) = 11 |
| 5         | +      | +       | +       | -     |          |
| 6         | +      | +       | +       | +     | Texture  |
| 7         | -      | -       | +       | +     | (+) = 10 |
| 8         | +      | -       | +       | +     |          |
| 9         | +      | +       | +       | +     | Flavour  |
| 10        | -      | -       | +       | +     | (+) = 12 |
| 11        | +      | -       | +       | +     |          |
| 12        | +      | +       | -       | -     | Taste    |
| 13        | +      | +       | +       | +     | (+) = 11 |
| 14        | +      | -       | -       | +     |          |
| 15        | +      | +       | -       | +     |          |

## SET F

| PANELLIST | COLOUR | TEXTURE | FLAVOR | TASTE |          |
|-----------|--------|---------|--------|-------|----------|
| 1         | +      | +       | +      | -     |          |
| 2         | +      | +       | +      | +     |          |
| 3         | -      | +       | -      | -     | Colour   |
| 4         | -      | -       | -      | -     | (+) = 9  |
| 5         | +      | +       | -      | +     |          |
| 6         | +      | +       | +      | -     | Texture  |
| 7         | -      | +       | -      | +     | (+) = 12 |
| 8         | -      | +       | -      | +     |          |
| 9         | -      | -       | -      | -     | Flavour  |
| 10        | +      | +       | +      | -     | (+) = 7  |
| 11        | +      | +       | -      | -     |          |
| 12        | +      | +       | -      | +     | Taste    |
| 13        | +      | +       | +      | +     | (+) = 6  |
| 14        | +      | +       | +      | -     |          |
| 15        | -      | -       | +      | -     |          |



## APPENDIX VII

SENSORY EVALUATION OF GA KENTEY

## 1. DIFFERENCE TEST

SET A - MZ + 0% SOY

MZ + FULL FAT (FFBF)

MZ + FULL FAT (FFBF)

SET B - MZ + FULL FAT (FFBF)

MZ + FULL FAT (FFBF)

MZ + FULL FAT (FFBF)

SET C - MZ + 0% SOY

MZ + DEFATTED (DFBF)

MZ + DEFATTED (DFBF)

SET D MZ + EXTRUDED (EXBF)

MZ + EXTRUDED (EXBF)

MZ + 0% SOY

SET E MZ + FULL-FAT (FFBF)

MZ + DEFATTED (DFBF)

MZ + DEFATTED (DFBF)

SET F MZ + EXTRUDED (EXBF)

MZ + EXTRUDED (EXBF)

MZ + DEFATTED (DFBF)

MZ = Maize dough.

## Q2 Preference tests

1. MZ + 0% SOY - 015

2. MZ + FULL-FAT (FFBF) 020

3. MZ + EXTRUDED (EXBF) 011

4. MZ + DEFATTED (DFBF) 023

5. MZ + FULL-FAT (FFAF) 012

APPENDIX VIII

SENSORY EVALUATION QUESTIONNAIRE

DEPARTMENT OF NUTRITION AND FOOD SCIENCE

SENSORY EVALUATION OF GA KENKEY AND AKASA PORRIDGE

NAME: ..... SEX: ..... DATE: .....

1. You have been provided with three (3) samples of Ga Kenkey.

For each set please write the code number of the odd sample with respect to the following characteristics.

Set A    Set B    Set C    Set D    Set E    Set f

Colour

Texture

Flavour

Taste

2. Please indicate your preference for the quality attribute by ranking the coded sample.

Indicate your rank by making a vertical line on the scale.

Colour

\_\_\_\_\_

1      2      3      4      5      6      7      8      9      10

Texture

\_\_\_\_\_

1      2      3      4      5      6      7      8      9      10

Flavour

\_\_\_\_\_

1      2      3      4      5      6      7      8      9      10

Taste

\_\_\_\_\_

1      2      3      4      5      6      7      8      9      10

Acceptability

\_\_\_\_\_

1      2      3      4      5      6      7      8      9      10

Comments: .....

.....

.....

.....



## APPENDIX IX

SENSORY EVALUATION & GA KENKEY

| <u>CODE</u> |   | <u>SAMPLES</u>                                 |
|-------------|---|--|
| 1020        | - | MAIZE DOUGH + 20% FULLFAT (FFBF)               |
| 2023        | - | MAIZE DOUGH + 20% DEFATTED SOYFLOUR (DFBF)     |
| 3011        | - | MAIZE DOUGH + 20% EXTRUDED SOYFLOUR 20% (EXBF) |
| 4012        | - | MAIZE DOUGH + 20% FULL-FAT (FFAF)              |
| 5015        | - | MAIZE DOUGH + 0% SOY                           |

## APPENDIX X

## RESULT ON DIFFERENCE TEST (GA KENKEY)

## SET A

| PANELLIST | COLOUR    | TEXTURE   | FLAVOUR   | TASTE     |         |
|-----------|-----------|-----------|-----------|-----------|---------|
| 1         | +         | -         | +         | +         |         |
| 2         | -         | +         | +         | -         |         |
| 3         | +         | +         | +         | +         |         |
| 4         | +         | +         | +         | +         |         |
| 5         | +         | -         | -         | -         |         |
| 6         | +         | +         | +         | +         |         |
| 7         | +         | -         | -         | -         |         |
| 8         | +         | +         | +         | -         |         |
| 9         | +         | -         | -         | +         |         |
| 10        | +         |           | +         | +         |         |
| 11        | +         | -         | -         | -         | COLOUR  |
| 12        | +         | -         | +         | +         | = 87%   |
| 13        | +         | +         | +         | +         |         |
| 14        | +         | +         | +         | +         | TEXTURE |
| 15        | +         | +         | -         | +         | = 58%   |
| 16        | +         | -         | -         | +         |         |
| 17        | +         | -         | -         | +         | FLAVER  |
| 18        | +         | -         | -         | +         | = 70%   |
| 19        | +         | +         | +         | +         |         |
| 20        | +         | -         | +         | +         | TASTE   |
| 21        | +         | +         | +         | +         | = 70%   |
| 22        | -         | +         | -         | +         |         |
| 23        | -         | +         | -         | -         |         |
| 24        | +         | +         | -         | +         |         |
| 25        | +         | -         | +         | -         |         |
| 26        | +         | -         | +         | +         |         |
| 27        | +         | -         | +         | -         |         |
| 28        | +         | +         | +         | +         |         |
| 29        |           | +         | +         | +         |         |
| 30        | +         | -         | -         | -         |         |
| 31        | -         | +         | +         | +         |         |
|           | <u>27</u> | <u>18</u> | <u>22</u> | <u>22</u> |         |

RESULTS ON DIFFERENCE TEST (GA KENKEY)SET B

| PANELLIST | COLOUR             | TEXTURE            | TASTE              | FLAVOUR            |
|-----------|--------------------|--------------------|--------------------|--------------------|
| 1         | -                  | +                  | -                  | -                  |
| 2         | -                  | -                  | +                  | -                  |
| 3         | +                  | -                  | +                  | +                  |
| 4         | +                  | +                  | -                  | +                  |
| 5         | +                  | -                  | -                  | -                  |
| 6         | +                  | +                  | +                  | +                  |
| 7         | +                  | -                  | -                  | -                  |
| 8         | -                  | +                  | +                  | -                  |
| 9         | -                  | +                  | +                  | -                  |
| 10        | +                  | -                  | +                  | +                  |
| 11        | +                  | +                  | -                  | -                  |
| 12        | -                  | -                  | -                  | -                  |
| 13        | +                  | +                  | +                  | +                  |
| 14        | -                  | +                  | -                  | +                  |
| 15        | +                  | -                  | -                  | +                  |
| 16        | +                  | -                  | +                  | +                  |
| 17        | +                  | +                  | +                  | +                  |
| 18        | +                  | -                  | +                  | +                  |
| 19        | +                  | -                  | +                  | +                  |
| 20        | -                  | -                  | +                  | +                  |
| 21        | +                  | +                  | +                  | +                  |
| 22        | -                  | +                  | -                  | +                  |
| 23        | +                  | +                  | -                  | +                  |
| 24        | +                  | +                  | -                  | +                  |
| 25        | +                  | -                  | +                  | -                  |
| 26        | +                  | -                  | +                  | +                  |
| 27        | -                  | +                  | +                  | -                  |
| 28        | +                  | +                  | +                  | +                  |
| 29        | +                  | +                  | +                  | +                  |
| 30        | +                  | -                  | +                  | +                  |
| 31        | +                  | -                  | +                  | +                  |
|           | <u>22</u><br>===== | <u>16</u><br>===== | <u>20</u><br>===== | <u>21</u><br>===== |

SET C

RESULT ON DIFFERENCE TEST (GA KENKEY)

| PANELLIST | COLOUR    | TEXTURE   | TASTE     | FLAVOUR   |
|-----------|-----------|-----------|-----------|-----------|
| 1         | +         | -         | +         | +         |
| 2         | +         | -         | +         | +         |
| 3         | +         | -         | -         | +         |
| 4         | +         | +         | +         | -         |
| 5         | +         | -         | -         | -         |
| 6         | +         | -         | -         | -         |
| 7         | +         | -         | -         | -         |
| 8         | +         | +         | -         | -         |
| 9         | +         | -         | +         | +         |
| 10        | +         | -         | +         | +         |
| 11        | +         | -         | -         | -         |
| 12        | +         | -         | -         | -         |
| 13        | -         | -         | -         | -         |
| 14        | +         | +         | -         | -         |
| 15        | +         | +         | +         | -         |
| 16        | +         | -         | +         | +         |
| 17        | +         | -         | -         | +         |
| 18        | +         | -         | -         | +         |
| 19        | +         | -         | -         | -         |
| 20        | +         | -         | +         | +         |
| 21        | +         | +         | -         | +         |
| 22        | -         | +         | -         | -         |
| 23        | -         | -         | -         | +         |
| 24        | +         | +         | +         | +         |
| 25        | +         | +         | +         | -         |
| 26        | +         | -         | -         | -         |
| 27        | +         | +         | +         | +         |
| 28        | +         | +         | +         | +         |
| 29        | +         | +         | -         | +         |
| 30        | +         | -         | -         | +         |
| 31        | +         | -         | +         | +         |
|           | <u>28</u> | <u>11</u> | <u>12</u> | <u>17</u> |

SET D

## RESULT ON DIFFERENCE TEST (GA KENKEY)

| PANELLIST | COLOUR | TEXTURE | TASTE | FLAVOUR |
|-----------|--------|---------|-------|---------|
| 1         | +      | +       | +     | +       |
| 2         | +      | -       | +     | +       |
| 3         | +      | +       | +     | +       |
| 4         | +      | -       | +     | +       |
| 5         | +      | -       | +     | +       |
| 6         | +      | +       | -     | -       |
| 7         | +      | -       | +     | -       |
| 8         | +      | +       | -     | +       |
| 9         | +      | +       | -     | -       |
| 10        | +      | -       | -     | +       |
| 11        | +      | +       | -     | +       |
| 12        | +      | +       | +     | +       |
| 13        | -      | +       | +     | +       |
| 14        | +      | +       | -     | +       |
| 15        | +      | -       | -     | +       |
| 16        | +      | -       | +     | +       |
| 17        | +      | -       | +     | +       |
| 18        | +      | -       | +     | +       |
| 19        | +      | -       | +     | +       |
| 20        | +      | +       | +     | +       |
| 21        | +      | -       | +     | +       |
| 22        | -      | +       | -     | -       |
| 23        | -      | -       | +     | +       |
| 24        | +      | -       | -     | +       |
| 25        | +      | -       | +     | +       |
| 26        | +      | +       | +     | -       |
| 27        | +      | -       | -     | +       |
| 28        | +      | +       | +     | +       |
| 29        | +      | +       | +     | +       |
| 30        | +      | -       |       | +       |
| 31        | +      | +       | +     | +       |
|           | 31     | 15      | 20    | 26      |

SET E

RESULT ON DIFFERENCE TEST (GA KENKEY)

| PANELLIST | COLOUR    | TEXTURE   | TASTE     | FLAVOUR   |
|-----------|-----------|-----------|-----------|-----------|
| 1         | +         | -         | +         | +         |
| 2         | +         | +         | +         | +         |
| 3         | +         | +         | -         | -         |
| 4         | +         | -         | -         | -         |
| 5         | -         | -         | -         | -         |
| 6         | +         | -         | +         | +         |
| 7         | +         | -         | +         | +         |
| 8         | +         | +         | +         | +         |
| 9         | +         | -         | +         | -         |
| 10        | +         | -         | +         | +         |
| 11        | -         | -         | -         | -         |
| 12        | -         | -         | -         | -         |
| 13        | +         | +         | +         | +         |
| 14        | +         | -         | -         | -         |
| 15        | +         | -         | -         | -         |
| 16        | +         | -         | -         | -         |
| 17        | +         | +         | +         | +         |
| 18        | -         | -         | +         | -         |
| 19        | +         | -         | -         | -         |
| 20        | +         | -         | -         | -         |
| 21        | +         | +         | +         | +         |
| 22        | -         | -         | +         | -         |
| 23        | +         | +         | +         | +         |
| 24        | +         | -         | +         | -         |
| 25        | -         | +         | -         | -         |
| 26        | +         | -         | +         | +         |
| 27        | +         | -         | +         | +         |
| 28        | +         | +         | +         | +         |
| 29        | +         | +         | +         | +         |
| 30        | -         | -         | +         | -         |
| 31        | +         | -         | -         | +         |
|           | <u>24</u> | <u>10</u> | <u>19</u> | <u>15</u> |

## RESULT ON DIFFERENCE TEST (GA, KENKEY)

SET F

| PANELLIST | COLOUR | TEXTURE | TASTE | FLAVOUR |
|-----------|--------|---------|-------|---------|
| 1         | -      | +       | -     | -       |
| 2         | -      | +       | +     | -       |
| 3         | -      | -       | +     | -       |
| 4         | -      | -       | +     | -       |
| 5         | +      | +       | +     | +       |
| 6         | -      | +       | -     | +       |
| 7         | -      | -       | -     | -       |
| 8         | -      | -       | -     | +       |
| 9         | -      | +       | +     | +       |
| 10        | -      | +       | -     | -       |
| 11        | -      | -       | -     | -       |
| 12        | -      | +       | +     | -       |
| 13        | -      | -       | -     | -       |
| 14        | -      | +       | -     | +       |
| 15        | -      | -       | +     | -       |
| 16        | +      | -       | +     | +       |
| 17        | -      | -       | -     | -       |
| 18        | -      | +       | -     | -       |
| 19        | +      | -       | +     | -       |
| 20        | -      | +       | +     | +       |
| 21        | +      | +       | +     | +       |
| 22        | -      | -       | -     | +       |
| 23        | -      | -       | -     | -       |
| 24        | +      | -       | -     | +       |
| 25        | -      | -       | -     | -       |
| 26        | +      | +       | +     | +       |
| 27        | +      | -       | -     | -       |
| 28        | +      | +       | +     | +       |
| 29        | -      | -       | -     | -       |
| 30        | -      | -       | +     | -       |
| 31        | +      | +       | +     | -       |
|           | 9      | 14      | 15    | 12      |