

DEVELOPMENT OF PRECOOKED FOODS  
PROCESS AND PRODUCT EVALUATION



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DECLARATION

The work described in this report was carried out by me in the Department of Nutrition and Foodscience, University of Ghana, Legon, under the supervision of Dr. S. Sefa-Dedeh.

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DEDICATION

I wish to express my gratitude to my supervisor, Mr. S. Sefa-Dwivedi, for his good advice, encouragement, tolerance and help which has made this work successful.

I am also grateful to Mr. Akiba and Mother for the patience and explanations they gave during the course of the work, and Mr. Paul Abbey of the Chemistry Department for typing my manuscript.

My special thanks go to MY DEAR PARENTS for his readiness to give help when needed.

Finally I am very grateful to all those who in one way or the other contributed to the success of this work.

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Sensory evaluation of the corn-cakes product showed that the product was acceptable. Analysis of variance calculations showed a significant ( $P \leq 0.01$ ) effect of hulling and germination on the colour, odor, flavor and the general acceptability of the products.

A B S T R A C T

A pre-cooked food was developed from cornmeal and cowpead flour. The cowpea seeds were germinated and also dehulled. Control seeds of these treatments were made. Method used in the preparation of the product was steaming and traditional roasting in the earthenware mashing bowl.

Chemical analysis on the products showed that the product developed had a higher protein content than cornmeal.

Evaluation of the functional characteristics revealed that the water absorbed by the products increased with an increase in the number of germination days. The unhulled products also absorbed water and swelled more than the dehulled products. This was attributed to the presence of the seed coat in the unhulled seed products. There was not much difference in the water absorption and swelling properties with respect to the levels of corn and cowpea.

Viscoamylography runs showed no change in the gelatinisation of the germinated seed products, however there was a little increase in the viscosity of the ungerminated seed product during the holding and cooling sections.

Sensory evaluation of the corn-cowpea product showed that the product was acceptable. Analysis of variance calculations showed a significant ( $P \leq 0.01$ ) effect of dehulling and germination on the colour, odor, flavor and the general acceptability of the products,

The panelists could detect differences in the different products subjected to the different treatments.

A second product similar to the corn-cowpea product was developed from corndough. Fermented and unfermented corndough were used. Functional characteristics analysis showed a high water absorption and swelling of unfermented corndough products. Analysis on the product showed no significant difference in the colour, odor etc. of the fermented and unfermented corndough products. However, the unfermented corndough product was more acceptable.

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INTRODUCTION1.1 Nutrition and Food Problems

The total food production throughout the world has been increasing steadily, the F.A.O. of the United States reported an increase in Food production from 1975 - 1977 in both developed and developing countries (Anon. 1971). Despite this some segments of the population do not receive their recommended nutrients. These nutrients are carbohydrates, proteins, lipids, minerals and vitamins.

The major characteristic which affects the food consumption patterns in Africa is the diversity of ethnic groups. Thus some foods which may be abundant in an area may not be consumed because of traditional beliefs. Apart from the traditional beliefs, a certain, degree of regionalization in the population and utilization of foods can be recognized in Africa. The geographic belts indicates the major foods grown and the nutrients likely to be available in any region. The common foods found in the three geographic belts in Ghana are summarized in Table 1.

Table 1: Staple food crops produced in Relation to the Geographic belts of Ghana

Geographic belt	Staple Foods Produced
Drier Savanna	Milletts, Sorghum, Yam, Cassava
Coastal belt	Maize, rice, cassava, (not in large amounts) local vegetables eg. tomatoes, okro, gardeneggs
Forest belt	Yam, Plantain, banana

Thus people of the drier savanna are found to consume more of millets and sorghum than people of the coastal belt. There is therefore a difference in the food patterns of people of the same country. These are not the only problems associated with food consumption in Ghana.

Other factors contributing to the nutrition and food problems as stated by Sai (1969) are:

- 1) an increase in population. This is due to high fertility rate and a relatively low infant mortality rate.
- 2) Increase in urbanisation, and the third factor contributing to the food problem is the Governments interest in the production of more cash crops than food crops. Thus agricultural extensions are orientated in cash crop and this adversely affects food crop production.
- 4) Food habits also contribute to the food problems. People will eat foods that they have been brought up to consider as food. The final factor is protein availability. The foods making the largest contribution to the total protein intake are the staples. Thus in the savanna where sorghum and millet form the basis of their foods, the overall protein intake is adequate (for adults). However, this is not so for children. The protein content of these staple foods are not adequate to meet their requirements. The forest diets are the most lacking in protein. The general protein intake is low and this leads to protein malnutrition in children around the forest zone.

1.2 Overcoming Child Food Problem-Use of local weaning foods

The food problems stated above are usually found to affect children. There is therefore a need to solve the food problem in relation to the infants.

Most children grow well when milk from breastfeeding by the mother is adequate to meet the nutritional requirements of the child. The advantage of breastfeeding has been widely recognised particularly for the infants in developing countries. The breastmilk, when available is convenient, has the right composition at any moment and relatively inexpensive. The different nutrients and their levels in breastmilk are shown in Table 2.

Table 2: Nutrients and their levels in breastmilk

Nutrients	Level
Total solids	12.4g
Protein	1.2g
Lactose	7g
Fat	3.8g
Vit. A.	5.3 ug
Vit. D.	0.01 ug
Vit. C.	4.3 g
Carotene	27 ug
Thiamine	0.16 mg
Riboflavin	0.43 mg
Niacin	1.72 mg
Folic acid	0.18 ug
Iron	0.15 mg
Calcium	33 mg
Phosphorous	15 mg
Potassium	55 mg
Sodium	15 mg
Chlorine	45 mg

The high nutritional level indicates the need for a proper replacement of breastmilk, otherwise malnutrition will set in. Protein malnutrition usually occurs at the end of lactation or when the infants are being weaned. During this time the infant food should be supplemented. This is usually achieved by introduction of high level nutrient foods.

In developing countries many foods are prepared according to local customs and traditions but seldom specifically for the young child. There is a need for a weaning food which can be eaten and utilized by the infant's body.

There are such foods on the market but these are expensive. They cannot be afforded by the low-income group in the country. These imported foods from the developed countries reach mostly the people living in the urban areas. However the majority of the population live in the rural areas and they are unable to reach these food. Even when available they cannot afford to buy them. Apart from this, most of these people are illiterates and therefore cannot read the illustrations on the packages. Dilute mixtures are finally mixed for the child. Locally produced weaning foods should be introduced. Apart from this, a pre-cooked home made weaning food that can be stored dry and reconstituted instantly with just water seem ideal.

Home prepared food mixtures need to be recognised as a most economic and scientific approach to weaning in the developing countries. A mixture of cereals and legumes raises the chemical score to 60 by

improving the balance of amino acids while individually both cereal and legumes have a chemical score of 40 each (Ghosh, 1979).

### 1.3 Cereals and Legumes

Many cereals are eaten in Ghana. These include wheat, rice, maize, millet and sorghum. They are a good source of calories but poor protein source. Consumption of large quantities of these foods without any protein supplement leads to protein malnutrition.

The data in Table 3 gives the nutrient contents of the common cereal in Ghana.

Table 3: Analysis of Various Grains Consumed (%)

Cereal	Protein	Fat	Carbohydrate	Fibre
Maize (Zea.mays)	10	4.5	71	2.0
Finger millet	6	1.5	75	3.0
Bullrush millet	11	5.0	69	2.0
Sorghum spp.	10.4	3.4	71	2.0
Wheat	11.5	2.0	70	2.0
Rice	8.0	1.5	77	0.5

(Source: Muller, 1970)

The table shows the large amounts of carbohydrates as to the low levels of protein. Thus cereals contain mostly carbohydrates. However proteins are important for the growth of the child.

Cereal grains are used in the preparation of a variety of foods although the processing practice vary from group to group.

Cereal foods in Ghana can be classified into 4 groups:

1. Beverages:- e.g. Hausa beer or pito
2. Porridges:- e.g. Koko or akasa. Porridges are boiled preparation of whole or ground cereal usually thicker in consistency than cereal soups.
3. Dumplings:- e.g. Kenkey, banku.
4. Baked or fried products: eg. bread, doughnuts.

These foods are not usually consumed alone but as part of a meal or snack containing other sources of proteins. In this way the nutritional quality of the diets are improved. However, some mothers due to ignorance and poverty feed their children on only cereals without a protein supplement. Such protein supplements are usually legumes or fish.

Consumption of legumes follow a variety of processing procedures. Some steps include boiling, frying, germination, fermentation, steaming and milling. Cowpea is used very widely in Ghana and like other legume grains, it is used in soups, stews and porridges.

Table 4 shows some of the foods prepared from cereals and legumes in Ghana.

Table 4: Cereal and Legume foods in Ghana

Ingredients	Local Name	Comment
Cowpea, rice	Waakye	Boiled and eaten with stews
Groundnut, maize	Gboda, ashikoo	boiled and eaten as snack
Roasted cornflour	ablemanu	usually made into porridge The ingredient can be used in preparing other meals. e.g. apkledzii.
Cowpea/maize groundnut/cowpea/ millet groundnut/cowpea/ sorghum.		These are usually used as weaning foods. They are made into porridges or dumplings.

The above foods shown in Table 4 are only a few of the many different foods prepared from cereals and legumes in Ghana.

#### 1.4 Use of Germination and fermentation to improve the nutritional value of legumes

In some parts of the world, developments include the use of germination to improve the nutritional value of many seeds. Germination of cereal or legume grains result in increased levels of vitamins and other important nutrients. It also improves digestibility, taste and flavour (Brandtzaeg, 1982). Germinated grains can be dried and milled into flour. Porridges made from such flour has been used as food for infants.

Another method that can be applied to cereal grains and leguminous seeds is fermentation. This is a common method of preservation in warm and humid climates where food drying is not practical. In fermented foods, micro-organisms play an important role in modifying the original material to improve nutritional value, digestibility and to prolong keeping quality (Brandtzaeg, 1982).

Spontaneous fermentation is common in the villages and homes of Ghana. In Ghana fermentation is carried out on mainly corn.

The above two processes can be achieved locally and the germinated and fermented grains and seeds can be used to prepare a local weaning food.

## Objectives

In the light of this discussion, the following objectives were set for this study.

1. To develop a pre-cooked food from germinated legumes and fermented corndough.
2. Evaluate process and product characteristics by investigating:
  - (a) Processed parameters
  - (b) Material balance
  - (c) Functional properties of products (water absorption swelling)
  - (d) Chemical properties (protein, fat, moisture)
  - (e) Organoleptic analysis to determine product acceptability.
  - (f) Cost analysis.

## 2. REVIEW OF LITERATURE

### 2.1 Weaning of Infants

The term wean is from an ancient word that means "accustom," thus it has come to mean the period during which an infant gradually becomes accustomed to foods other than breastmilk (Cameron and Ingve, 1974).

Priyani (1981) defined weaning as the introduction of food other than milk of the infant. Olfat et al (1982) also defined weaning as the period from complete breast feeding until the infant is entirely on an adult diet.

Appropriate timing for complementary feeding of the breast fed infant is necessary. The age at which complementary foods are introduced depends on many biological, cultural, social and economic factors. (Priyani, 1981).

Supplemented foods based on blends of corn, soybeans and skimmed milk fortified with vitamins and minerals are introduced and distributed at mothercraft centers, (Pelto, 1981). A proper weaning should be based on this pattern of caloric distribution in order to provide the infant with adequate amounts of proteins for growth. Berggren (1982) stated that adequate supplementary feeding during the first two years of life prevents malnutritions and retardation in growth and mental development. At four to six months,

the rapidly growing child normally needs his first supplementary food usually a calorie dense porridge or gruel.

olfat et al (1982) investigated the reasons given by mothers in Egypt for weaning. They found out reasons which they divided into two basic groups. The first group of reasons was related to the mother. Reasons given were insufficiency of breastmilk, beginning of a new pregnancy and the desire to become pregnant thus wants to stop breastfeeding. The other group of reasons were related to the infant. Some of these reasons were that the infant became old enough to be able to eat the usual family diet, or that it no longer wanted to be fed from the breast.

In the light of these reasons, investigations on weaning foods have been going on. The main food groups for preparation of weaning foods were protein rich foods of either animal or plant origin, starch puddings, foods rich in vitamins and minerals, e.g. fruits. Mixed diets were prepared from a combination of the above groups (olfat et al, 1982).

## 2.2 Problems and Solutions to Improper Weaning

(1974)

Cameron and Yngve presented the problems in providing nutritionally adequate weaning foods and human milk substitutes in the developing countries. The major problems stated were generally low income, poor environmental conditions and lack of

education. The need to educate families to exploit locally cultivated foods to produce nutritional adequate products was stated as important.

Home prepared food mixtures need to be recognized as the most economic and scientific approach to weaning in the developing countries. A mixture of cereals and legumes raised the chemical score to 60 whilst chemical score of the individual constituents is 40 each. The increment is achieved by improving the balance of amino acids (Valyasevi and Baker, 1979). These mixtures when given together with breastmilk further improves the nutritional status of children. Kansra et al (1974) showed the calories deficiency of children between the ages of 6 - 11 months, 12 - 23 and 24 - 36 months being fed on only breastmilk was stated to be 301, 889, 992 kcal/day respectively. However when these infants were fed on multimix supplements made from home grown cereals, pulses and groundnuts in conjunction with breastmilk, the deficiency reduced to 193, 703, and 207 kcal/day respectively. Thus in cases where the basic staples were nutritionally poor, protein foods can be added to weaning foods.

### 2.3 Plant Protein Fortification-Cereals and Legumes for Human Consumption

Many cereal products are consumed in the world. These are prepared into different foods both in the developing and developed countries. In U.S.A. for example, a junior cereal product was prepared from a slurry of cornflour which was drum dried and flaked

to produce an instant meal (Cloud, 1976). A number of such products are being processed in the developed countries. Mixtures of these foods are usually fortified with proteins and vitamins (Gralak, 1975).

Cereal fortification with plant protein and animal proteins such as milk is also common in most parts of the world.

More developments on cereal foods for both weaning and breakfast are being introduced.

Leguminous plant proteins are usually used to fortify low protein content and are generally deficient in lysine (Altshul, 1974). It is logical to conclude that bean proteins should supplement the protein in cereal grains. Adolph et al (1955) indicated that the protein value of a mixture of beans and cereal is superior to that of each of these components fed individually.

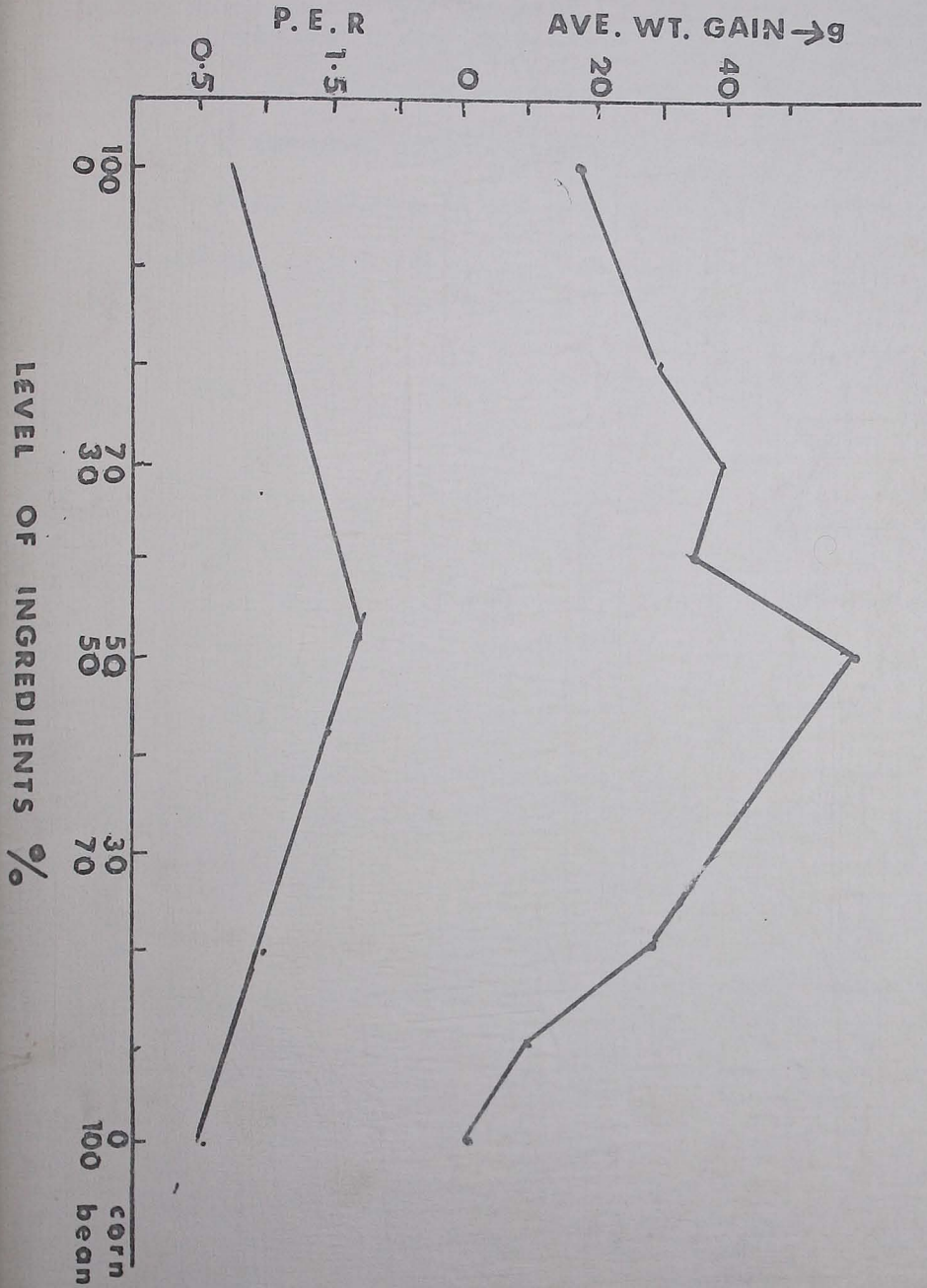
Bressani and Elias (1969) also reported on the protein value of various combinations of cooked black beans and opaque 2-corn. Their results showed that the highest protein quality was obtained when 50% of proteins of the diet was derived from each one of the components.

They fed rats on beans and corn at different levels as shown in Fig.1. The diets contained 8 - 9% protein in which corn proteins was replaced isoproteincally by Phaseolus Vulgaris. He measured the

Fig. 1

Graph of weight gain in Rats and PER against  
the % corn/bean levels

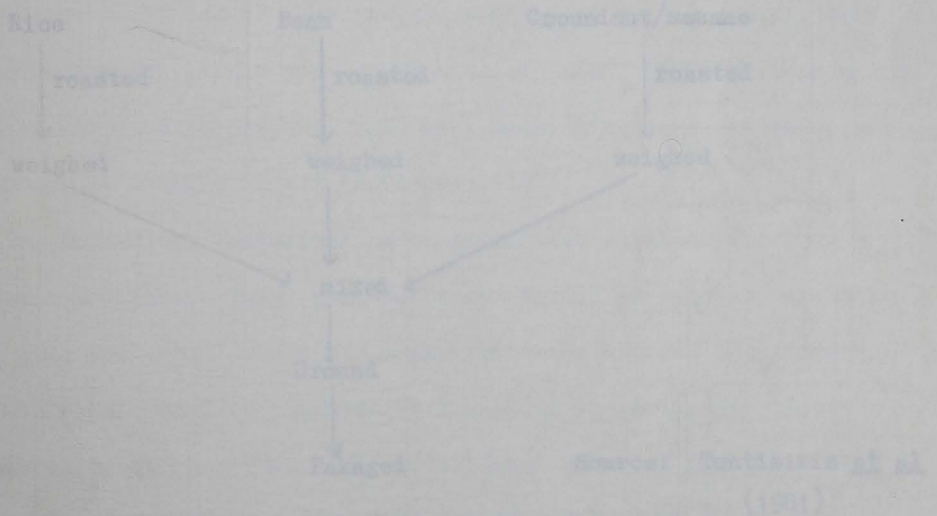
- A : Gain in weight against % corn/bean level  
B : PER against % corn/bean level.



protein Energy Ratio (PER) and the average weight gain of the rats fed on this diet. The graph obtained showed that the best corn-bean levels was at 50% corn and 50% bean. Optimum growth was obtained at this level other appreciable percentages were 70% corn and 30% bean, and 60% corn/40% bean.

These mixture have been used in attempts to treat malnourished children.

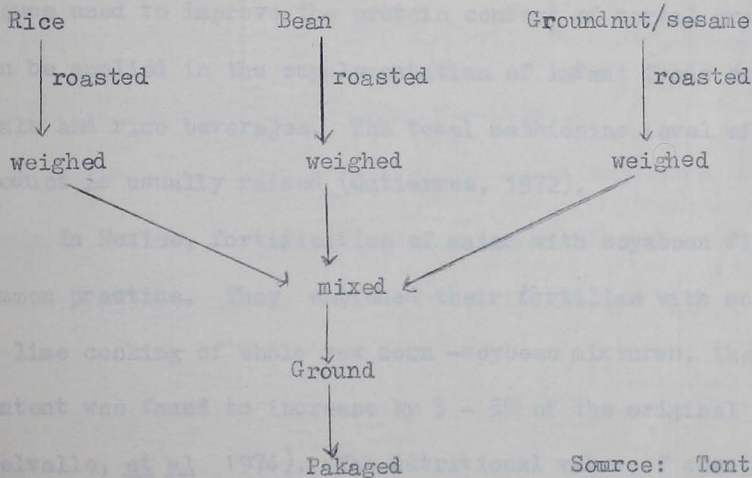
Operational Flow chart for the Preparation of Supplementary food mixtures



In further studies, bean proteins were replaced partially by egg proteins using human subjects (Spartburg et al, 1958). They found that the egg replacement value was 95.1% for non protein alone and 100% for methionine supplemented egg proteins.

Gomez et al (1957) reported an attempt to treat protein malnourished children with corn-bean diets consisting of about 87% corn and 13% bean. Recently, other protein foods containing chickpea, sesame and groundnuts were developed by Hanafy et al (1970) in Egypt. A blend ratio of 3:2:1 was found to be readily acceptable by both children and adults. He showed a simple operational flow chart for the preparation of the blend similar that in Fig. 2.

Fig. 2: Operational flow chart for the Preparation of Supplementary food mixtures



Source: Tontisirin et al (1981)

In further studies, bean proteins were replaced partially by egg proteins using human subjects (Esselbough et al , 1952). They found that the egg replacement value was 95.1% for pea protein alone and 100% for methionine supplemented pea proteins.

Many low cost balanced foods for feeding weaned infants based on corn, oilseed meals and skimmed milk powders have also been reported. Sirinit et al (1965) also reported that optimum nutritional performance was attained when beans constituted 20-30% by weight of mixture with cereals. These results have served as the basis for development of protein rich foods known as K-1000 which is given to mothers at mothercraft centers.

In the developed countries, soyabean is the most common legume used to improve the protein content of cereal grains. They can be applied in the supplementation of infant foods such as maize meals and rice beverages. The total methionine level of the final product is usually raised (Gutierrez, 1972).

In Mexico, fortification of maize with soyabean flour is a common practice. They enriched their tortillas with soy proteins. By lime cooking of whole raw corn-soybean mixtures, the protein content was found to increase by 3 - 5% of the original value (Delvalle, et al 1974). The nutritional value of corn tortillas was also improved by adding cotton seed flour. The amino acid, leucine and isoleucine ratio was improved. The acceptability test showed no significant difference between the supplemented and un-supplemented tortillas (MacPheson, 1976).

Dutra de Oliveira (1974) carried out a study on opaque-2-corn. They mixed this variety with wheat flour which is used in bread making. The opaque-2-corn has high levels of lysine and tryptophan and thus when mixed with the wheat flour was found to increase the lysine content of the flour.

The enrichment of cereal flours by plant protein foods can also improve not only the nutritive value of the foods but also improves the dough properties. In cases where baking is involved the baking properties are also improved (Henselman *et al.*, 1974).

#### 2.4 Effect of Processing on Cereals and Legumes

Cereals and legumes are treated in various ways before consumed. These treatments have profound effects on the final products. The chemical and nutritional characteristics are mainly affected.

Dako (1966), discussed the nutritive value of African legume food in relation to the pretreatment to which they are subjected in that area of the world. He found that cooking of pigeon peas improved their nutritional value but that supplementary soaking or germination did not further improve protein quality. Toasting was also reported by Altshul (1974) to cause a slight improvement in the biological value of proteins of various legume foods.

The majority of food stuffs are subjected to heat treatment of varying degrees before they are consumed. The conditions and extent of the heating procedure may affect foods adversely or beneficially.

The heat treatment applied to legume foods does improve their texture and palatability and also helps to destroy or inactivate some heat labile toxic compounds such as trypsin inhibitors, and hemagglutinins (DeGroot, 1963). However Altshul (1974) has reported that excessive heat treatment causes a reduction in the nutritive value of legume foods.

Further studies conducted on the effect of various pre-treatments on the milling characteristics of a cereal grain was conducted. The pre-treatments included soaking in water and steaming at various temperatures. The results showed that the particle size of the grits tended to increase with increase in steaming temperatures (Seiler, 1974). During soaking the quality of dry matter and protein passing into the solution is characteristic for individual grains and seeds, (Tregubor and Zakharenko, 1971). The traditional treatment of overnight soaking of dried beans followed by prolonged cooking has now been replaced by a simple economic process of preparing legumes into quick cooking products. The process improves the organoleptic qualities and also saves fuel (Rockland et al, 1974). The nutritional value of pre-cooked products are altered

during processing. Analysis on cowpea and pigeon pea gave higher levels of sulphur amino acids but lower levels of lysine (Fabriani and Fraloni, 1972). Elias et al, (1976) found out that the digestibility and nutritional value of cooked ground samples of cowpea were found to be lower than that of the whole legume seeds.

In addition, oilseeds such as peanut, sunflower seeds when added to doughs reduced the mixing tolerance, increased adsorption and reduced the volume of breads (Matthews, 1972).

Other effects of processing on cereals and legumes can be obtained when grains are subjected to germination and fermentation.

## 2.5 Effect of Germination and Fermentation on the Chemistry and Nutrition of Legumes and Cereals

The availability of plant proteins can be improved by the use of germinated leguminous seeds in the preparation of foods. This process makes nutrients in the seeds available by breaking them down to the forms in which they are absorbed into the human body. During germination of legumes the proteins undergo considerable changes because of proteolytic activity (Mayer and Paljakoff-Mayber, 1975). This results in an increased in the level of free amino acids and peptides which are translocated to the embryonic axis. Although many questions are still open with regard to detailed mechanism of protein metabolism during germination there is some information about the fate of breakdown products. Chibnall (1939) showed that during germination in the dark, proteins are broken down to amino acids.

The chief amindes formed are glutamine and asparagine depending on the plants. A little evidence about amino acids synthesis is available. (Mayer and Paljakoff-Mayber, 1975) were able to show the synthesis of homoserine in pea seeds during the first 24 hours of germination. Homoserine was not present in the dry seed; thus during germination there occurred the rapid synthesis of an entirely new amino acid. A general rise in the amino acid content of lettuce seeds during germination was shown by Klein (1955). Mayer and Paljakoff-Mayber (1975) reported that globulins are the predominant class of protein in legumes. With germination the globulin content decrease while little change is observed in the albumin content. In India legumes are the primary source of dietary proteins, conventionally they are also used in the germinated forms since the nutritional value has been reported to be better (Chen and Thacker, 1978).

Table 5: Changes in Amino acids content of lettuce seeds during germination

Amino acid	Time of Germination/days		
	0	1	2
Alanin	5	30	220
Threonine	5	20	190
Leucine	20	20	280
Serine	30	30	250
Lysine	15	5	40
Tryptohan	5	5	-
Aspartate	40	35	40
Glutamate	60	80	160
Glutamin	60	40	700
Asparagine	30	40	240

Source: Klein (1955)

During a six day germination period, Adjei Twum (1976) showed a decrease in carbohydrates and lipids in soybean seeds, Stachyose and Raffinose (are indigestible in man) decreased to about 80% in three days and disappeared in six days. Proteins decreased slightly while amino acids increased rapidly. Changes occurring during germination of soybean seeds over ten days were studied. The protein reserves were hydrolysed to amino acids which were translocated to the axils where re-synthesis of insoluble proteins occurred (Adjei Twum, 1976).

There were changes in the carbohydrate content during germination. Breakdown of starches in peas was shown by Swain and Dekker (1966). To follow the pathway: starch  $\longrightarrow$  soluble oligosaccharides  $\longrightarrow$  maltose  $\longrightarrow$  glucose.

Maltose levels increased, sucrose showed smaller increases, raffinose and maltotriose stayed more or less steady. The changes in the carbohydrates of barley during germination have been studied in detail because of their importance in the malting process. Glucose and fructose rise considerably up to six day germination at 21°C and then begins to fall again. After six days the seedlings were 5 - 7cm long. Other sugars also showed marked changes (Hegazi, 1974).

Chemical characteristics of peas as affected by cooking involves phytates, divalent cations, pectates and lignins. Work carried out on the cookability of different germinated legumes showed the pattern of how cooked germinated legumes differ. The time required for cooking decreased with germinated time, in some legumes such as chickpea.

The reverse happens in cowpea (Reddy *et al*, 1978). In cowpea there is a general decrease in phytin content with progressive stages of germination. The progressive decrease in phytin with germination may be attributed to an increase in phytase activity during germination (Reddy *et al*, 1978). Considering the changes in the mineral content, there is a considerable loss of calcium during germination (the later stages). Magnesium content is also reduced during germination but this effect is less in cowpea (Ganesh, 1978). The loss of the minerals may be due to leaching during the bulk germination of seeds. Leaching in inorganic and organic compounds has been reported in legumes during germination (Mayer and Paljakoff-Mayer, 1975).

Experiments showed a higher ascorbic acids, niacin, pyridoxin, pantothenic acid, inositol, biotin, tocopherol, vitamin k and folic acid levels in germinated seeds (Robert, 1974).

Leguminous seeds contain a number of constituents which may have deleterious effects on their nutritional value. These include proteinase inhibitors, phytohemagglutinins, tanins, phytic acids etc. Proteinase inhibitors are the most common. This appears to decrease generally during germination (Yuh-Yun and Field, 1978).

Apart from germination, fermentation can be used to improve the nutritional levels of foods. It was stated that some micro-organisms can be used to manufacture amino acids through fermentation procedure. Five components were detected by gas chromatography in the headspace vapor of green olive fermented by *Lactobacillus*. Three

of these components were acetaldehyde, methylsulphide, and ethanol. These were <sup>not</sup> present in unfermented olives (Fleming, 1968).

Many fermented products are available in different parts of the world. Some of these products are shown in Table 6: The products are common dishes eaten in Ghana and Nigeria.

Table 6: Some Common Fermented dishes in Ghana and Nigeria

Beverages	Porridges	Dumpling	Baked or fried product
Kaffir beer	Ogi	Banku	Bread
Pito	Koko	Kenkey	-
Iced Kenkey	-	-	-

## 6 Functional Properties

Due to the increasing cost of food proteins and the trend towards complete food formulation from refined ingredients, there is a growing need for less expensive protein. These should possess requisite functional properties for their successful utilization in various food products (Kinsella and Kevin, 1976). The critical functional properties necessary in protein ingredients include solubility, heat coagulation, water and fat absorption, gelation, emulsion whippability and good organoleptic properties.

Processing most starch foods require gelatination of starches in the presence of other substances that may compete for the available moisture. Proteins, native or supplemental is invariably present in

most natural goods. Bechtel (1950) revealed the relationship between starch gelatinization and protein during baking. Proteins in bread dough are highly hydrated whereas starch absorbs little water. At higher temperatures the proteins become denatured and loses its water binding capacity. In the presence of insufficient water during gelatinization, swelling of starch granules may be greatly inhibited (Katz, 1978).

Watson and Johnson (1965) studied some effects of egg albumen, gelatin, methyl cellulose and carboxymethyl cellulose on the gelatinization of un-modified corn and waxy maize starch. Gelatin inhibited gelatinization of starches more than albumen. Methyl cellulose affected starch gelatinization but the effect is less. Carboxymethyl cellulose had pronounced effect on starch gelatinization at all temperatures and moisture levels.

Some functional properties were showed by Kay (1976). Defatted peanut was treated with NaCl and pH of suspension was adjusted. Those at pH of 4 produced extracts which failed to form emulsions, suspension at pH.6 produced the least increase in foam volume and formed poor emulsions. Multiple regression analysis showed that functionality of peanut meal was influenced by complex interactions of suspension medium, pH level and character of soluble proteins.

Oilseed protein act as emulsifiers and extenders in meat products, fat and water absorption agents in toppings and confections (Walt and Cowan, 1971).

Cereal product exhibited different functional properties.

The functional characteristics of two millet starches were determined and compared with those of wheat and rye starches. The millet starches showed higher water binding capacity values and gelatinization temperatures than the wheat starches. Solubility of millet starches were lower than those of wheat. Amylograph viscosities of millet starches were higher. The millet starches produced swelling power values at 90°C which were similar to wheat starch (Klaus and Greg, 1976).

Kay and Kinsella (1976) studied the functional properties of succinylated and acetylated soy protein. The color and aqueous solubility of soy proteins were markedly improved by succinylation of amino groups. Both emulsifying activity and emulsion stability were improved, foaming capacity and foam stability were also improved. Sodium chloride enhanced foaming capacity. Acetylation of soy isolates caused negligible changes in the functional properties.

The intensive research concerning the development of novel and functional proteins has dramatised the need for standard methods for quantifying functional properties of proteins. The capacity of proteins to stabilize emulsions according to Kinsella and Kevin (1976) is related to the interfacial area that can be coated by the protein. Turbidometry was evaluated as a method for measuring emulsifying properties.

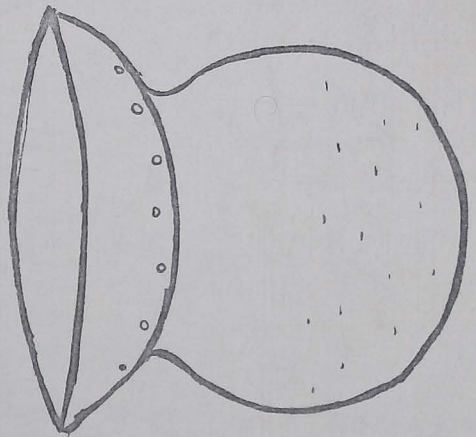
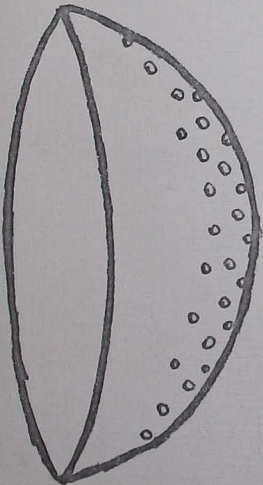
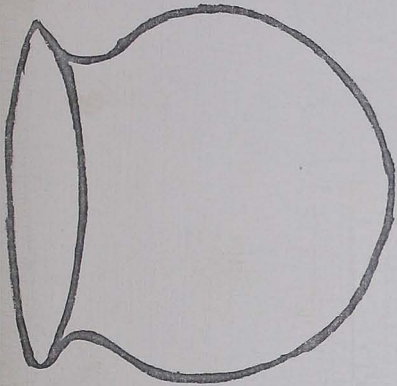
The partial hydrolysis of peanut proteins by papain increased solubility in water and foaming capacity and decreased viscosity. These results suggested that incorporation of partially hydrolysed peanut proteins in certain foods, where those characteristics are desired has some advantages (Larry, 1977). Other treatments on peanuts has pronounced changes in the functional properties. Larry (1977) reacted succinic anhydride with defatted peanut flour at pH of 7.4 - 8.0. Water retaining capacity increased, water absorption capacity increased, and the emulsion capacity also increased.

27.

Fig. 5

TRADITIONAL EARTHENWARE MASHING BOWL AND STIRRER

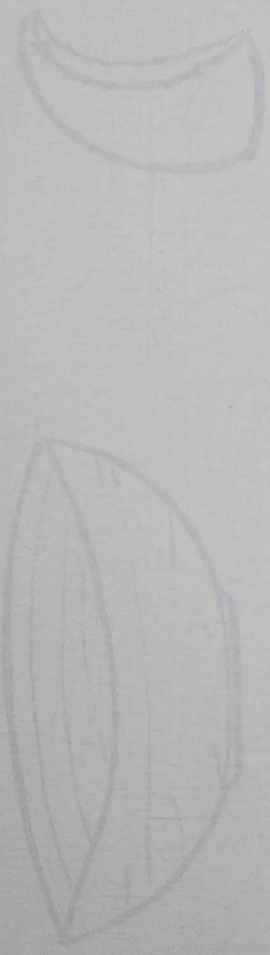


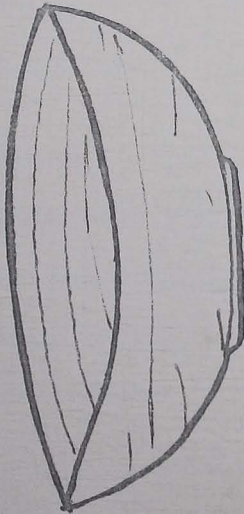
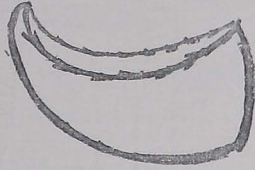


↑  
HEAT

Fig. 6:

A SET UP OF THE USE OF THE TRADITIONAL EARTHENWARE STEAMING BOWL.





### 3: MATERIALS AND METHODS

#### 3.1 MATERIALS

##### Equipments

- 3.1.1.
- a) Muslin cloth
  - b) Exhaust box
  - c) Centrifuge (Gallenkamp) A. Gallenkamp and Co. Ltd., England.
  - d) Blender (Waring) - (Eberbach Corporation, Ann Arbor, Mich, USA).
  - e) Electric Cooker (Creda)
  - f) Traditional Earthenware bowl
  - g) traditional Earthenware steaming bowl
  - h) Grinding Mill, Straub Model 4E, Straub Co. Phila, Pa 19020, U.S.A.
  - i) Sieve Mesh

#### 3.1.2 Raw Materials

Corn (Zea mays) obtained from market (Makola)

Cowpea (Vigna injuiculata) obtained from market (Makola)

#### 3.2. Experimental Methods

##### 3.2.1. Experimental Design

Three blends of corn-cowpea mixtures were made using cowpeas which has been germinated for 1, 2 and 3 days and a control which was not germinated.

% Corn/cowpea	DAYS OF GERMINATION							
	0		1		2		3	
	U	D	U	D	U	D	U	D
50/50								
60/40								
70/30								

U = Undehulled      D = Dehulled

Each of the 4 batches of seeds was divided into 2. Half was dehulled whilst half was left undehulled. A total of 24 products were obtained.

Chemical analysis - Fat, moisture, protein and functional characteristics - water absorption, swelling, gelatinisation were performed using the above products. Sensory evaluation to determine the acceptability of the different products was done.

Analysis of variance was used to show any significant effects the treatments on the product.

(ii) Corn Product:

A pre-cooked product was prepared from fermented and unfermented corn dough. The functional characteristics - swelling, water absorption, and gelatinisation were determined. Sensory evaluation was done to determine the difference if any on color, flavor, odor and general acceptability of the two products. The student's 't' distribution was used to analyse the results.

### 3.2.2. Germination of Cowpea Seeds

4 batches of 500 gms of cowpea seeds were weighed into 1 litre beakers. They were cleaned with water and the excess water was drained off. One batch of beans was not germinated, serving as the control. The other three batches were germinated for 1, 2, 3 days respectively.

The seeds were spread in aluminum trays, sprinkled with water covered with wet muslin cloth. Seeds were constantly sprinkled with water to prevent drying and kept at room temperature.

After the required days of germination, the seeds were collected and the sprouts were broken and disposed off. Each batch was divided into two. One part was dehulled and the other was left unde-hulled. Both the dehulled and unde-hulled seeds were spread into trays and dried in the sun. The dried seeds were milled into flour using the laboratory milling machine.

### 3.2.3. Preparation of Cornmeal

The corn was cleaned, washed and steeped in water for 24 hours. The grains were removed from the water and drained to get rid of the excess water.

The Corn was milled into flour using the laboratory milling machine. The flour obtained was used to prepare the corn-cowpea products. Part of the corn flour was used to prepare the corn product.

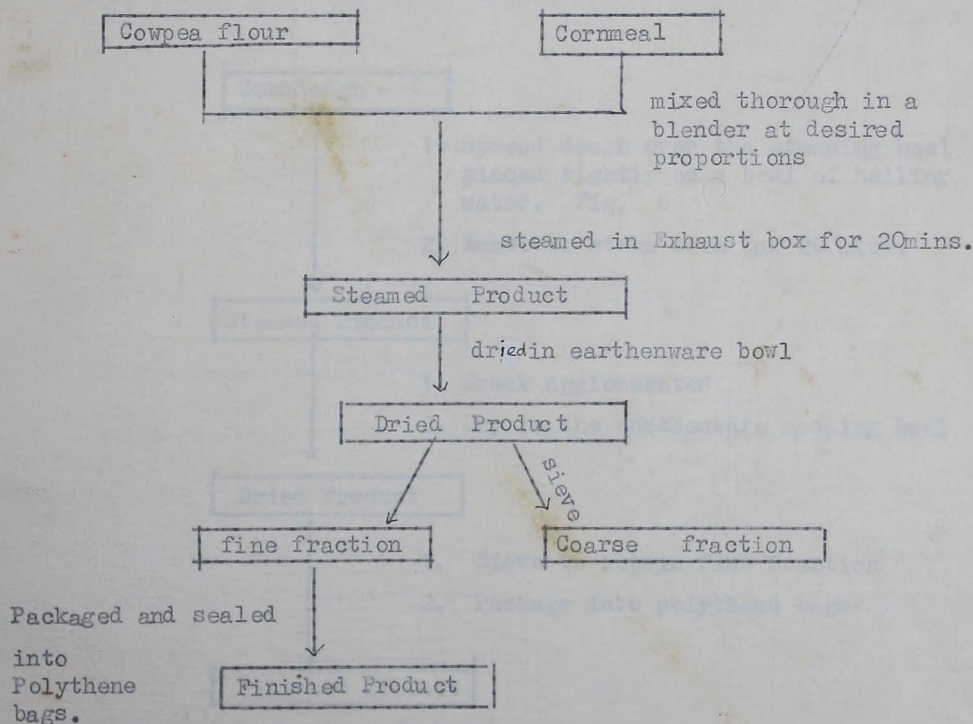
### 3.2.4. Preparation of Corn-Cowpea Product

3 levels of corn-cowpea mixtures were prepared. Dehulled and unde-hulled cowpea seed flour were used. The 3 levels were

Corn %	70	60	50
Cowpea %	30	40	50

150 grams of each level was prepared.

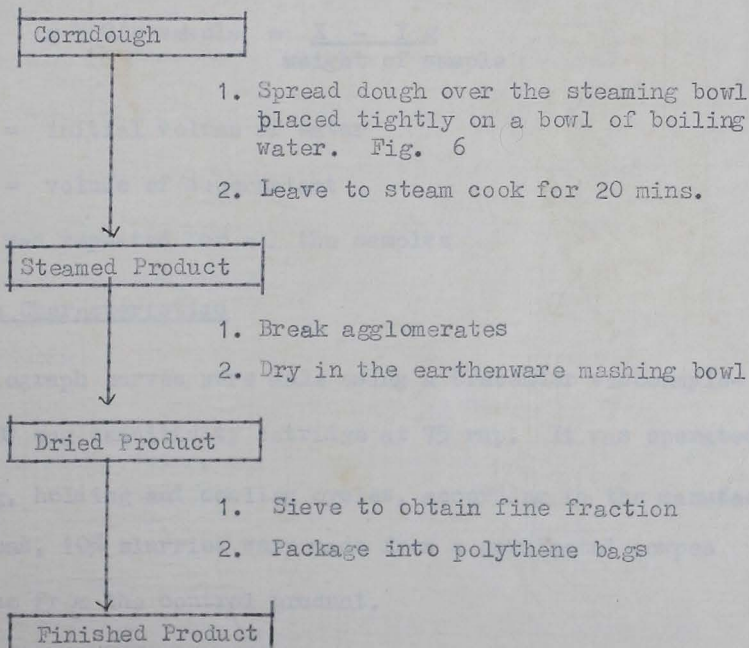
Fig. 3 Flow Chart of steps for the Preparation of Corn-Cowpea product



3.2.5 Development of a Pre-cooked Product from corndough

3.2.5.1 Fermented and unfermented corndough were used to prepare the products. The methods of preparation was the same as that in Fig. 3, except that the traditional earthenware steaming bowl was used instead of the exhaust box.

Fig.4. Flow Chart of the steps in the Preparation of the corndough Product



### 3.3 Evaluation of Products

#### 3.3.1. Water Absorption Characteristics of Products

Two grams of sample was weighed into a graduated centrifuge tube. 10 mls of water was added and stirred. The mixture was allowed to stand for 30 minutes before centrifuging at high speed (5000 rpm) for 15 minutes. The volume of the supernatant was read.

Water absorption was calculated in  $gH_2O/g$  sample.

$$g H_2O/g \text{ sample} = \frac{X - Y}{\text{weight of sample}}$$

where X = initial volume of water

Y = volume of supernatant

Experiment was repeated for all the samples

#### 3.3.2 Gelatination Characteristics

Viscoamylograph curves were made using a Brabender viscoamylograph with a 500 cmg sensitivity cartridge at 75 rpm. It was operated through heating, holding and cooling cycles, according to the manufacturer's instructions, 10% slurries were made from a germinated cowpea product and also from the control product.

#### 3.3.3 Swelling Characteristics of Products

Five grams of the sample was weighed and poured into a 100mls graduated measuring cylinder, and the volume occupied was read (Dry bulk volume). 100mls of water at room temperature was added and the

suspension was stirred. Suspension was left for one minute to settle and the volume was read. Swell volume was then read at 5, 10, 15, 30, 45 and 60 minutes.

#### 3.3.4 Proximate Analysis

Moisture content was determined using the air oven method. (American Association of Cereal Chemist (AA CC) methods 44-40, AA CC Approved methods (1969)).

Protein content was determined using the macro-kjeldahl method (Association of Official analytical Chemistry (AOAC) method 2.049. Official methods of analysis AOAC (1975)).

Fat was extracted from sample using the method of crude fat determination from the Association of Official analytical Chemistry method 7.045 AOAC (1975) pg. 134.

#### 3.3.5. Sensory Evaluation

A taste panel of 15 students was used to determine the acceptability of color, odor, flavor and the general acceptability of the different products.

##### Preparation of Slurries

35 grams of the product was mixed with 60 mls of water, to prepare the slurries. 15mls of evaporated milk was added to each mixture. 5 grams of sugar was finally added to prepare the complete meal. Panelists were required to fill the questionnaire (App. 1).

3.3.6 Costing Analysis

The costing was only approximate since it was done only on the basis of raw material cost. Cost of water, steam electricity and labour were excluded.

Total cost of corn =  $\text{C}_x/\text{kg}$

" " " cowpea =  $\text{C}_y/\text{kg}$ .

ii) Cost of weight of material use. e.g. corn

$$= \frac{X \times \text{weight of material}}{1000}$$

Thus the total cost of the product made

$$= \text{total cost of all the individual cost calculated in (ii) for the materials}$$

iii) The total yield of the product from 100gs composite was known e.g. z gs.

$$\therefore Z \text{ gs cost} = \text{total cost of all the individual cost calculated at (ii) for the materials.}$$

Although pasteurizing is a slow and long method of drying, there is little or no charring of the product. It is also a simple and easy

4: RESULTS AND DISCUSSION4.1 Raw Material Treatment - Germination and drying of Cowpea seeds

About 500g of cowpea seeds (*Vigna unguiculata*) were used in each batch of germination.

Table 7 shows the increase in weights of the cowpea seeds after germination.

Table 7: Increase in weight of cowpeas after germination

Germination days	w e i g h t s / g		
	Initial	Final	Increase
0	500	850	350
1	500	988.5	488.5
2	500	1080.0	580
3	500	941.8	441.8
Average Increase			464

There was an average increase of 464 grams. The increase in weights may be attributed to the absorption of water by the seeds and also the presence of sprouts. Some of the seeds were then dehulled and washed whilst some were unde-hulled and washed. The seeds were later dried in the sun for 10 hours.

Although sundrying is a slow and long method of drying, there is little or no charring of the product. It is also a simple and easy

method of drying, involving no sophisticated equipments. Apart from these, sundrying can be used by both rural and urban folks. However, sundrying is not the best method of dehydration when production is on a large scale.

Table 1 shows the weights of cowpea during the drying period. The data was plotted as shown in Fig. 7. The change in weight of the cowpea seeds after the drying was over was calculated. These values are shown in Table 8. Analysis of variance was evaluated on these values. Table 9 is a summary of the analysis of variance calculations.

Table 8: Difference in the initial and final weights of seeds during sun drying

Treatment	Germination days			
	0	1	2	3
Dehulled	1441	230.4	286.5	216.4
Undehulled	2075	273	359.2	352.7

Table 9: Summary of 'ANOVA' of the effects of germination and dehulling on the change in weight of seeds during sundrying

Source	d.f	SS	MS	F	
Germination	3	23345.6	7781.86	9.5	**
Dehulling	1	12442.53	12442.53	15.28	**
Error	3	2442.67	814.22		
T o t a l	7	38230.8			

\* - Significant at  $P \leq 0.05$

\*\* Significant at  $P \leq 0.01$

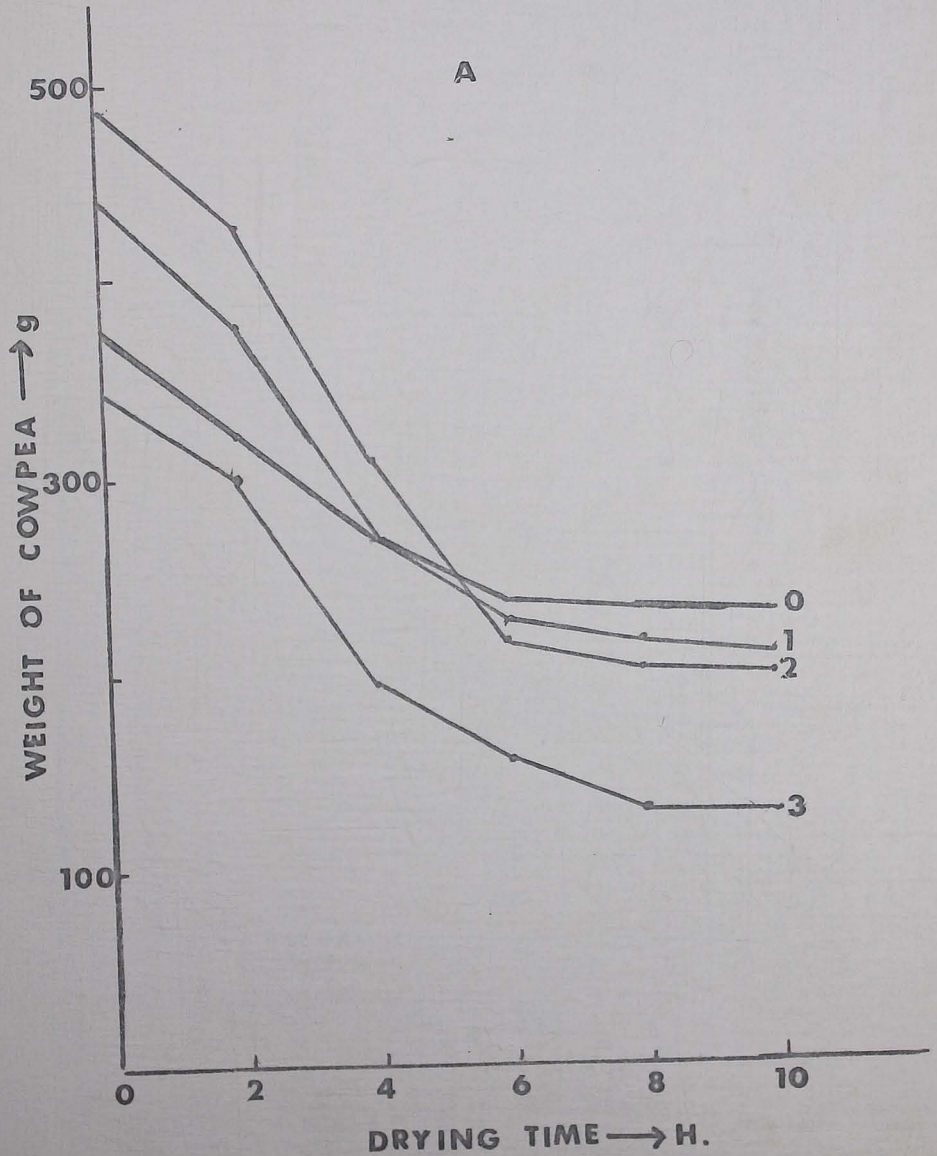
Fig. 7:

The drying rate graphs of Undehulled and dehulled  
cowpea seeds

A - Dehulled seeds

B - Undehulled seeds

0, 1, 2 and 3 are the various germination days.



From Table 1, the initial weights of the dehulled seeds were less than that of the unde-hulled seeds. This may be due to the dehulling process where all seeds coats were got rid off. This treatment also involved the loss of raw materials thus contributing to the reduction in the initial weights of the dehulled seeds. The difference in the initial weights of dehulled and unde-hulled seeds shows the significant weight which the seed coats add to the total weight of seeds. However when dried the weight of the seed coats are greatly reduced. The rate of dehydration of seeds coats are also high since structurally they are basically simple. Table 8 further shows a greater change in weight of the unde-hulled seeds during sundrying. This means a greater lost of moisture in these seeds. However, this higher changes in weight may be due to the change in weight of seed coats after it had been dried.

Analysis of variance shown a significant effect of the germination and dehulling processes in the lost of moisture in the seeds. Change in weight increased with the increase in number of germination days.

However the moisture content of seeds before and after sun drying were not determined so as to compare the initial and final moisture content to the rate of lost of moisture during the process.

Charm (1963) stated that the final moisture a material achieves on drying is usually not less than the equilibrium moisture of the dried material when it is in equilibrium with the drying air condition at the end of the drying operation.

Fig.8: Flow Chart of Materials and weights as they enter each processing stage

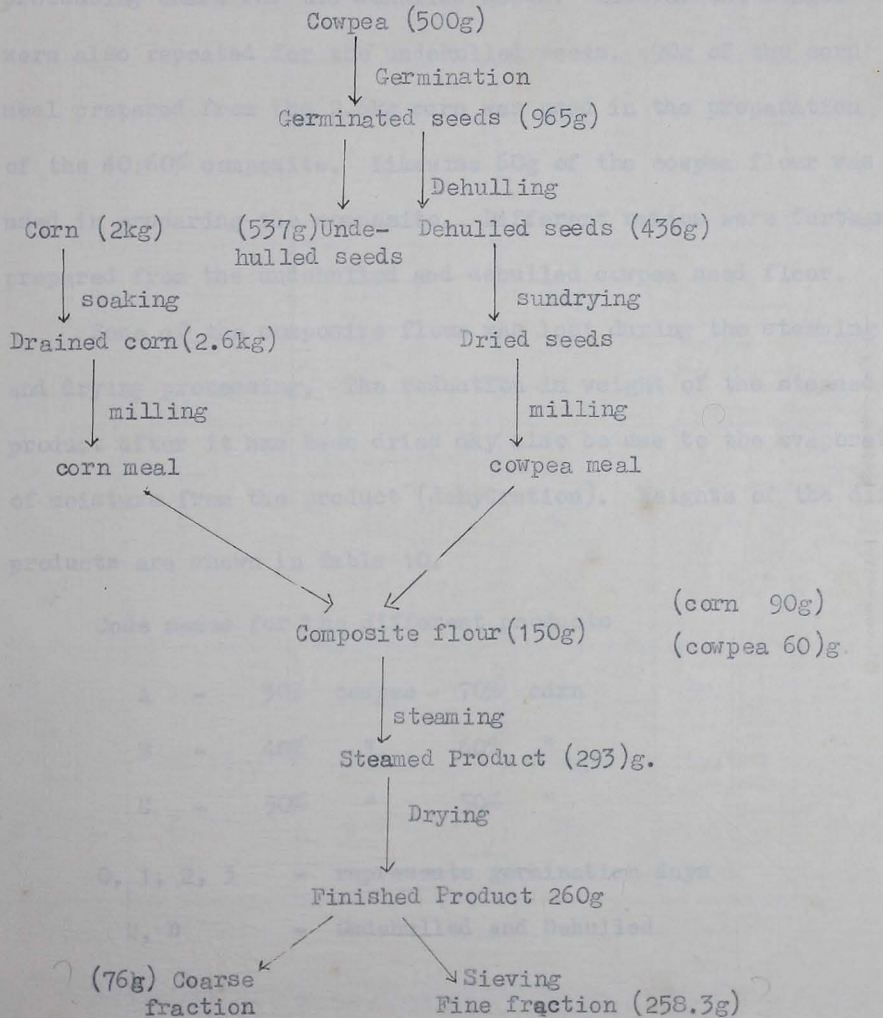


Fig. 8 shows the materials and their various weights as they enter each processing stage. The figure shows a complete processing chart for the dehulled seeds. However the stages were also repeated for the undehulled seeds. 90g of the corn meal prepared from the 2.6kg corn was used in the preparation of the 40:60% composite. Likewise 60g of the cowpea flour was used in preparing the composite. Different ratios were further prepared from the undehulled and dehulled cowpea seed flour.

Some of the composite flour was lost during the steaming and drying processing. The reduction in weight of the steamed product after it had been dried may also be due to the evaporation of moisture from the product (dehydration). Weights of the different products are shown in Table 10.

Code names for the different products

A	-	30%	cowpea	70%	corn
B	-	40%	"	60%	"
C	-	50%	"	50%	"
0, 1, 2, 3	-	represents germination days			
U, D	-	Undehulled and Dehulled			

Table 10: % Yield of Products after drying

Sample	Yield %	Weight/g	Sample	Yield %	Weight/g
AD <sub>0</sub>	59.1	88.65	AV <sub>0</sub>	47.5	71.2
BD <sub>0</sub>	60.9	91.4	BV <sub>0</sub>	55.3	83.0
CD <sub>0</sub>	66.2	99.3	CV <sub>0</sub>	57.3	85.9
AD <sub>1</sub>	57.2	85.8	AV <sub>1</sub>	49.4	74.1
AD <sub>1</sub>	57.9	86.9	BV <sub>1</sub>	56.3	84.5
AD <sub>1</sub>	61.9	92.9	CV <sub>1</sub>	66.5	99.7
AD <sub>2</sub>	54.4	81.6	AV <sub>2</sub>	57.86	86.8
BD <sub>2</sub>	56.9	85.4	BV <sub>2</sub>	53.9	80.8
CD <sub>2</sub>	60.2	90.3	CV <sub>2</sub>	52.9	79.3
AD <sub>3</sub>	52.86	79.3	AV <sub>3</sub>	59.5	89.2
BD <sub>3</sub>	56.86	85.3	BV <sub>3</sub>	61.4	92.10
CD <sub>3</sub>	60.3	90.5	CV <sub>3</sub>	62.03	93.05

To find out if the difference in the weights of the different products were real or due to chance, analysis of variance was done on the values (weights) obtained.

Table 11 is a summary of the analysis of variance calculations.

Table 11: Summary of ANOVA on the effect of treatments on weights of products

Source	d. f	SS	MS	F	
Germ.	3	58.7	19.56	2.605	
Ratio	2	346.64	173.32	23.087	**
Dehull.	1	59.22	59.22	7.88	**
Error	83	623.09	7.507		
Total	89	1087.65	12.22		

\*\* - significant at  $P \leq 0.01$

ns - no significance

The different treatments given to the products during the processing attributed to the differences in weights of the products. Analysis of variance on the weights of the product (Table 11) showed that dehulling and preparation of the composite had significant effect on the final weight of the product obtained. The presence of more cowpeas in the product gave a higher yield. This may be the reason for the significant effect of the ratios on the weight of the finished product. In practice, therefore to obtain a higher yield the amount of cowpea in any product can be increased. However, this will be at the expense of cost.

The effect of dehulling was also significant. Table 10 shows that dehulled seed products had relatively higher weights and yield than the unde-hulled seed product.

There was not much change in the weights of products prepared from the different germinated seeds. The Anova table therefore shows a non-significant effect of germination on the final weights of the products. Differences in weights of the products are due to factors such as dehulling and ratios of the raw materials in each product.

#### 4.2.2. Steaming and Drying

The different samples were steamed separately in the exhaust box. After steaming some of the steamed products adhered to the trays used. This does not usually occur when the steaming time is less than 20 minutes. Previous work on similar product development showed that the best steaming time for such products was 10 - 15 minutes (Mensah, 1981). The adhesion of products may therefore be due to the long steaming time.

The extended steaming time also affected the moisture content of the products. In an attempt to further dry the product to lower moisture contents, browning occurred. The browning may be due to over-cooking of steamed products. Browning may also be due to the prior treatments given to the raw materials. These treatments being germination and fermentation. Proteins and carbohydrates are reduced to their simple forms (peptides amino acids, glucose) during germination. These components can enhance browning since they are the main starters of non-enzymatic browning.

The products also formed large agglomerates which could not be broken up completely during the drying period. The agglomerate formation affected the yield of products and hence the significant effect of the ratios on yield, since agglomerate formation increased with increase in cowpea level.

Coarse and fine fractions of the product were obtained. Evidence of the high protein content of the coarse fraction is an indication of agglomerate formation by the cowpea component. Agglomerates are also formed easily with high moisture foods. Pre-heating by steaming is another factor which aids in agglomerate formation (Dovlo et al, 1975). The reduction in the yield which resulted partly from agglomerates (Coarse fraction) can be avoided if this fraction is further milled to finer particles.

#### 4.3 Product Evaluation: Protein, Fat and Moisture analysis

The moisture, fat and protein contents of the different samples are shown in Table 12. Coarse and fine fractions of dehulled seed product were analysed for their protein content. Due to the lack of products moisture analysis was done on only dehulled seed samples. Dehulled and undehulled seed samples were analysed for their fat content.

Table 12: Moisture, Protein and Fat content of Products

Sample	MOISTURE	PROTEIN		FAT	
	%	Fine	Coarse	Dehulled	Undehulled
AD <sub>0</sub>	16.49 ± 0.14	15.41±0.25	9.62±0.07	2.60±0.91	2.98±0.03
BD <sub>0</sub>	9.68 ± 0.21	15.64±0.16	10.55±0.41	2.51±0.11	2.62±0.41
CD <sub>0</sub>	8.91 ± 0.07	19.64±0.28	10.96±0.53	2.37±0.03	2.04±0.08
AD <sub>1</sub>	11.87 ± 0.27	12.55±0.7	9.61±0.74	2.27±0.32	2.31±0.19
BD <sub>1</sub>	10.81 ± 0.69	15.64±0.61	13.40±0.25	1.90±0.55	2.51±0.24
CD <sub>1</sub>	11.51 ± 0.54	16.93±0.30	13.28±0.27	1.40±0.07	1.21±0.17
AD <sub>2</sub>	10.56 ± 0.67	11.02±0.77	9.48±0.18	1.90±0.71	3.35±0.01
BD <sub>2</sub>	13.62 ± 0.17	16.11±0.21	10.74±0.56	2.31±0.23	2.70±0.56
CD <sub>2</sub>	8.81 ± 0.28	16.68±0.38	14.23±0.05	2.18±0.04	1.53±0.06
AD <sub>3</sub>	16.25 ± 0.19	10.78±0.05	9.75±0.69	1.71±0.03	2.41±0.33
BD <sub>3</sub>	11.9 ± 0.72	14.65±0.65	12.04±0.71	1.38±0.36	2.62±1.02
CD <sub>3</sub>	10.5 ± 0.38	15.45±0.81	9.48±0.52	1.98±0.86	2.33±0.86

Mean of 2 values ± standard deviation

The moisture content of the products were relatively high as compared to similar dry products eg. Cerelac 30% and Gari 11.7% (Eyeson & Ankrah). Observation from Table 12 indicates a slight increase in moisture content with an increase in the level of corn. The corn used was soaked for 24 hours. The moisture content of the corn meal was therefore high. This may have affected the moisture content of the products with a high level of corn.

In attempt to reduce the moisture content to the minimum, products were browning. Because of the high moisture content, it is possible that these products will not store long. Lower moisture levels can be attained if browning could be prevented.

The extended steaming time in the processing also contributed to the high moisture of content of the products. Protein content of dehulled seed samples were determined. The protein content of the coarse fractions were also determined. This was to find out if the coarse portion contained high amounts of proteins. The proteins of the fine fraction increased with an increase in the cowpea flour of the blends. There was a decrease in the percentage protein as germination days increased. This may be attributed to the usage of proteins and other food components by the growing shoot. In the ungerminated seed product containing 50% cowpea ( $CD_0$ ), the protein content was very high. This is because the seeds from which the product was made were not germinated and also, the amount of cowpea in this blend was high. Hence the high protein content of the product. The percentage protein of the coarse fraction was rather high, in some of the products. These

products were mostly the blends containing 40% and 50% cowpea flour. These products formed more agglomerates during the steaming and drying stages.

The cowpea added to the maize was to increase the total protein of the product and also to improve some functional characteristics. The protein content of maize is 8.8% (Eyeson & Ankrah, 1975). From the protein content of the products, there is an increase in the percent protein (of maize). This indicated that the cowpea had supplemented the protein of the maize since itself decreased in protein content.

The fat content of the products are also shown in Table 12. The fat content of maize is 3.9% and that of the cowpea is 1.5% (Eyeson & Ankrah, 1975). The contents of the products are between these values. The corn fats supplemented the cowpea fats.

Undehulled seed products showed a higher fat content than those of the dehulled seed products. This may be due to the presence of the seed coat. The germ of the cowpea contains some fats, and this might have added to the higher amounts of fat in the undehulled seed product. Apart from this the seed coat of some varieties of legumes (eg. Vigna unguiculata) have waxy surfaces (Sefi-Dedeh & Stanley, 1979). These waxy surfaces may have contributed to the higher fat content in the undehulled seed product. The fat content of the product is higher than that of Gari (made from cassava).

Comparison of the corn-cowpea product with gari reveals the higher nutritive value of the product. Nutritionally the above product can be used instead of gari.

The treatment given to the cowpea seeds was reflected in the fat content of some of the products. Products prepared from ungerminated cowpea seeds showed a higher fat content. Within the germinated seed products, the 2 days germinated seed product had relatively higher values. This also applied to the protein content. Thus in selection of the number of days to germinate seeds (to prepare product) in order to obtain an optimum nutritive value, it is best to germinate for 2 days.

#### 4.4 Functional Properties

##### 4.4.1. Water Absorption of Corn/Cowpea Product

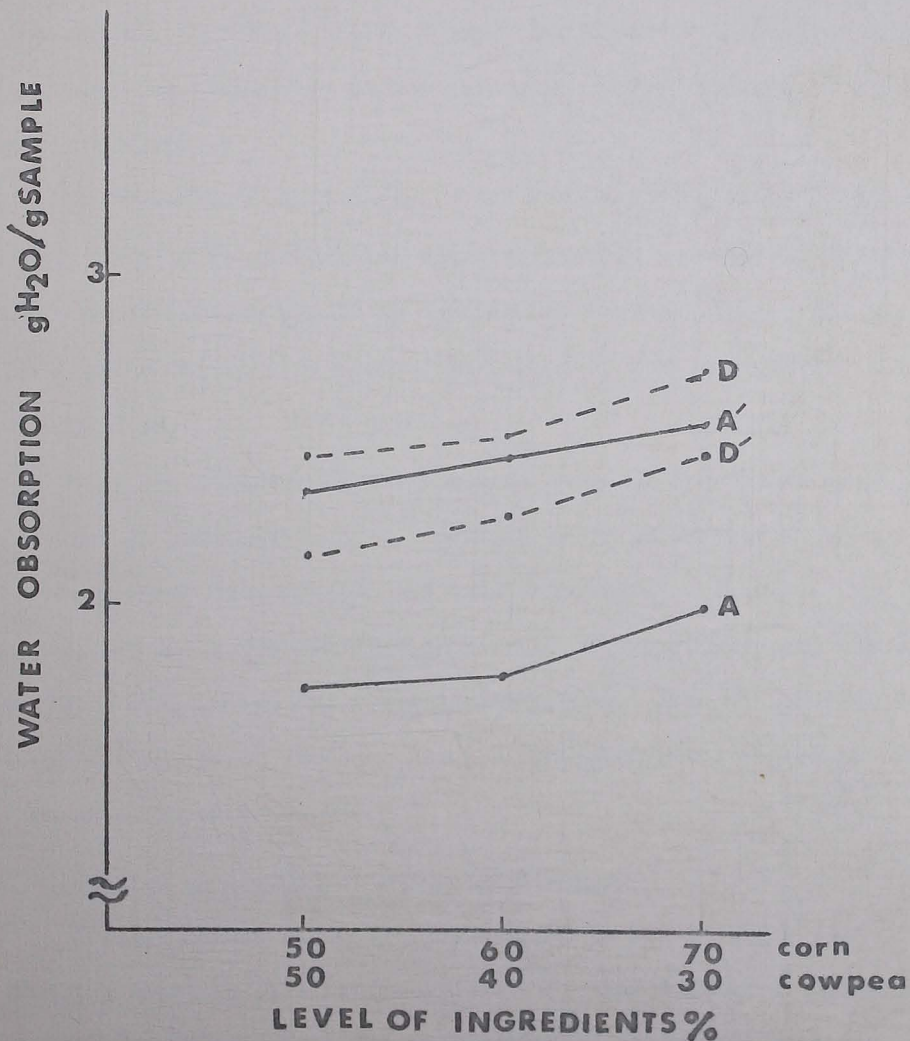
Proteins when present in even small amounts may have significant effects on the physical properties of foods, some of these properties are emulsion stability, foaming, water binding and solubility. The product prepared has a high protein content, and thus may influence the functional properties of the product. Therefore studies on some of these characteristics of the product were made. The water absorption, swelling and gelatinisation properties of the product were studied. The effects of the different treatments given to the products on these functional characteristics were studied using graphs plotted from data obtained in the laboratory analysis.

Water absorption of dehulled seed products were higher than that of the dehulled seed product. The dehulled seed product contains the seed coat and this might have contributed to the water absorption capacity of the product. The presence of fibre and other constituents

Fig. 9:

Effect of the level of Ingredients on water absorption  
of corn/cowpea product

- A' - Ungerminated undehulled seed product
- A - Ungerminated dehulled seed product
- D' - 2 days germinated dehulled seed product
- D - 2 days germinated <sup>un</sup> dehulled seed product.



from the seed coat might have absorbed water. Comparisons of the water absorption characteristics of a similar product and gari showed that corn/cowpea product did not have a high absorption as gari (Mensah, 1982).

Particle size is also a contributing factor to the water absorption of products. Pomeranz (1971) showed that flours with smaller average particle size would have higher absorption values because of greater specific surfaces.

Hydration was also showed to be more rapid at finer particle size. So that to improve the water absorption capacity of the product, finer particle size should be obtained by further milling the product. The finer particle size product will also be more acceptable as a weaning food.

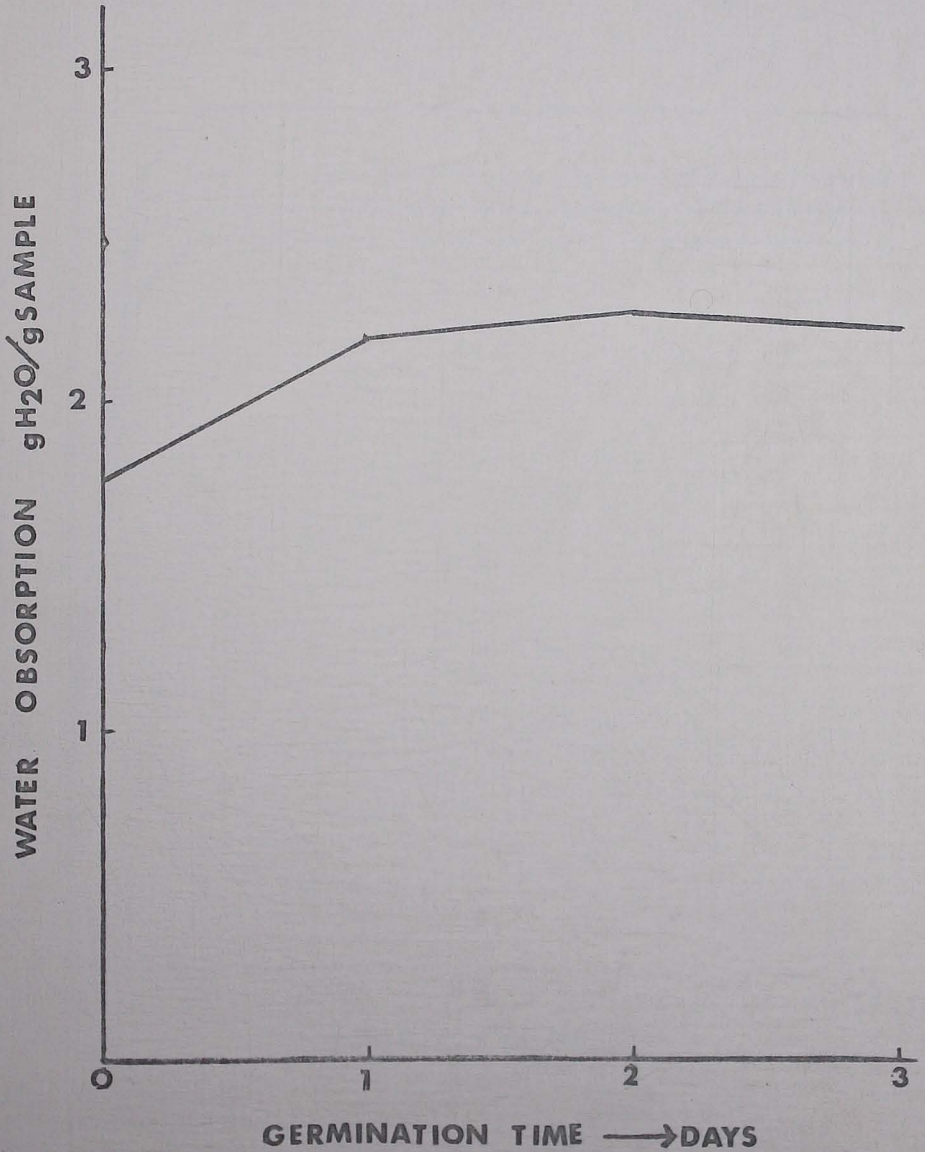
Fig. 10 illustrates the increase in water absorption with an increase in germination days. Optimum water absorption is observed in the product from the two day germinated seeds. Further, Fig. 9 shows that the curves for the germinated seed products were higher on the graph, indicating a higher absorption. Thus in practice the treatment of cowpea seeds by germination can improve the water absorption capacity of products.

#### 4.4.2. Swelling and Gelatination Characteristics

A small amount of sample is required in the swelling determination. Swelling as it relates to few proteins is expansion accompanying the uptake of solvent. Swelling of proteins by inhibition of water is

Fig. 10:

Effect of Germination time on water  
Absorption of corn/cowpea product



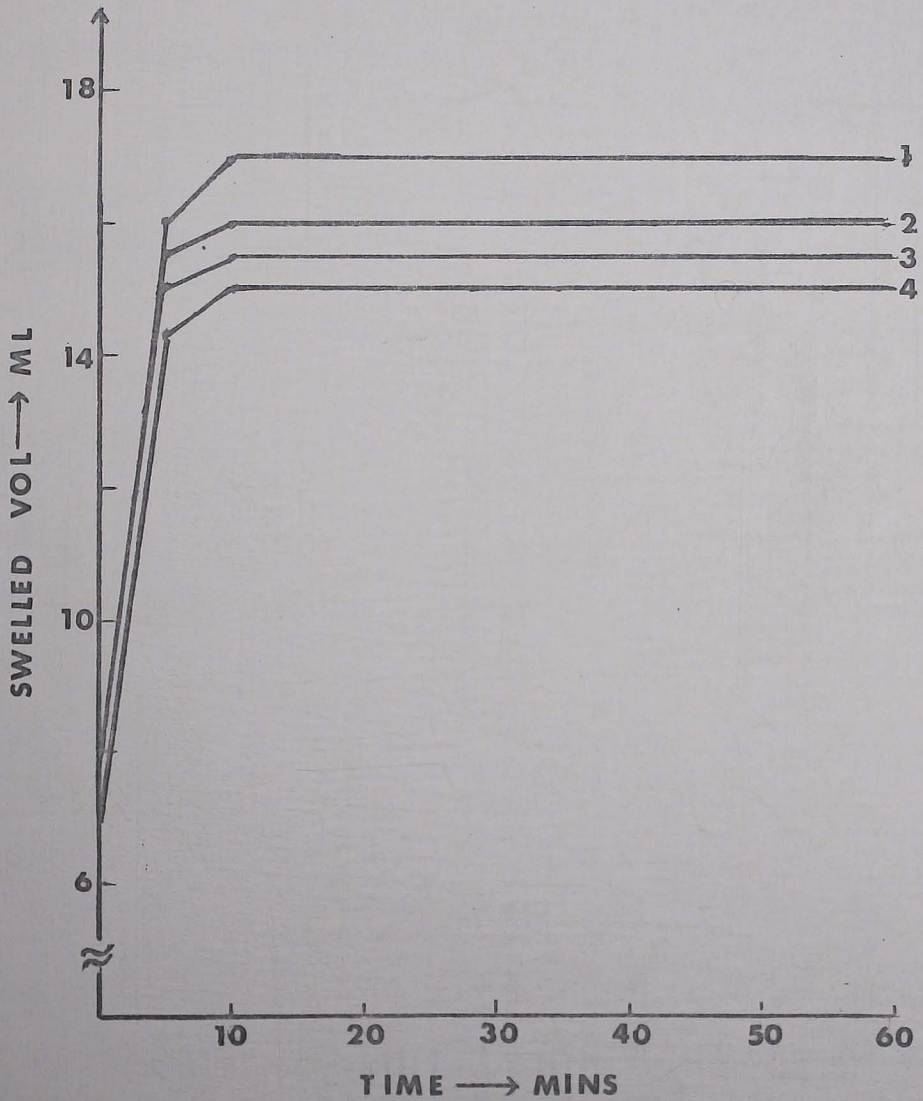


Fig. 11:

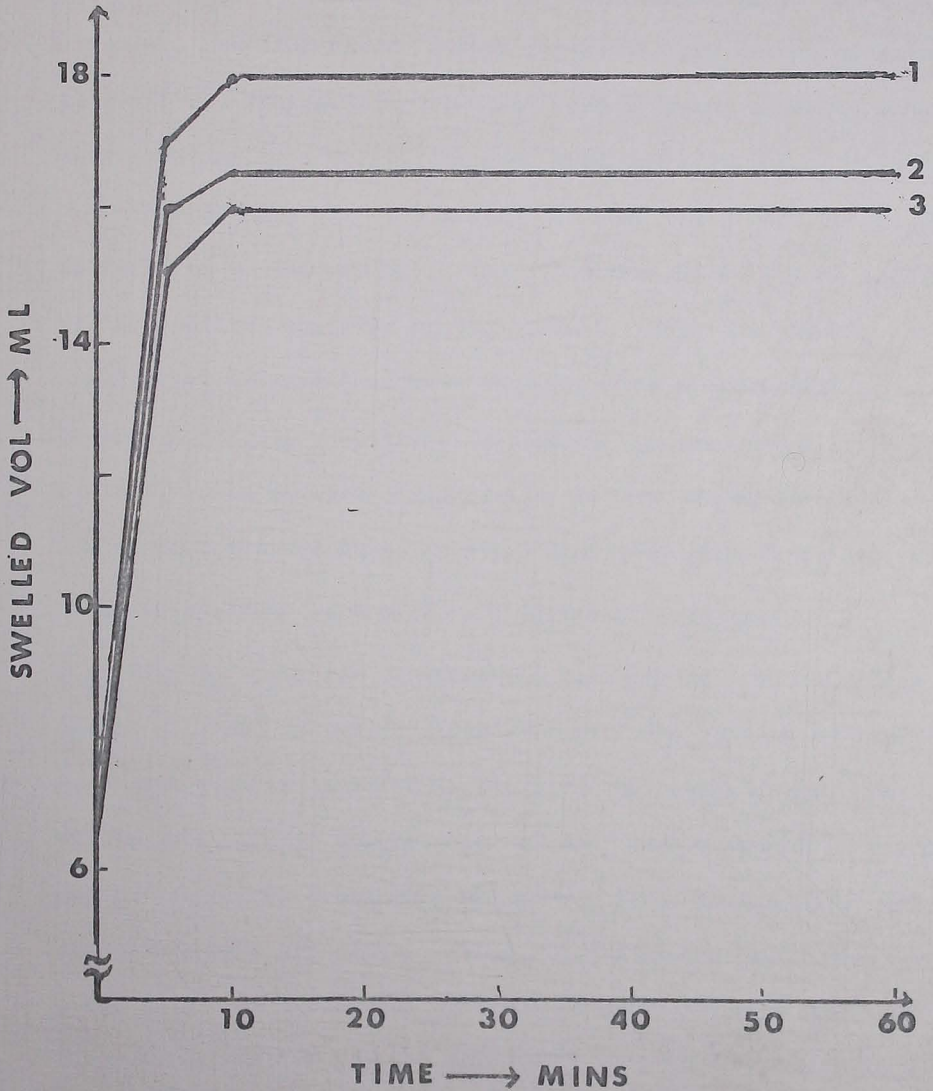
Effect of Germination on the swelled volume of  
corn/cowpea product

1, 2, 3 and 4 represent the curves for products prepared from 0, 1, 2, and 3 day germinated dehulled seeds respectively.

Fig. 12:

Effect of time on swelled volume of corn/cowpea product

- 1 - 30% cowpea dehulled and ungerminated
- 2 - 40% " " "
- 3 - 50% cowpea dehulled and ungerminated



important in foods and they impart characteristics such as body, thickening and viscosity.

The extent of cold water swelling is governed by the granule structure and also other factors related to the extent of water absorption. Thus usually there is a high degree of water absorption corresponding to a relatively high swelling activity.

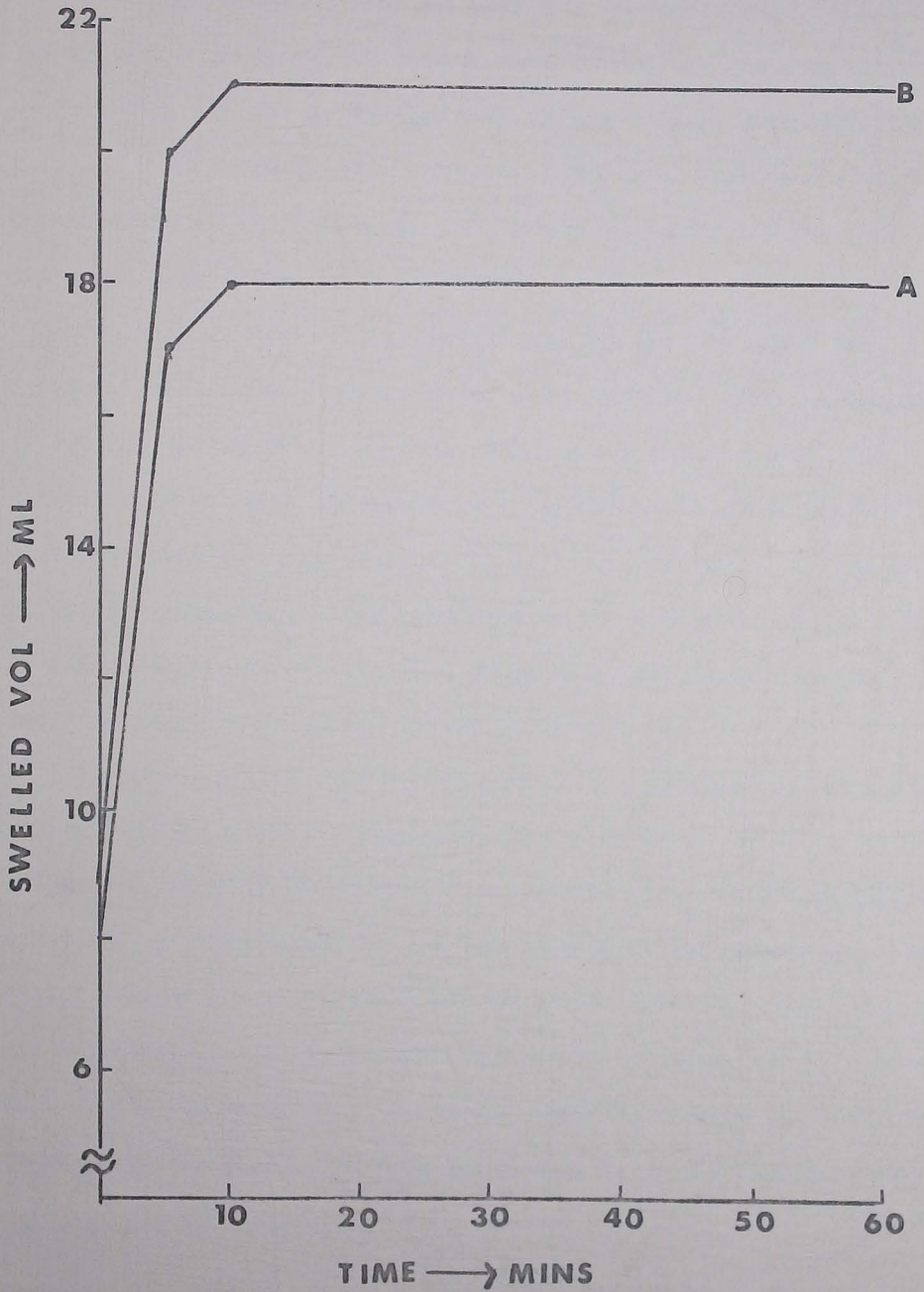
Figures 11 - 13 were plotted to show the effect of the treatments on swelling of the product. Fig. 11 shows the effect of germination on the swelling capacity of the product. From the graphs, the maximum swelled volume decreased as the number of germination days increased. Maximum swelling is observed in the ungerminated seed product. Thus adversely germination of the cowpea seeds to produce the product reduces some important characteristic functions expected from the product, making it more different from gari.

Fig. 12 shows the relationship between the swelled volume and the amount or level of cowpea flour present. The maximum swelled volume decreased with an increase in the level of cowpea flour. The effects of the level of the cowpea flour on the swelled volume of the product may be due to the treatments which were given to the seeds prior to processing into the flour. These effects become pronounced when the level of cowpea increases. Thus since germination of the seeds reduces the maximum swelled volume, there will be a further reduction if the seed flour level is increased.

Fig. 13:

Effect of dehulling on swelling of corn/cowpea  
product

- A - Ungerminated, dehulled seed sample  
30% cowpea
- B - Ungerminated, unde-hulled seed sample  
30% cowpea.



Swelling relates to some proteins and as germination reduces the levels of proteins, it will in turn reduce the swelling capacity.

In Fig. 13, the dehulled seed product swelled more than the dehulled seed product. The presence of the seed coat contributed to the swelling of the dehulled seed product by adding other food component (eg. fibre) to the product.

Swelling in most of the products reach a maximum after ten minutes. This means that the water absorption and swelling components of the samples reach a saturation point after ten minutes. The initial rate of water absorption was high when the molecules were then imbibing water and thus swelling (i.e. 1 - 5 minutes). As the saturation point was approached, the rate<sup>of</sup> water absorption was decreased until it became constant. In practice therefore the maximum length of time to attain a maximum swelled volume is ten minutes.

Viscoamylographs were run to compare the gelatinisation characteristics of ungerminated and germinated seed products. 10% slurries were prepared. There was no change in the viscosity of the germinated seed products. However there was a slight change in the viscosity of the slurry made from the ungerminated seed product during the holding and cooling stages. The small increase in the viscosity may be a result of a dilute slurry so that the starch particles responsible for the increase in the viscosity had a lot of free space and thus were not close enough to gelatinise.

The increase in the ungerminated cowpea samples may be due to the presence of more starches in this sample than in the germinated seed sample. (Adjei Twum and Splittstoesser, 1976) showed a decrease in carbohydrates during germination. This may have led to the germinated seed sample showing no increase in viscosity.

The low and no increase in viscosity of the slurries may be that during steaming, gelatinisation of the starches occurred. Thus there was no further gelatination during the heating period in the farinograph.

Previous work done on a similar product also showed no gelatination properties (Mensah, 1981).

#### 4.5 Sensory Evaluation on Corn/cowpea Product

##### 4.5.1. Color

Analysis of variance was used to analyse the results of the sensory evaluation of the corn/cowpea product. Table 13, shows a summary of the analysis.

Table 13: Summary of ANOVA on the data from color measurements

Source	d.f.	S S	MS	F	
Dehulling(D)	1	21467	214.67	98.93	**
Blend (B)	2	7.2	3.6	1.66	ns
B X D	2	15.56	7.78	3.6	**
Error	84	182.67	2.17		
Total	89	420.1			

\*\* - significant at  $P \leq 0.01$

ns - not significant.

Table 13 shows the different effects of the treatment on the color of the product. Dehulling had significant effect on the color of the product. Analysis did not show any significant effect of the different ratios on the color of the product. The three blends could not be separated on color basis. The color of the products were almost identical (with dehulled and unde-hulled sample). Thus there was not much difference in the sum of the acceptability scores given by the panelists on the three ratios. The low value of the summation of these scores (for dehulled samples) is an indication of the high acceptability of the color of the products.

However, there was a significant effect of dehulling on the color of the products. The dehulled seed products showed an acceptable bright yellow color, whilst the unde-hulled seed products had a dark color. The darkness of the unde-hulled seed product was mainly due to the seed coat. This presented dark specks in the product giving it an undesirable color. Thus the summation of the scores of the unde-hulled seed product were very high as compared to the dehulled seed products, this shows a low acceptability of the unde-hulled products (Table IV).

The interaction of the ratios and dehulling treatments has a significant effect on the color of the product. This means that the effect of dehulling changes the color of the product at the different ratios of cowpea. This is obvious by merely observing the products. The ratios with a greater amount of unde-hulled cowpea flour showed less acceptability. Therefore in practice, a dehulled seed flour used in preparing the products will be more acceptable on the market.

Table 14: Summary of ANOVA on the effect of germination on color measurements

Source	d. f	S S	MS	F
Germination	3	23.78	7.93	4.61 **
Error	56	96.39	1.72	
Total	59	120.18		

Table 14 further shows a significant effect of germination days on the color of the product. During the germination time there were sparsely distributed mould growth on the seeds, which was unacceptable. As the number of germination days increased, these growths also intensified. These were washed off but the presence of a few of these mould growths were still present on the dehulled seeds. This had an effect on the color of dehulled seed products making them unacceptable. However these growths were completely got rid off in the dehulled seeds thus the high acceptability of the dehulled seed product.

Apart from the presence of moulds, the germination process itself change the color of the seeds. This was showed by the scores of the dehulled seed products (Table VII). Those products prepared from the three day germinated seeds gave higher scores and therefore were unacceptable.

4.5.2. Flavor

Table 15: Summary of ANOVA on the data from the flavor measurements

Source	d. f	SS	MS	F	
Dehulling (D)	1	31.31	31.31	11.06	**
Blend (B)	2	15.09	7.54	2.66	N.S
B X D	2	6.86	3.43	1.21	N.S
Error	84	237.87	2.83		
Total	89	291.12			

Table 16: Summary of ANOVA on the data of effect of germination on flavor

Source	d. f	SS	MS	F	
Germination	3	45.41	15.14	3.27	**
Error	56	259.33	4.63		
Total	59	304.74			

Analysis show a significant effect of dehulling on the flavor of the product (Table 15). The level of corn and cowpea showed no significant effect. However the summation of the scores (in Table V) of the ratios shows a higher acceptability of the products with lower levels of cowpea.

The flavor of dehulled seed products were less acceptable. Germination also affected the flavor of the product. Ungerminated seed product had a desirbale flavor. One and two days germinated seed products were also acceptable. The summation of the scores for the 3 days germinated product was high showing a slight unacceptability. (Table X).

Although germination had some effect on the flavor of the product it was not very undesirable. To obtain a particular flavor in the products, variations in the dehulling and germination treatments can be done.

#### 4.5.3 Odor

Table 17: Summary of ANOVA on the data from odor measurement

Source	d. f	SS	MS	F	
Dehulling(D)	1	48.40	48.40	24.16	**
Blend (B)	2	6.43	3.21	1.605	ns
B X D	2	0.46	0.231	0.115	ns
Error	84	168.27	2.003		
T o t a l	89	227.56			

Table 17 shows that only the dehulling treatment of seeds had an effect on the odor of the final product. The dehulling seed products were more acceptable as compared to the undeulled seed product. The panelists were able to detect the difference in odor of the two sets of products. There was no significant effect of the levels of corn and cowpea on the odor of the products. Any difference in the odor may be due to change. However, these difference were small and may be neglected. The interaction of the two treatments i.e. blend and dehulling showed no effect on the odor of the products. Thus dehulling does not change the flavor of the product as the amounts of cowpea is varied.

Table 18: Summary of ANOVA on the data of the effect of germination on odor of corn/cowpea product

Source	d. f	SS	MS	F	
Germination	3	8.56	2.86	1.63	ns
Error	56	97.07	1.73		
Total	59	105.65			

Germination of seeds had no significant effect on the odor of the products (Table 18). However, the summation of the scores on the different germinated seed product showed differences although these differences had no effect on the acceptability of the odor of the product.

During germination a number of changes occur in the organic and inorganic constituents of the seed. Organic compounds are the main constituents that result in the flavor and odor of foods. These compounds may be activated or formed by the process of germination, thus giving the difference in odor and flavor of the different day germinated seed product.

#### 4.5.4 General Acceptability of corn/cowpea Product

Table 19: Summary of ANOVA on the data of the general acceptability measurements

Source	d. f	SS	MS	F	
Dehulling(D)	1	41.34	41.34	10.88	**
Blend	2	4.95	2.47	0.65	ns
B X D	2	15.63	7.81	2.056	ns
Error	84	319.2	3.80		
Total	89	381.12			

Table 20: Summary of ANOVA on the data of effect<sup>of</sup> germination on the general acceptability of corn/cowpea product

Source	d. f	SS	MS	F	
Germination	3	46.98	15.66	3.495	**
Error	56	250.67	4.48		
Total	59	297.65			

Germination and dehulling had effect on the general acceptability of the product. The general acceptability is basically the taste of the product. Dehulling improved the general acceptability of the product, since the summation of the acceptability (Table VI) scores of the dehulled seed products were lower than that of the unde-hulled seed products. Germination had adverse effects on the general acceptability of the products. The two and three day germinated seed products were preferable.

There was no significant effect of the different levels or ratios on the general acceptability of the products (Table 19). The difference showed in the summation of the scores may be due to chance and not necessarily the treatment given. However, in the dehulled seed product, the acceptability was improved as the amount of cowpea increased. The reverse happened in the unde-hulled seed product. It is obvious that the cowpea treatment produced the difference in the acceptability of the product. As the level of the unde-hulled cowpea flavor increased, the products became less acceptable.

#### 4.6 Corndough Product

The product was prepared from fermented and unfermented corndough. The functional characteristics of the two products were compared. Organoleptic analysis to compare the acceptability of the two products were also carried out.

#### 4.6.1 Water absorption and Swelling characteristics

Table 21: Water absorption of Products

Sample	$\text{gH}_2\text{O/g sample}$
Unfermented	1.85
Fermented	0.85

The unfermented product absorbed more water than the fermented product as shown in Table 21. This was also observed in Fig. 14. The unfermented sample swelled more than the fermented product.

Fermentation could have affected these properties. The production of alcohol from the metabolism of starches reduces the starch content. Water absorption and swelling were characteristic functions of starches and proteins. In the absence of proteins the degree of water absorption is reduced. So that the corn/cowpea which has a high protein content absorbed more water than the corndough product.

The high fibre content of the corndough products attributed to the relatively high swelled volume.

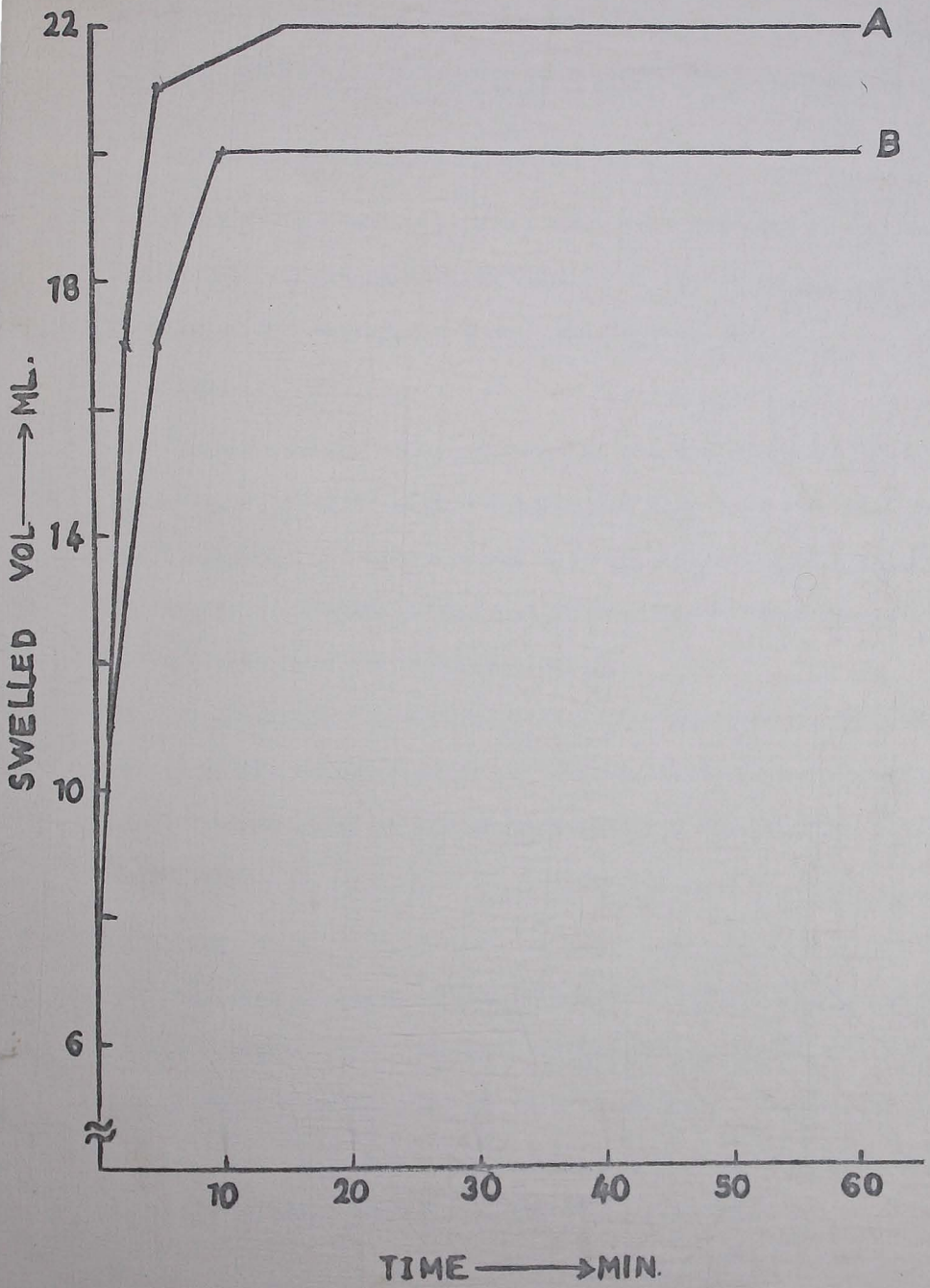
#### 4.6.2 Gelatination of the Corndough Product.

The capacity to form gels under practical conditions is an important functionality in many food proteins and starches. In the corndough product, gel formation is mainly the function of starches, since the protein content of corn is very low. There was however no increase in the viscosity in any of the products. The observation may be

Fig. 14:

Effect of Fermentation on the Swelled Volume of  
Corndough Product

- A - Unfermented corndough product
- B - Fermented corndough product.



attributed to the fact that the 10% slurries were too dilute, and also the product may have been over cooked during steaming.

#### 4.7 Sensory Evaluation of Corndough Product

Statistical analysis using the t-test was used in analysing the results of the sensory evaluation on the corndough product. The results of the t-test are summarised in Table 22.

##### 4.7.1 Color

Scores for the color analysis of the two products indicated a higher acceptability of the unfermented corndough product. However the t value of the data did not show any significant difference between the colors of the two products. This indicated that the colors of the two products were statistically equal.

In observing the products, the fermented product showed a darker color, which was not desirable. Fermentation, from observation had an effect on the color of the product although this was not statistically significant.

##### 4.7.2. Odor

The odor analysis of the fermented corndough product showed a higher acceptability. However statistically analysis did not reveal any difference in the odor of the two products. During fermentation, alcohol, acids and some organic gases are produced. These together will alter the overall odor of the fermented product.

Panelists have showed high acceptability of the unfermented corndough product. This was indicated by the lower value of the summation of scores of unfermented product in Table XIII.

#### 4.7.3. Flavor and General Acceptability

In Table 22, the  $t$  values for flavor and general acceptability of the two products were not significant. The hypothesis was rejected and therefore the flavor of the two products were equal. The same applied to the general acceptability.

From the summation of the acceptability scores on flavor and the general acceptability, the unfermented product was more acceptable. Fermentation therefore made a difference in the products. The acids and alcohols produced during fermentation gave the product a sharp and pungent taste. These flavor characteristics are sometimes acceptable in some foods. However in the prevailing product, these characteristics rather reduced the acceptability of the fermented product.

Table 22:  $t$  values of the analysis on the corndough product

	Color	Odor	Flavor	G.acceptability
$t$	- 1.1136	-0.225	-0.822	-1.185
	ns	ns	ns	ns

4.8. Costing4.8.1. Costing of corn/cowpea product

Ratio	Cost of Product ¢/kg
30 : 70	84 . 47
40 : 60	85.27
50 : 50	85.83

Calculations:

Cost of 2.5kg of cowpea = ¢160.00

To prepare 40:60 blend (150 composite)

60 g of cowpea was used.

$$\therefore \text{Cost} = \frac{60 \times 160}{2500}$$

$$= \text{¢}3.84$$

Cost of 3kg of corn = ¢120.00

∴ 90g cost ¢3.60

∴ The total cost of the finished product weighing  
87.25g = 3.84 + 3.60 = ¢7.44

∴ 1kg of the product cost

$$\frac{7.44 \times 1000}{87.25} = \text{¢}85.27$$

Cost of the other ratios were calculated in the same way.

4.8.2. Costing of Corndough Product

3kg of corn cost = ¢120.00

200g cost ¢8.00

This yielded 184g of the product

$$\therefore 1000\text{g cost} = \frac{1000 \times 8}{184} = \text{¢}43.48$$

Cost of 1kg of corndough product = ¢43.48

The cost of the products were relatively high when compared to similar products on the market e.g. cerelac. 1kg of cerelac cost 7  
 ₵40.00, averagely this product has similar nutritional value as the corn/cowpea product. Some of the nutrient contents of cerelac are as follows:

Protien : 14.5%

Fat : 7.5%

Moisture : 3.0%

The products however does not cost too much when compared to Gari, since 1kg of Gari cost ₵90.00 on the market. The developed product which was nutritionally better than gari has a lower cost. Thus the product can be used to substitute gari.

The high cost of the product was due to the lack of local food materials on the markets at the time of production of these products. Since the raw materials were scarce, the prices were high. This also led to the production of a limited amount of the product.

The high cost of the product was due to the lack of local food materials on the markets at the time of production of these products. Since the raw materials were scarce, the prices were high. This also led to the production of a limited amount of the product.

The product can be eaten by school children and adults without prior cooking. As the meal was prepared purposely for weaning infants, the product was fine starchy. Finishes products can further be milled into finer particles.

## CONCLUSION

The germination of seeds in the laboratory was successful and seeds were germinated with few problems as mould growths on seeds. The method of germination does involve simple equipments which can be afforded by any social class. This means that the use of germination to improve the nutritional value of seeds for the preparation of infant meals can be possible. The sun was also effective in the drying of the seeds. This method can however be used by only small scale processors.

Infant weaning foods in Ghana is usually prepared from corn. The protein content of the corn-cowpea product was higher than that of corn. This product can therefore be used conveniently by weaning mothers. It can also be used as a breakfast meal for school children and adults.

Analysis on functional properties of the product showed that the product could not be prepared into porridge since it did not show much gelatinisation properties. However the ungerminated seed product heated in the farinograph showed a little change in gelatinisation. The meal obtained had better flavor and tastes, as compared to the unheated product. Therefore the meal will be more acceptable if mothers could boil the product for a short time before eaten by the infants.

The product can be eaten by school children and adults without prior cooking. As the meal was prepared purposely for weaning infants, the product was too grainy. Finished products can further be milled into finer particles.

Sensory evaluation on the different products showed a higher acceptability of the dehulled seed products. The color, odor and flavor were preferable as compared to that of the unde-hulled seeds.

Ungerminated seed products were also more acceptable. Further improvements on the germinated seed product can increase its acceptability.

A second product from corndough was also prepared successfully. The traditional steaming method was used instead of the exhaust box. There were a few disadvantages in this method. Since corndough could not be spread in trays as in the exhaust. Agglomerate formation was more feasible in this product. The product was therefore very coarse. However, it can be further milled to breakdown larger particles. Although there are problems with the traditional method of steaming, it can be used in the home rather than the sophisticated exhaust box which is not also available even in the country.

The product lost its gelatinisation ability and therefore was not like the familiar corn porridge when prepared. The product showed qualities of gari. Sensory evaluation on the fermented and unfermented corndough product, showed a higher acceptability of the unfermented product. The color, flavor and odor of the unfermented product was more acceptable. The fermented product was however slightly acceptable and further improvement on the quality of the product will improve this acceptability.

The two products prepared can be used by any class of the population especially infants and children who need more proteins than adults. This will improve their health conditions and therefore reduce protein energy malnutrition in both rural and urban areas.

6. Suggestions for further study

1. Studies to find out the changes in the content of some vital vitamins and amino acids of cowpea during germination.
2. Studies on the use of the traditional steaming bowl to prepare the conr-cowpea product rather than the exhaust box should be investigated.
3. Studies on storage stability of product since moisture content of the products were high.
4. Studies to improve the quality of dehulled, germinated and fermented seed products.

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APPENDICESTable 1: Weights of cowpea during sundrying

Time(H)	Germination days							
	0		1	2		3		
	Dehulled	Undehulled	Dehulled	Unde.	Dehul.	Unde.	Dehul.	Unde.
0	370	475	436.5	547	485	590	343.4	593.4
2	320.5	419	377.5	492.2	424	522.3	293.3	544
4	261.5	353.8	262.5	371.0	308.8	386.8	194.5	409
6	232.5	287.3	221.1	307	213.8	263.0	153	320.5
8	226.7	272	207.3	275.5	200	236.3	129.5	246.1
10	225.9	267.5	206.1	274	198.5	230.5	127	240
Change in weight	144.1	207.5	230.4	273	286.5	359.2	216.4	352.7

Table II: Water Absorption of samples

Sample	$gH_2O/gSample$	Sample	$gH_2O/gSample$
AD <sub>0</sub>	1.99	AV <sub>0</sub>	2.52
BD <sub>0</sub>	1.79	BU <sub>0</sub>	2.45
CD <sub>0</sub>	1.74	CU <sub>0</sub>	2.39
AD <sub>1</sub>	2.27	AU <sub>1</sub>	2.27
BD <sub>1</sub>	2.19	BU <sub>1</sub>	2.10
CD <sub>1</sub>	1.16	CU <sub>1</sub>	2.07
AD <sub>2</sub>	2.45	AU <sub>2</sub>	2.70
BD <sub>2</sub>	2.26	BU <sub>2</sub>	2.50
CD <sub>2</sub>	2.13	CU <sub>2</sub>	2.44
AD <sub>3</sub>	2.25	AU <sub>3</sub>	2.15
BD <sub>3</sub>	1.99	BU <sub>3</sub>	1.15
CD <sub>3</sub>	1.73	CU <sub>3</sub>	1.91

Table III: Color Scores of corn/cowpea Product

AD <sub>1</sub>	BD <sub>2</sub>	CD <sub>3</sub>	AU <sub>1</sub>	BU <sub>2</sub>	CU <sub>3</sub>
3	2	2	6	5	4
3	2	1	5	6	4
2	2	2	3	5	3
2	2	2	6	6	6
2	3	2	6	3	3
2	2	3	7	8	3
2	2	2	3	8	6
2	4	9	6	7	8
2	1	2	6	8	4
2	2	1	7	9	8
3	3	2	6	9	3
2	1	2	3	4	5
3	3	2	5	5	6
2	2	7	3	8	5
2	2	4	5	5	5

= 34 =            33            39            77            96            72

Table IV: Odor Scores of corn/cowpea Product

AD <sub>1</sub>	BD <sub>2</sub>	CD <sub>3</sub>	AU <sub>1</sub>	BU <sub>2</sub>	CU <sub>3</sub>
2	2	3	5	4	6
2	3	2	5	4	7
2	2	2	3	3	7
3	2	3	5	4	6
3	3	3	3	3	4
1	1	1	7	7	7
2	2	2	3	4	3
3	5	6	6	7	3
2	4	5	2	6	6
5	6	2	6	7	5
2	4	2	3	5	3

Table V: Flavor Scores on corn/cowpea Product

AD <sub>1</sub>	BD <sub>2</sub>	CD <sub>3</sub>	AU <sub>1</sub>	BU <sub>2</sub>	CU <sub>3</sub>
3	2	1	7	6	5
2	2	2	1	2	2
2	4	3	2	4	4
4	2	1	4	6	7
4	3	2	6	7	4
6	2	6	1	3	6
3	2	3	4	8	8
3	4	9	2	3	7
1	3	2	3	3	4
3	2	2	4	7	6
2	3	3	2	3	4
5	5	4	4	5	5
1	2	6	4	3	3
4	4	6	5	4	5
3	3	3	3	4	5

Table VI: General Acceptability scores of corn/cowpea Product

AD <sub>1</sub>	BD <sub>2</sub>	CD <sub>3</sub>	AU <sub>1</sub>	BU <sub>2</sub>	CU <sub>3</sub>
5	5	5	6	7	7
7	3	6	8	4	6
2	2	3	2	6	3
6	6	3	6	5	6
2	3	3	3	3	3
2	3	2	3	8	8
3	2	2	4	6	3
3	8	9	2	3	6
3	2	3	4	7	8
4	2	6	2	3	7
7	4	2	7	8	7
4	2	1	4	5	4
2	4	2	3	3	2
3	3	1	1	3	2
3	1	2	4	5	6

Table VII: Data on effect of germination on the color of product (corn/cowpea)

$AD_0$	$AD_1$	$AD_2$	$AD_3$
2	3	3	2
2	2	2	2
2	3	5	6
1	3	5	4
3	3	4	6
2	2	2	2
5	5	2	5
3	3	3	3
2	2	3	4
2	3	7	6
2	2	2	2
2	3	3	4
1	3	3	3
5	3	3	6
2	2	2	6

= 36      41      49      61

Table VIII: Data on effect of germination on the odor of corn/cowpea product

$AD_0$	$AD_1$	$AD_2$	$AD_3$
2	3	2	4
4	4	3	3
6	2	3	3
3	3	3	4
3	3	3	3
5	5	4	5
2	2	3	4
3	3	3	3
5	7	7	5
5	2	2	3
2	3	3	5
2	2	3	6
2	3	2	3
2	2	3	3
1	2	4	3

= 47      46      48      60

Table XI: Data on effect of germination on the flavor of corn/cowpea product

AD <sub>0</sub>	AD <sub>1</sub>	AD <sub>2</sub>	AD <sub>3</sub>
1	2	4	6
3	2	7	3
8	7	6	7
2	4	7	7
2	3	9	9
2	4	9	9
6	8	8	8
6	5	5	3
4	2	3	3
2	4	5	4
3	2	2	2
2	4	5	5
5	3	5	4
2	3	3	2
4	2	4	7
= 52	55	80	79

Table X: Data on effect of germination the general acceptability of corn/cowpea product

AD <sub>0</sub>	AD <sub>1</sub>	AD <sub>2</sub>	AD <sub>3</sub>
2	2	6	9
5	3	6	3
3	2	3	3
4	3	6	4
2	3	2	2
4	5	5	5
2	2	3	4
4	5	3	3
7	7	6	6
6	4	9	8
3	3	9	9
2	6	7	7
8	7	7	7
2	2	6	3
2	3	7	9
= 56	57	84	82

Scores on qualities of corndough productTable XI: Color scores

<u>Unfermented</u>	<u>Fermented</u>
3	6
6	8
2	3
7	8
3	3
5	7
3	5
2	4
5	5
4	6
3	3
2	8
7	6
3	8
7	4
= 62	84

Table XII: Odor scores

<u>Unfermented</u>	<u>Fermented</u>
3	4
6	9
2	3
2	3
3	3
7	7
2	1
5	4
5	4
4	6
4	2
3	5
5	3
3	3
= 56	61

Table XIII:

Table XIV:

<u>Flavor scores</u>		<u>General acceptability</u>	
<u>Unfermented</u>	<u>Fermented</u>	<u>Unfermented</u>	<u>Fermented</u>
3	3	2	2
2	6	2	4
5	3	2	3
2	3	2	3
4	4	4	4
3	4	2	3
3	7	4	7
2	3	3	4
6	3	6	3
8	3	8	7
3	7	3	2
4	3	4	3
2	3	2	6
5	3	4	8
4	8	6	8
	6		
<hr/>		<hr/>	
= 56	66	= 54	67



Section B

Please evaluate the products by eating and express your degree of acceptability with respect to

a) Flavor

b) General acceptability

Code No.						
Flavor scores						
General accepta.						