DEVELOPMENT AND QUALITY EVALUATION OF PRE-GELATINIZED INSTANT WEANING FOODS BASED ON CEREALS AND LEGUMES

BY

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A REPORT ON A PROJECT UNDERTAKEN IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF B.Sc. (HONS) DEGREE (BIOCHEMISTRY AND FOOD SCIENCE)

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LEGON.

JULY, 1991.

DECLARATION

The work which has been described in this report was carried out by me in the Department of Nutrition and Food Science, University of Ghana, Legon, under the supervision of Dr. W. A. Plahar.

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DEDICATION

TO: My beloved parents MR. TETTEH ABUTSI AND MADAM PATIENCE KPODO whose care and love have brought me this far.

AND My brothers and sisters ; JOSEPH, ALFRED, ALBERT, AGNES and AUGUSTINA who also helped me in one way or the other to achieve my ambition.

ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to my supervisor Dr. W.A. Plahar for his patience, tolerance, guidance and help which has made this work successful.

I am also grateful to Professor S. Sefa-Dedeh who most of the time put one on ice just to reason out for yourself, I am also grateful to him for making his materials available.

Further thanks go to Mr. Kuma, Mr. Quansah, Mr. Bonney, Mr. Theo, Mr Dickson, Mr. Francis, Mr Firibu Saalia for their kindness and help throughout the course of my work. Mr. Eric William Ampadu is not left out at all.

My special thanks go to Mr. Philip Nuedzro and Miss Mispah Tettey for their financial and moral support respectively throughout my study.

My special thanks will not complete if I left out my best friends on campus Mr. Eric Anthony Affram and Mr. Samuel Kwami who in no small ways contributed to what I am today.

I am grateful to Mr. George Bada, Balme Library, who typed the manuscript for me.

My greatest thanks however go to my Lord Jesus Christ who has brought me thus far.

Finally, I am very grateful to all those who in one way or the other contributed to the success of this work and have not been mentioned.

ABSTRACT

Cereal-legume blends (70:30) were prepared from roasted groundnut, roasted corn, roasted cowpea, sprouted corn, fermented corn dough, steamed cowpea and steamed groundnut. The blends were pre-gelatinized and dried on the drum drier to give ready-to-eat products.

Chemical analysis such as protein, moisture, fat, calcium and crude fibre contents were evaluated on the products. Functional properties such as water absorption swelling properties of ingredients and the drum drier were found to affect chemical composition of the products.

Moisture content of the products was found to range from 2.41% - 6.08%. High moisture was observed with the product containing sprouted corn and cowpea flour (steamed).

Protein analysis shows that the products have high protein content than whole cereal grain. The protein content ranges from 16.9% to 24.3%. The protein content was generally found to be high in products containing groundnuts.

Fat content was also found to be high and ranges from 4.32% to 16.84%. The fat content was found to be generally high in products containing groundnut crude fibre content of the products was generally low and ranges from 1.02% to 2.8%. Productscontaining cowpea are found to have high fibre content.

Calcium content was found to be generally lower than the recommended dietary allowance issued by FAO/WHO. The calcium content ranges from 26.10% to 39.01%. Products containing cowpea have high calcium content.

The processing treatment of ingredients such as drum drier gelatinization, fermentation, malting etc. were observed to influence the functional cha-

racteristics of the products. Water absorption of the products were higher at 70°C than at 29°C. except fermented corn dough product. The highest water absorpbed was found in product containing sprouted corn and cowpea flour and corn dough (fermented), Cowpea flour and steamed groundnut products. Low water absorption was generally found in products containing roasted corn due to the modification of proteins.

Swelling of blends was observed to be higher at 70°C than 29°C except product containing corn dough (fermented), cowpea flour and steamed groundnut. But this blend had the highest swelling capacity at 29°C while the roasted corn blends had the highest swelling at 70°C.

The cooked paste viscosity characteristics of products shows that initial pasting temperature and peak viscosity decrease with increasing roasting time. No viscosity change was observed in blends containing sprouted corn due to amylose activity.

The sensory evaluation conducted on the products shows that the products are highly acceptable. In terms of colour, the panelists showed no difference and the treatments also did not contribute to acceptability of the products. This applies to taste and flavour. Consistency showed that there is difference in the treatment.

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CHAPTER 1

INTRODUCTION

1.1 The Protein Problem and attempts to Solve it

Protein Energy Malnutrition (PEM) has for a long time been associated mainly with the developing countries and starchy roots as their main source of nourishment (Hanson 1974).

In most developing countries the weaning foods prepared at home usually consist of bulky mono-cereal food which is inadequate in energy and nutrient content. In Ghana, the most common traditional weaning food is porridge prepared by cooking a slurry of fermented corn dough into a porridge or pap known as "koko", "akasa" or "akatsa" by the different ethnic groups. The pap also produced from roasted corn is also commonly called "Tombrown". These corn foods have low protein quality and therefore there is the need for fortification with high protein sources. Moreover the high starch of these foods allow them to bind so much water, yielding a gruel of fluid consistency suitable for the delicate mouth structures of infants. This dilution however increases bulk and renders the food more difficult to consume in one sitting and thus in turn limits the amount of nutrients that could have been derived from the gruel. Therefore when these foods are supplemented with high protein foods, their protein content will improve and their bulky nature during reconstitution will not affect their nutritional status.

Animal protein supplies all the essential amino acids and is the best source of protein to combat malnutrition. Unfortunately, this source is very expensive and connot be met by the majority of the people in the developing countries. To overcome the ever-increasing problem of protein-energy malnutrition in developing countries, fortification of commonly used cereal products with inexpensive plant protein is needed. Most cereal grain protein are low in lysine but have adequate amounts of sulphur amino acids. Legume proteins on other hand are rich in the essential amino acid lysine but naturally deficient in sulphur-containing amino acids such as cysteine and methionine. Because of the high lysine content, legumes are capable of improving the protein value of cereals by mutual complementation of the limiting amino acids.

Attempts have been made towards solving the problem by formulation of blends of locally available legumes (pulses and oilseeds) and cereals to increase the protein content. These attempts were made based on the following criteria:

1. Local availability of raw materials (legumes and cereals).
2. Ability to give products similar to already known traditional foods.
2. Suitable functional and sensory characteristics.
3. Nutritional advantages through mutual complementation.

In Ghana, 2 main approaches are being used to combat the protein-energy malnutrition problem:

a) Campaign for domestic preparation of weaning foods by mothers using predetermined proportions of available legumes and cereals. This method has not been very successful as at now because obvious shortcomings and potential problems such as ignorance of preparation techniques and seasonal availability of ingredients (Plahar and Hoyle, 1987)

b) The promotion of semi-industrial units for the production of ready-made weaning foods of high nutritional quality based on local cereal and legumes. In Ghana, the food research institute, the Nutrition and Food Science Department of the University of Ghana, Ministry of Health (Nutrition Division), UNICEF, Ghana National Commission on Children and World Vision International are the major organisations actively involved in research, development and extension work on such formulations (Plahar and Hoyle 1987).

In view of this, the National Food and Nutrition Committee (NFCC) of the Ministry of Health (Nutrition Division) has recently been promoting a new infant weaning product called "Weanimix" in towns and villages. This is a blend of major cereal with one or two local legumes especially cowpeas and groundnuts. The blend is a powdered food prepared from a combination of 4 parts of cereals with one part of legumes. The cereal used is mainly corn, sorghum or millet with the legume being cowpeas or groundnuts or a combination of both legumes. This product has been found to be the cheapest, high quality, high protein and energy weaning food.

In developing new protein-rich cereal-based diet, it is essential that the criteria of quality, traditionally applied in each market or geographic region be fulfilled. This require intimate, accurate knowledge of the nature (colour, texture and flavour) of the traditional food and the physical and chemical properties of the protein source being used in the new or imitation product. Thus, it is not only 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 at low cost.

Plahar and Hoyle 1987 noted that to achieve the maximum benefit from protein supplementation in the common cereal diets, a careful formulation and processing procedures for the production of the creal/legume blend is required. With regards to the PEM problems in developing countries, cereal/legume mixtures are capable of solving this widespread problem through closely and carefully monitored blend formulations and controlled processing techniques. Industrial preparation of such blends for distribution as against home preparations will be more convenient.

The protein Advisory Group of the United Nations System (PAG 1972) also noted that acceptability of formulated foods can be enhanced by modern industrial processing such as pre-cooking and roller drying extrusion cooking and enzyme treatments. They suggested that the food mixture should be formulated and processed so that by the addition of minimal amounts of freshly boiled water, it is easily and quickly prepared as a gruel or porridge of the proper consistency for feeding.

This industrial methods of preparing precooked foods have advantages over the home preparation blends. These advantages are their convenience to the consumers since it is ready to eat food just after adding freshly boiled water. The food would be more convenient to ignorant mothers who know little about formulation and processing of weaning foods. Another advantage is that, it would save time in preparing weaning food at home. This industrial preparation also enhanced nutritional value by added nutrients and the increase caloric density.

One company which is actively producing ready to eat weaning food is

Nestle Ghana Limited who produces Cerelac. This is formulated from locally available cereal (corn) and legume (cowpea).

In view of the above advantages of ready-to-eat food over the home preparation ones, this project is being undertaken to prepare pre-cooked weaning food with high quality but at low cost. The following objectives are therefore being set.

1.2 OBJECTIVES OF THE PROJECT

1. To formulate cereal-legume blends from maize, cowpea and groundnut.
2. To develop products from the cereals and legumes using treatments such as fermentation, roasting and germination.
3. To evaluate the effect of pregelatinization on the chemical composition of the formulated blend.
4. To evaluate the effect of pregelatinization, fermentation, roasting and germination (malting) on some functional characteristics such as water absorption capacity, swelling and cooked paste viscosity of the products.
5. To conduct sensory evaluation on the products with reference to colour, flavour, taste, consistency and general acceptability using hedonic scale.

CHAPTER 2

2.1 LITERATURE REVIEW

Although the production of weaning food mixtures has been encouraged at the household level, it is not making appreciable impact. It is interesting to note that appearance on you markets with processed packaged infants foods are also making us resolve the problem. Many of such packaged weaning foods produced in several countries have failed to make any impact on problems of infant feeding because unless these products are subsidized the prices are not within the purchasing power of the majority of the people (Orr, 1972). In view of the above information it is necessary to formulate and process weaning foods with good quality but low cost.

The cereals mainly wheat, corn, rice and sorghum are the world dietary protein supplies of about 50%. The remaining 50% is provided by:

i) vegetables (20%) such as soy-bean, peas and dried beans and

ii) animal product (30%) in the term milk, fish and meat (Deutscher, 1978)

Hopkings and Steinke (1978) stated that the degree to which proteins are utilized is a function of the digestibility, amino acid composition and amino acid requirements of the organism fed the protein. The quality of protein is therefore determined by the proportion of the essential amino acids present. The amino acids present in the least quantity in relation to its relative requirements is known as the first limiting amino acid. It can be therefore be stated that the quantity of protein is not however the only consideration, the quality must also be taken into account.

2.2 Processing functional Characteristics of Cereal and Legume

The Cereals - corn

The most important cereal in Ghana on the bases of acreage production output and consumption is the corn grain. Corn has found a very wide use in the cereal industry. It is processed both traditionally and by modern technology. Corn appears to be the cheapest cereal commodity in Ghana. Below is the comparison of prices of some cereals and legumes by Ministry of Agriculture.

Table 1: Comparison of extreme prices of selected commodities at the wholesale for the week-ending 1/6/91

COMMODITY	UNIT OF SALE	HIGH-PRICED AREA	LOW-PRICED AREA
1. Maize	Bag 100kg	Obuasi (₵15,500)	Techiman (₵8,000)
2. Rice (local)	Bag 100kg	Bolgatanga (₵25,000)	Tamale (₵14,500)
3. Sorghum	Bag 109kg	Koforidua (₵19,000)	Tamale (₵11,000)
4. Millet	Bag 93kg	Cape Coast (₵20,000)	Bolgatanga (₵12,000)
5. Groundnut	Bag 82kg	Koforisua (₵27,000)	Tamale (₵17,000)
6. Cowpea (white)	Bag 109kg	Makesin, Sekondi/ Takoradi (₵29,500)	Techiman (₵20,500)

The chemical composition of corn (*Zea mays*) Inglett 1970 gave the average composition of the corn grain as follows:

Starch - 71.5%

Protein - 10.3%

Lipid - 48.0%

Sugar - 2.0%

Ash - 1.4%

The major compoenents of the whole grain are therefore starch, protein and lipid. The starch granule in corn contains about 27% amylose and 37% amylopectin. However, this ratio may vary depending on the variety of corn, soil consistuent and other factors. It is these chemical properties of the starch in the kernel which account for the textural behaviour of corn during processing e.g. formation of gel on cooking.

The protein in corn comprises:

i) Albumins (water soluble)

ii) Globulins (salt solubles)

iii) Prolamines (soluble in 70-80% ethanol solution)

iv) Glutelins (soluble in ageous solution).

The properties of the proteins influence certain functional and processing characteristics of corn e.g. water absorption capacity.

Dovlo (1970) reported that corn is the major source of calories and protein in Ghana. Plahat and Leung (1982 also reported that corn accounts for 90-95% of total calories of coastal Ghanaians.

Traditional food processing methods play an important role in the processing and utilization of corn foods, in Ghana and in many developing countries. Much of the corn foods available on the market for direct use are ready to eat foods or the food ingredient is processed using simple traditional technologies. Most of the technologies are based on local raw materials and equipment.

2.3 Processing Methods of Corn

2.3.1 i) Fermentation

Common products is "koko" - porridge for which corn is steeped in water for 2-3 days, wet milled wet sieved and fermented for at least 12-48 hours (Dovlo 1970). The final product is cooked to produce a thin gruel (porridge) which is used as weaning food for infants.

During fermentation, the flavour and nature of the food is altered due to microbial action. Cameron and Hofvande (1971) reported that fermentation of whole grain corn in West Africa resulted in an increase in riboflavin and niacin content. But fermented corn meal is high in moisture content and therefore spoils easily (Harnod and Field 1979).

Banigo and Muller (1972) identified eleven carboxylic acids in corn meal during fermentation. Of these acids, lactic, acetic and butyric acids were important. Plahar and Leung (1982) also found that the development of carboxylic acids during corn meal fermentation was influence by the initial moisture content of the dough.

2.3.2 ii) Roasting

Roasting causes:

i) improved colour development as a result of formation of more melanoidins and

ii) formation of desirable flavour compounds.

Apart from pleasant aroma and increasing acceptability in products, Manero et al (1988) reported that stability of cereal and legumes is improved by toasting because it inactivates the enzyme that cause the development of objectionable flavour during storage. Toasting also reduces the moisture content of the grain and can thus be described as drying process.

The stability of the grain is also improved.

During roasting the husk colour changes and fuse to the aleurone and testa. The endosperm also undergoes a pyrolytic transformation. The starch undergoes partial hydrolysis and cross-linking within the granule resulting in new glycosidic bonds formation. At the same time reaction resulting in the transformation of the starch, cell wall and protein matrix into a homogenous mass which is water soluble occurs. Some of the endosperm glucose, is dehydrated to form 1, 6 anhydro-B-glucose (laevoglucosan) and ultimately to 5-hydroxymethyl furfural through the Maillard reaction (carbonyl-amino condensation reaction). This gives characteristics brown colour and flabour compounds formed during roasting.

Nutritional availability of some amino acids on the side chain of lysin ($E-NH_2$) is the preferred site for initiation of maillard reaction. The lysine bound as a result of sugar carbonyl-amino reaction has low nutritional value and cannot be utilized by the body. Amino acids such as argininine, tryptophan, Histidine and Threonine have also been found to react with carbonyl group of sugar during heating of the grain. Hence roasting of cereal and legume result in considerable damage to nutritive value of protein.

In Ghana, roasted products are usually eaten as snack foods e.g. Abelemamu (roasted corn) or as roasted corn porridge popularly called "Tom brown" which serves as weaning for infants as well as breakfast beverages for the adults and children.

2.3.3. iii) <u>Germinating or Malting</u>

Important in brewing industries as well as traditional processes. It is now getting wider use in Ghana e.g. in the preparation of local malt beverages such as Nmeda, Ahei and Aliha. Sprouting is a process that involve the germination of seeds and can be achieved without the use of sunlight or soil. The reactions involved in sprouting include the breakdown of certain material in the seed transport of material from one part of the seed to another especially from the endosperm to the embryo or from the cotyledon to the growing parts. There is loss of dry weight due to oxidation of substances on one hand and leakage out of the seed on the other hand. Total lipids decrease both in the endosperm and the cotyledon as germination proceeds.

Corn starch has been hydrolysed to simple sugars by amylose enzymes during malting. Corn malt contains low molecular weight compounds from degradation of high molecular compounds in addition to enzymes, amino acids, vitamins and sugars. Corn malt has been reported to differ from the corn seed due to biochemical changes during steeping and germination which affect the chemical composition of the grain (Briggs et al 1971 and Plahar 1976).

Plahar and Halm (1976) reported that there is gradually decrease in starch content with corresponding increase in sugars as a result of germination.

There are enzymes found to be associated with malting. These include x- and B-amyloses which hydrolyse starch, cyteses, protecses, phytases and Exidases (Svanberg 1985). Amyloses catalyst the hydrolysis of x-D (1,4) linkage of starch. The x-amylases are endoglycosidases attacking glucose away from the chain and producing various type of oligosaccharides. Amylopectin portion is hydrolysed by x-amylase to give x-maltose, gluco glucose and isomaltose.

In evaluating nutritionally acceptable and microbiologically safe weaning food formulations prepared from 70 : 30, cereal: legume combination of germinated rice: munghean, germinated corn: cowpea, germinated corn: munghean and germinated rice: cowpea, L.M. Marero et al (1988) reported that germination reduced the dietary bulk of the formulations due to decrease in viscosity of gruels, hence, increasing their nutrient density compared to the ungerminated ones. They further reported that germination increased the content of micronutrients such as phosphorus, Fe and especially in the corn formulations, B-carotene, thiamin, riboflavin, niacin and ascorbic acid but decreased in calcium. Marero et al also identified that the germinated blends worked on had amino acid scores that approximated the FAO reference pattern except for the s-containing amino acids.

The effect of using malt for reducing the dietary bulk of gruel base has also been demonstrated by Svanberg and Mosha (1983). They showed that viscosities of thick gruels are affected by the addition of germinated corn when cooled down to 40°C after cooking.

2.3.4 iv) Gelatinization of Starch

When starch is mixed with cold water, no apparent change occurs; but when the water is heated the viscosity of the mixture increases and if the concentration of the starch is sufficiently great, gel is formed. Often if the starch suspension does not gel at the elevated temperature, it will when the mixture is cooled. This is the gelatinization of starch. This depends on

1. Temperature
2. pH at which gelatinization is measured is important

3. Temperature at which observations are made and the length of heating are important
4. The size of the grannule. The temperature of gelatinization decreases as grannule size decreases.

Process of gelatinization

This is in 3 stages.

1. In cold water, there is imbibition of approximately 25 to 30 percent of water. This is reversible since the starch can be dried. In this stage the viscosity of the starch-water misture does not change.
2. Occurs at approximately 65°C for starches. The granules begin to swell rapidly and take up a large amount of water. Meyer and Benfelf reported (cited by Meyer 1964) that corn starch at 60°C takes up 300% water, 1000% at 70°C and at point of maximum swelling 2500% based on origin of starch. At this starch, some of the more soluble starch granules leach out and the granules change in appearance. This stage is not reversible.
3. More selling occurs. The granule becomes enormous and often ovoid is formed. Much more starch is leached out and finally the granule ruptures, spilling more starch out into the surrounding fluid. The viscosity of the fluid increases markedly and the starch granules stick together so that they can no longer be picked apart.

Chemistry of gelatinization

The swelling of starch, particularly amylose which results in an increase in viscosity of a starch-water mixture and the formation under proper conditions of a gel, is now believed to occur through the binding of water, In starch granuele amylopectin and amylose molecules are closely bound together by H_2 bonds of the hydroxyls. A H_2 on OH of one molecule is attracted by the negative charge of the Q_2 of a hydroxyl on another molecule and this attraction forms a weak link between the molecules as below

These aggregate of molecules held together weakly from micelles. As the temperature of a water-starch mixture rises, H_2 bonding decreases for both the starch-starch bonds and water-water bonds and the size of the particles diminishes. The tiny H_2O molecules begin to freely penetrate between starch molecules. Conversely as temperature decreases, H_2O molecules are bound between the starch molecules and there is an increase size or swelling. See diagram below:

When 2 starch molecules are originally bound together, there are now the 2 starch molecules with H_2O molecules in between. The sticking together of granules is believed to be the result of molecules from adjacent granules becoming attracted and enmeshed in one another.

Gel formation occurs through the formation of a 3-dimensional network of starch molecules particularly the long straight chain amylose molecules. These molecules become interlaced through attractive forces between the molecules and particularly through H_2 bonding on H_2O molecules. Highly branched glycogen does not form gels or crystals and gel formation in starch consequently believed to be primarily the function of amylose rather than amylopectin (Meyer 1964).

In the laboratory drum driers can be used to gelatinize starches.

2.4 LEGUMES

Legumes are recognized as important dietary source of protein and the B-vitamins in developing countries. In Ghana and most West African countries, cowpea is grown and consumed daily as steamed or field (akara) foods by a large proportion of the population (Philips et al 1988).

Sefa-Dedeh and Yiadom-Fakye (1988) reported the chemical composition of cowpea as shown in the table below.

Table 2: Chemical composition of two varieties of cowpea grown in Ghana on dry matter bases

Characteristics	Westbred (white variety	Adu aayere (red variety)
Moisture	11.36	13.50
Protein (NX 5.7)	22.71	23.80
Fat	1.81	1.55

Eyeson and Ankra (1975) also gave the chemical composition of groundnuts which also consumed extensively usually as snack in Ghana and is presented in table below.

Table 3:

	Composition in terms of 100g of dible portions		
	Moisture	Protein (NX 5.7)	Fat
Groundnuts			
Dried	4.9	22.7	48.1
Roasted	2.3	21.8	50.5
Paste	2.6	24.4	5.0

Legumes contain antinutritional factors such as tannins, raffinose, stachyose, phytic acid and trypsin inhibitors.

Ogun et aal (1989) reported that processes like dehulling, cold and hot-soaking, cooking have effect on antinutrients such as tannins, raffinose, stachyose, phytic acid and trypsin inhibitors, From the results, while little decrease in raffinose was observed as a result of the processing of cowpea, stachyose was considerably lowered by all processing methods except cold-soaking. As stachyose plays a key role in the incidence of flatulence, the observed reduction may be important. Phytic acid was not affected by any of the treatments. The tannins were eliminated by dehulling, indicating that only the testa of cowpea contained these substance. Trypsin inhibitor was greatly reduced by application of heat. Apparently heat denatured the proteinaceous trypsin inhibitors which must be absent in the testa since dehulling had no effect on the trypsin inhibitor capacity of cowpeas. Tannins are known to render ionizable dietary Fe unavailable to the body.2.4.1 Problems with Groundnut

2.4.1 Problems with Groundnut

The literature review will not be complete if mention is not made of the problem with groundnut. Feaking (1964) reported that in 1960 some 100,000 young turkeys died in Britain in the course of a few months. After investigation several possible causes, it was realised that a factor common to all the outbreaks was the presence in the feed material of groundnut meal taken by a particular consignment. Further work indicated that a toxin produced by a microorganism might be the cause of the trouble and this led to the discovery that strains of the fungus Aspergillus flavus were responsible for the producing of the toxic factor which was named

'Aflatoxin'. It further reported that *A. flavus* grows best between 10° and 45°C at relative humidity of 75% or more, although the optimum conditions for aflatoxin production are between 25 and 30°C at 85% relative humidity. The equilibrium moisture content of groundnut at 75% relative humidity is 9% and this fact is of considerable practical importance in the search for effective ways of controlling infection. This shows that *A. flavus* grows only when the moisture content of the groundnut exceeds 9%. Hence there is need to keep the moisture of groundnut below 9%.

CHAPTER 3

3.1 MATERIALS

3.1a EQUIPMENT

a) Christy and Moris laboratory Mill (Christy and Morris Ltd., Chemsford, England)

b)

b) Benley B.S. 400 centrifuge

c) Gallenkamp stove

d) Visco-Amylograph (Brabender Instruments Co. USA)

e) Laboratory Mill (Straud Co., Phila Pa 120201, USA)

f) Solar Drier

g) Thermoregulated Water Bath

h) Drum Drier

3.1b RAW MATERIALS

a) Corn (*Zea mays*) - obtained from the market, Accra)

b) Cowpea (white type) - *Vigna unguiculata* - obtained from market, Accra.

c) Groundnut (*Arachis Hypogea*) obtained from Accra.

3.1c PREPARATION OF SAMPLES

1. ROASTED CORN

The grains were cleaned to remove dirt, stones etc., divided into 3 batches and roasted on the stove at medium heating for 10, 15 and 25 minutes respectively. The roasted corn were then bagged in a polythene bag and stored in a cold room.

3.1d FERMENTED CORN MEAL

Traditional method described by Muller and Nyarko-Mensah (1972) The corn grains were cleaned, washed and steeped for 20-24 hours. It was then milled in a disc attrition mill to obtain a fine meal. The meal was kneaded with water (approximately 1:3 corn-water ratio) to form a smooth dough. The prepared dough sample was packed into large rectangular plastic bowl with cover and the surface smoothened to seal any visible opening. The container was then covered and left to ferment at 29°C (room temperature) for 3 days. After fermentation, the dough was packed into polythene bags and kept in a deep freezer.

3.1e CORN MALT (SPROUTED CORN)

The corn was cleaned, washed thoroughly and steeped for 24 hours. The soaked seeds were then spread in a previously sterilised sack (in basket) and covered with a sterilised moist sack for 3 days. The sack was kept wet throughout the 3-day germination period by regular sprinkling of water. The sprouted seeds were solar dried for 12-18 hours, sealed in polythene bags and stored in cold room (5°C).

3.1f ROASTED COWPEA

The cowpeas were then cleaned by screening for dirt, pieces of stalk, stones, etc. The grains wer e then roasted on Gallenkamp stove put at medium heating for 15 minutes. The cowpeas were then dehaulled by coarse grinding using the disc attrition mill, hand-rubbing to remove loosely held husks and winnowed. The cowpeas were then sealed in polythene bags and stored in a cold room.

3.1g STEAMED COWPEA FLOUR

Cleaned cowpeas were dehaulled by steaming for 10 minutes in an exhaust box and then immediately cracked into fairly larger particles using the disc attrition mill. The grain were then rubbed in the hands to remove loosely adherring husks and then dried in a solar drier. After about 2 hours of drying the cowpeas were then winnowed and milled into flour. The flour was then steamed for 20 minutes in a steam exhaust box and dried for

2 hours in a solar drier and stored in the cold room (4 ^{o}C).

3.1h ROASTED GROUNDNUTS

Groundnuts were cleaned by screening for chaff, pices of sack etc. The nuts were then roasted on gallenkamp stove at medium heating for 15 minutes, dehulled by hand, winnowed to separate the hulls. The roasted dehaulled nuts were stored in cold room.

3.1j STEAMED GROUNDNUTS

Cleaned groundnuts were steamed in a steam exhaust box for 20 minutes and immediately dehaulled by hand and dried in the solar drier for 2 hours. The nuts were stored in polythene bags and kept in cold room.

3.1j MIXING

The raw materials were mixed and ground using the disc attrition mill at the ratio of 70:30 corn: legume or 70:15:15 corn: legumes: legume.

3.1k DRUM DRYING

Approximately 1:4 blend: water ratio slurry was prepared. The slurry was then put on the drum drier for 50 to 70 seconds to pregelatinize and dry the blends. (Marero et al 1989).

METHODS:

3.2 PROXIMATE ANALYSIS

3.2.1 MOISTURE CONTENT

Moisture was determined using the air-oven method (American Association of Cereal Chemists (AACC) method 44-40, AACC approved methods (1969). 2.0 grams of sample was used.

3.2.2. PROTEIN CONTENT

The protein content was determined by analysing for total nitrogen using the mackro-kjeldahls method (Association of Official Analytical Chemists (AOAC) method 47-021. Official methods of Analysis of AOAC (1975). The nitrogen determined was converted to protein using the conversion factor of 6.25.

3.2.3 FAT CONTENT

The method used is termed Dry extraction method and is based upon the extraction and subsequent weighing of all ether soluble material from a weighed sample. Association of official Analytical Chemist (AOAC) method 7-066 (1975).

2g of sample was used in the determination.

3.244 CRUDE FIBRE

Crude fibre was determined from the samples using the method of crude fibre determination from the Association of Official Analytical Chemists method 22.042 (AOAC 1975).

3.2.4 CALCIUM CONTENT

Calcium was determined using the EDTA titration method, Pearson, 1976. 2g of samples each were used.

3.2.5 SENSORY EVALUATION (Organoleptic Analysis)

Sensory evaluation is a part of food analysis, where the senses of human beings are used to evaluate a product. Taste panels were conducted for the samples using hedonic scale. The taste panels were conducted over a one-day period (in the morning and afternoon). Panelists were made up of 10 students from Nutrition and Food Science Department, teaching assistants and technicians, all in University of Ghana, Legon. The taste panels were conducted in the main laboratory of the Nutrition and Food Science Department.

Panelists were asked to assess their liking for quality attributes of colour, flavour, taste consistency and overall acceptability of the cereal-legume pre-gelatinized products developed. A 1 to 9 numerical hedonic scale was used. The panelists were asked to indicate their degree of likeness or dislikeness of the product. 8 samples were used and 4 were presented on one bench to avoid overcrowing.

3.2.6 STATISTICAL ANALYSIS

For sensory attribute therefore, a two-way analysis of variance (ANOVA) was carried out to determine significance of variations among sensory scores. Varience ratios (F-values) were obtained for

a) Effect of pretreatment process

b) Effect of variation due to panelists.

Whereever there was significance of the observed difference as given by F-value, the least significance Difference tests (LSD) were used for pairuise comparison of means sensory scores (Steel and Torrie, 1980).

3.3.1 FUNCTIONAL PROPERTIES

3.3.1 WATER ABSORPTION: (By method of Fleming et al 1974)

5g of each sample was mixed with 15ml of water in a centrifuge tube and left to stand for 30 minutes. The samples were then centrifuged at 3,000 rmp for 30 minutes in Benley 400 centrifuge. The supernatant was poured out and the sample weighed. The amount of water retained in the sample was reported as water absorption per 100g of sample (dry weight basis). The procedure was repeated for each sample at 70°C.

3.3.2 SWELLING (By method of Fleming et al 1974 with modification)

10g of sample was weighed and put into a 100ml graduated cylinger. The dry bulk volume was noted. 100ml of water was added and allowed to stand. The volume of the sample was read out at 1, 5, 10, 15, 30 and 60 minutes intervals. The procedure was repeated for each sample at 70°C in the water bath.

3.3.3. VISCOSITY

Pasting properties of cooked viscosities of samples were determined by AACC (American Association of Cereal Chemist) method (22.10 1962) in a Brabender Viscoamylograph (Brabender Instrument Inc.) equipped with a 500cmg sensitivity cartridge.

For the cereal legume blends 12% of the samples were prepared in 500ml of distilled water and poured into the amylography bowl. The temperature of the slurry was raised iniformly from 25° - 95°C, held at 95°C for ½ hour and then cooled uniformly to 50°C and held for 30 minutes.

The heating and cooling rate increased 1.5°C per minute.

FLOW CHART ON PRE-TREATMENT GIVEN TO RAW MATERIALS

ROASTED CORN

Corn
Clean
Roast (10,15,25 minuties
Roasted Corn
Mixed and milled (other components)
Hydrated
Drum dried(1:4 blend:water)
Product

SPROUTED CORN

Corn
Clean
Steep (24 hours)
Sprout (36 hours)
Solar dry
Radicle removed
Milling together (other components)
Hydrated(1:4 blend; H_2O)
Drum dried
Product

FERMENTED CORN DOUGH

Corn
Steep (24 hours
Mill
Dough
Fermented Corn dough
Mixed (other components)
Hydrated(1:4 blend: H_2O
Drum dried
Product

COWPEA ROASTED

Cowpea
Clean
Raast (10 Minutes)
Coarse grind
Dehull
Roasted Cowpea
Milling (other components)
Hydrated(1:4 blend: water)
Drum dried
Product

Costing of Product (Approximate):

This was an approximation because only the raw material was taken into consideration leaving out other services like water, steam electricity, labour and transport.

Cost of Corn = ¢ A/kg
Cost of Cowpea = ¢ B/kg
Cost of groundnut = ¢ C/kg

1000g corn cost ¢ A.

Therefore Dg of corn cost $\frac{D \times A}{1000}$ = ¢ F

1000g cowpea cost ¢ B

Therefore Gg cost $\frac{G \times B}{1000}$ = ¢ H

1000g groundnut cost ¢ C

Therefore Jg groundnut cost $\frac{J \times C}{1000}$ = ¢ K

Therefore cost of product = ¢ (F + H) or ¢ (F + H + K)

Since Lg of dry product was obtained from 100g composite, then Lg would cost ¢ (F + H).

Hence 1kg dry product would cost $\frac{1000 \times (F + H)}{L}$

= ¢ M

This ratio was also used for costing of corn, cowpea and groundnut product.

CHAPTER 4

RESULTS AND DISCUSSION

4 Evaluation of Blends

The proximate analysis was done on the blends in order to ascertain certain chemical indices and evaluate the protein supplementing effect and how the chemical composition may be affected by processing treatments or affect specific functional properties.

4.1.1 Moisture Content of Blends

The results of the moisture content of the cereal-legume pregelatinized products prepared are given in Table 4. Generally the results show that processing treatment or pretreatment of the ingredient prior to blending determines the moisture content of the blends.

For blends containing roasted corn, roasted groundnuts and cowpea f flour in which corn was roasted for 10, 15, 25 minutes, moisture content decreases with increasing roasting time. Small differences in the moisture content were observed. The corn roasted for 25 minutes gave the lowest moisture. This observation is due to the ability of the macro-molecules to release moisture during the drum drying process. The lowering of the moisture content with increasing roasting time can be attributed to the physico-chemical changes which take place in the corn during roasting which result in expulsion of water trapped in the grain. Thus roasting in addition to causing development desirable colour and flavour is also a drying process.

Initially, I was expecting all the blends to have the same moisture content since they were exposed to the same condition during the drum drying. But it seems the pre-treatment process effect on final moisture content of the product.

4 : 1 PROXIMATE ANALYSIS OF PRODUCTS

TABEL 4

PRODUCTS	MOISTURE %	PROTEIN %	FIBRE %	FAT %	CALCIUM %
Roasted : Roasted : Cowpea corn (steamed) (10 minutes) Groundnut flour	4.0 ± 0.12	24.3 ± 0.51	2.53 ± 0.03	10.92	31.32
Roasted : Roasted : Cowpea corn flour (steamed) (15 minutes) Groundnut	3.96 ± 0.08	23.7 ± 0.05	2.61 ± 0.011	10.70	30.80
Roasted : Roasted : Cowpea corn flour(steamed) (25 minutes) Groundnut	3.75 ± 0.04	23.5 ± 0.3	2.70 ± 0.09	10.64	31.19
Sprouted : Cowpea flour corn : (steamed)	6.08 + 0.20	16.9 ± 0.12	2.8 ± 0.50	4.32	39.01
Sprouted : steamed: Cowpea flour Corn Groundnut (steamed)	3.69 + 0.11	18.5 ± 0.07	2.43 ± 0.44	11.55	30.66
Roasted: Roasted : Roasted corn (10minutes Groundnut Cowpea	3.19 ± 0.14	23.4 ± 0.21	2.56 ± 0.33	14.55	30.86
Corn dough : Sprouted. Cowpea (Fermented) corn flour	3.10 ± 0.09	20.6 ± 0.32	2.58 ± 0.18	4.92	35.22
Corn dough : Steamed : Cowpea (fermented) Groundnut flour	2.41 ± 0.31	20.9 ± 0.18	1.02 ± 0.20	16.84	26.10

* Mean of two ± standard deviation

Protein, Fat, Calcium, Fibre contents are given on dry matter bas

The blend containing corn dough (fermented), steamed groundnut and steamed cowpea flour has the lowest moisture of 2.41%. This can be attributed to the action microorganisms in the dough which might have exposed the macro-molecules holding water hence the moisture was lost easily during the drying. This explanation becomes obvious because the blend containing corn dough (fermented) sprouted corn and cowpea flour (steamed) is next in moisture content of 3.10%.

The blends containing sprouted corn have the highest moisture content of 6.08%

Storage and preservation play important roles in securing food supplies from one season to the next and distribution from location to location. These usually depend on the lowering water activity in the food product.

The moisture content of the blends after drum dried ranges from 2.41% to 6.08%. This is an indication of good storage stability of the blends when packaged properly. Hence, low moisture content of the products implies decreased food loss through pest and microbial attack.

Thus apart from making the product more easily digested and utilised in human body the processing treatment given to the blend is a form of preservative method. This implies that drum drying is good method of ensuring increase in shelf-life of products. It provides ready-to-eat food which will help nursing mothers especially the illiterate ones.

1,2 Protein analysis of products.

The results are on Table 4.

The results show that the protein content of the blends were generally high ranging from 16.9 to 24.3%

The high protein content of the blends supports the view held by many researchers that cereal diet low in protein could be supplemented with inexpensive legume to augment the protein content of the diet and more importantly to increase the protein quality.

Roasting of corn at different times slightly affected the protein content of the blends. Although protein content of the blends may not be significantly affected, loss in biological value of the protein may increase roasting time as a result of increased formation of brown pigment (melanvidins) which involves the utilization of the amino acids in carbonyl-amino reaction in Arginine, through the browning reactions and therefore unavailable to the body.

It is also known that drum drying results in loss of the amino- acid lysine. This amino acid is the limiting amino acid of cereals. During drum drying of sprouted corn blends, lysine would freely react with the sugars, and other products form from the action of the amylases giving rise to loss of this essential amino acid. The endogenous enzymes don't hydrolyse the carbonyl-amino bonds hence the protein is not utilized.

4.1.3 Fat Analysis

The fat analysis result is on Table 4.

Processing treatments such as roasting, sprouting, steaming and fermenting affected the fat content of the blends. High fat contents were associated with blends containing groundnuts due to the high fat content in groundnuts. The fat content ranges from 4.32 to 16.84. The lowest value is given by sprouted corn and steamed cowpea blend while the highest was given by corn dough steamed groundnut and steamed cowpea. The high fat content of this blend may be due to the action of microorganisms on the corn which make nutrients more available.

with the blends containing roasted corn at different temperatures the highest fat content is realised on the one roasted at 10 minutes. The fat content slightly decrease with increasing roasting time.

Implication of Protein and Fat to weaning foods

The blends may perfectly serve as high protein-energy food formula for children and nursing mothers who are regarded as vulnerable group that is those exposed to protein deficiency. The implication is that the blends with high protein will provide adequate amount of protein in suitable form when used as weaning food to substitute whole corn porridge.

The high fat content in the blends may also contribute significantly to the energy or calorie requirement of the consumer. Most fats give 9kcal/g of the fat while carbohydrates give 4kcal/g of sample. The also serves as vehicle for absorption, transportation and utilization of fat soluble vitamins. As salad oils, they contribute to mouth-feed and carrier of flavours. These fats as shortenings impact tender quality to baked boods through combination of lubrication and ability to alter interaction among other constituents. The protein Advisory Group of the United Nations (1975) stated that the protein content for fortified food formula should not be less than 20%. Hence, the blends prepared can successfully be introduced as high-protein-energy rich formula to reduce the incidence of protein-energy malnutrition prevailing in developing countries.

4:1,4 Calcium analysis of product

The results on calcium analysis is in Table 4.

The calcium content ranges from 26.10 to 39.01. Those blends with high calcium contain cowpea in large proportion.

Marero et al (1988) recorded that the daily recommended calcium allowance of weaning foods is 600mg of infants between 6 to 11 months and 501mg for children between 1 to 3 years. This reports indicated that, the total calcium of the products developed are about 4 to 6% of the daily allowance. It is not possible for the infants to consume about 100g of the weaning food a day hence there is need to supplent the products formulated with calcium.

The supplementation of the products with calcium is important because of the roles calcium play in the body. Calcium and phosphorus make up our bones and teeth. Hence there will be mal-formation of bones resulting to rickets. The supplementation of the blends can be done during the blending of the components in the form of $CaCO_3$.

4:1,5 Crude fibre analysis of products

The results of crude fibre analysis is in Table 4. The result indicated that pretreatment processes affect the crude fibre level. N.L. Kent (1966) reported that crude fibre is mainly cellulose, hemicellulose and some materials that encrust the cell wall such as lignins and pectic substances. These cell wall component of plants are not broken down by endogenous fibre in diet can cause discomfort in children by its high water absorption property which can dehydrate the infant.

The highest fibre content are realised with products which have high amount of cowpea. Cowpea has high fibre content.

Roasted corn at different roasting times showed different fibre content. Fibre content increase with increasing roasting time. The highest fibre content is found in product made up of sprouted corn and cowpea flour (steamed) and the lowest is found in corn dough (fermented) blend. The microorganisms associated with fermentation might have had ability to digest the cell wall components to monosaccheride, dissaccharides, oligosaccharides etc. The highest crude fibre from sprouted corn and cowpea blend may be due to high cowpea in the blend and also inability of the enzymes (x-B-amyloses) to breakdown the (1 4) linkages in the cellulose while starch was broken down into lower molecular components. This action increases the fibre since it become imminent.

4:2 FUNCTIONAL PROPERTIES OF BLEND

4:2,1 Water absorption of Blends

The result is tabulated on Table 5.

Holmes et al (1982) reported that the type of heat treatment and duration significantly influence percentage water absorption. Sefa-Dedeh and Fakye (1988) also reported that proteins are the primary sites of water absorption. Philips et al (1988) working on the effect of pretreatment on functional and nutritional properties of cowpea meal reported that water absorption increase with mild heat treatment and then decline as heat become severe.

Narayana and Narasinga (1982) also reported that carbohydrates play important role in water absorption.

The water absorption produced interesting results. All the blends showed high water absorption. The lowest water absorbed is about 436.7%. The high water absorption of all the blends is due to the heat treatment (drum dryer gelatinization and drying). Meyer and Benfeld cited by Meyer (1964) said that corn starch at 60°C takes up 300% water, 1000% at 70°C. Hence the high water absorption of the products is significant.

Generally the water absorbed at 70°C is higher thant that at 29°C apart from corn dough (fermented) steamed cowpea flour and steamed groundnut blend. The decline in water absorption of this blend at 70°C is due to increase heat treatment at 70°C. The heat introduced by drum dryer might be enough to increase water absorption and as the heat becomes severe, water absorption decreases. The starch granules might have expanded to their limit hence take less water. There is lesser water binding sites of carbohydrates for water.

At 29°C, the blends containing roasted corn at different roasting times showed interesting results. As roasting time increase from 10 minutes to 15 minutes, the water absorbed increased, but declined considerably at 25 minutes roasting time. This observation can be due to the fact that w water absorption increases with increase mild heat but decline with severe heat treatment. Hence the 25 minutes roasting time might have made conditions unfavourable for water absorption.

At 70°C the water absorption of the blends containing roasted corn at different roasting times showed decrease water absorption as roasting time increases. It is possible that the decrease in water absorption capacity with increasing roasting time of the corn can be attributed to increase utilisation of the water binding site in protein which are polar amino acids in maillard reactions. The polar amino acids such as lysine are involed in carbonyl-amino condensation reaction leading to the formation of brown pigment, hence lesser binding sites for water on the protein.

The blends containing sprouted corn and cowpea flour (steamed) and sprouted corn, cowpea flour and steamed groundnut showed difference in water absorption. It is known that fats and surfactants slow down water

WATER ABSORPTION OF PRODUCTS AT 29°C AND 70°C

TABLE 5

PRODUCTS	WATER ABSORBED g/100g SAMPLE 29°C	70°C
Roasted : Roasted : Cowpea flour Corn Groundnut (steamed) (10 minutes)	460.0	528.0
Roasted : Roasted : Cowpea flour Corn (15 Groundnut (steamed) minutes)	476.1	484.0
Roasted : Roasted : Cowpea flour Corn (25 Groundnut (Steamed) minutes)	436.7	466.3
Sprouted : Cowpea flour Corn (Steamed)	516.0	536.2
Sprouted : Steamed : Cowpea flour Corn Groundnut (Steamed)	460.8	504.6
Roasted : Roasted : Roasted Corn (15 Groundnut Cowpea minutes)	488.5	520.0
Corn dough : Sprouted : Cowpea flour (fermented) corn (steamed)	508.3	520.4
Corn dough : Steamed : Cowpea flour (fermented) Groundnut (Steamed)	568.4	556.0

Student T-test	Tabulated Value	Experimental Value
Water absorption of products at 29°C and 70°C	1.895	2.9155

* The tabulated value is given at 5% level ($t_{0.05,7}$)

uptake hence the high fat content of the groundnut contributed to its low water uptake. The high protein and low fat in cowpea contributed to the high water absorption of the blend containing sprouted corn and cowpea.

Generally, from the results it can be said that high degree of fat component and high roasting time and enzyme activity in sprouted corn as well as microbial action on corn dough significantly affect water absorption characteristics.

Comparing the water absorption of the products to similar blends formulated but not pre-gelatinized done by Ampadu (1989), the products whicch are pre-gelatinized showed water absorption 4 times (about 25%) that of the non-gelatinized blends. This shows that the pre-gelatinization increased the water absorption capacity of the blends. This is significant with what Philips et al 1988 reported that increase in mild heat treatment increases the water absorption capacity of products.

The student T-test conducted on the water absorption at 29 °C and 70°C shows that there is significant difference in water absorption at the two temperatures. The T-test is at 5% level. However, at 1% level, the T-test was tabulated value was 2.998 while calculated was 2.9155. Therefore at 1% level, there is no difference in absorption at 29 °C and 70 °C.

2,2 SWELLING PROPERTIES OF BLENDS

Data on swelling is on Table 6.

Swelling is due to the expansion of the cells upon imbibing water i.e. the molecules of solvent enter the substance which is swelling causing solvation of the macro-molecule and in addition occupying the read capillary space and intermolecular spaces of the molecule (Sefa-Dedeh, 1978 cited by Ampadu 1989).

Fig 1

SWELLING OF ROASTED CORN (10, 15, 25 minutes), ROASTED GROUNDNUT AND STEAMED COWPEA FLOUR AT 290C

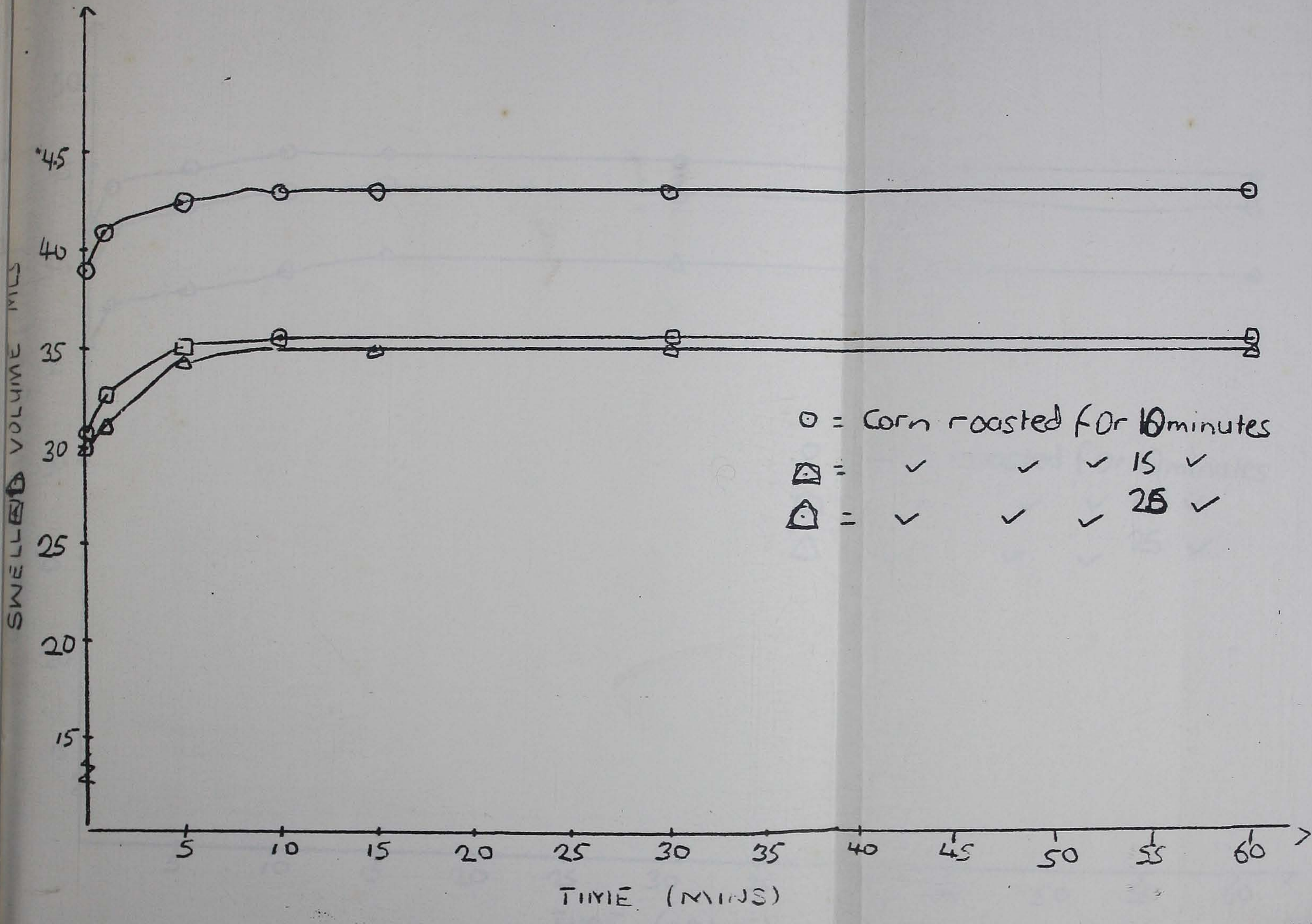
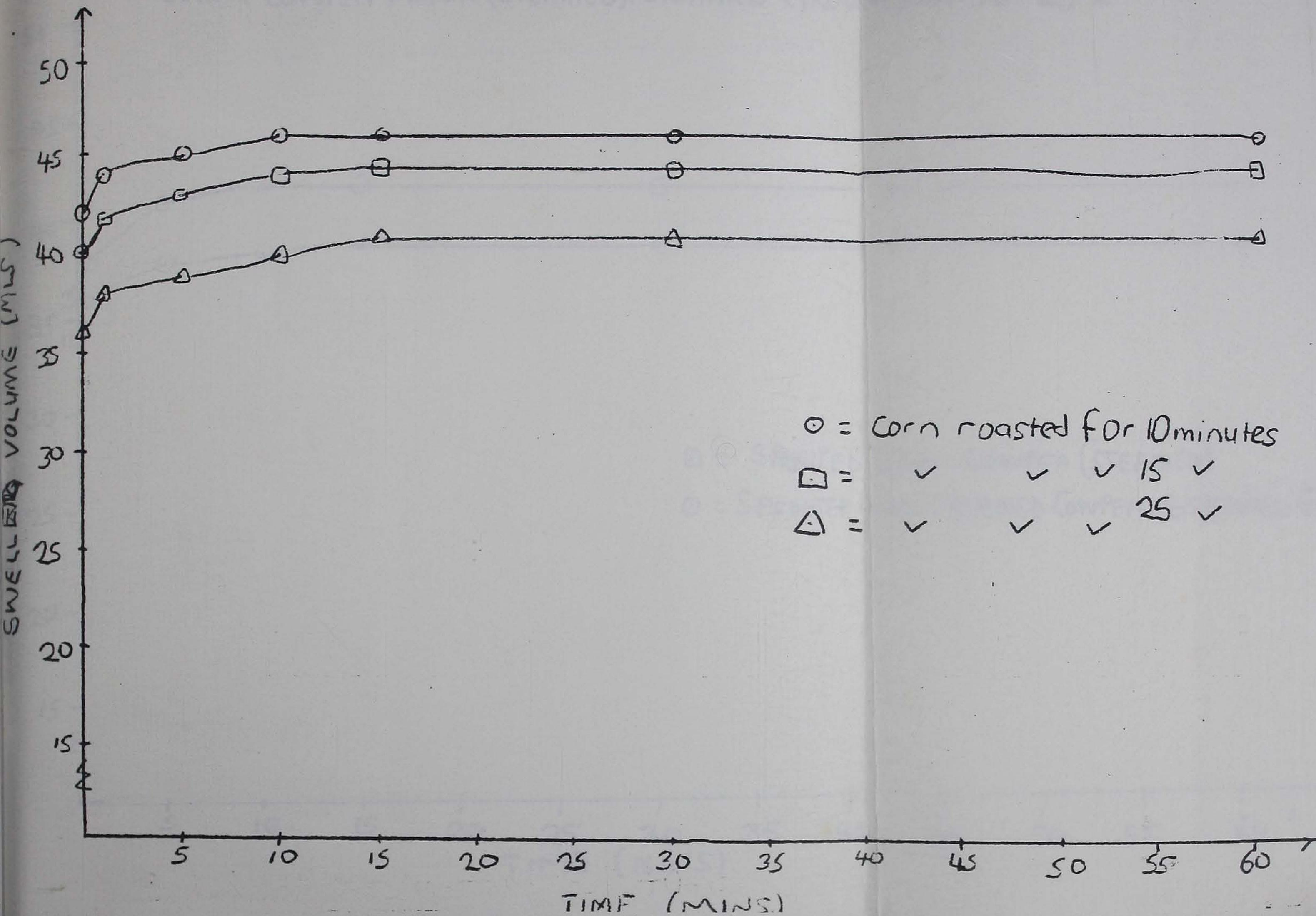


Fig 2

SWELLING OF ROASTED CORN (10, 15, 25 minutes), ROASTED GROUNDNUT AND STEAMED COWPEA FLOUR AT 70°C



SWELLING OF SPROUTED CORN: COWPEA FLOUR (STEAMED) AND SPROUTED CORN: COWPEA FLOUR (STEAMED): STEAMED GROUNDNUT AT 29°C

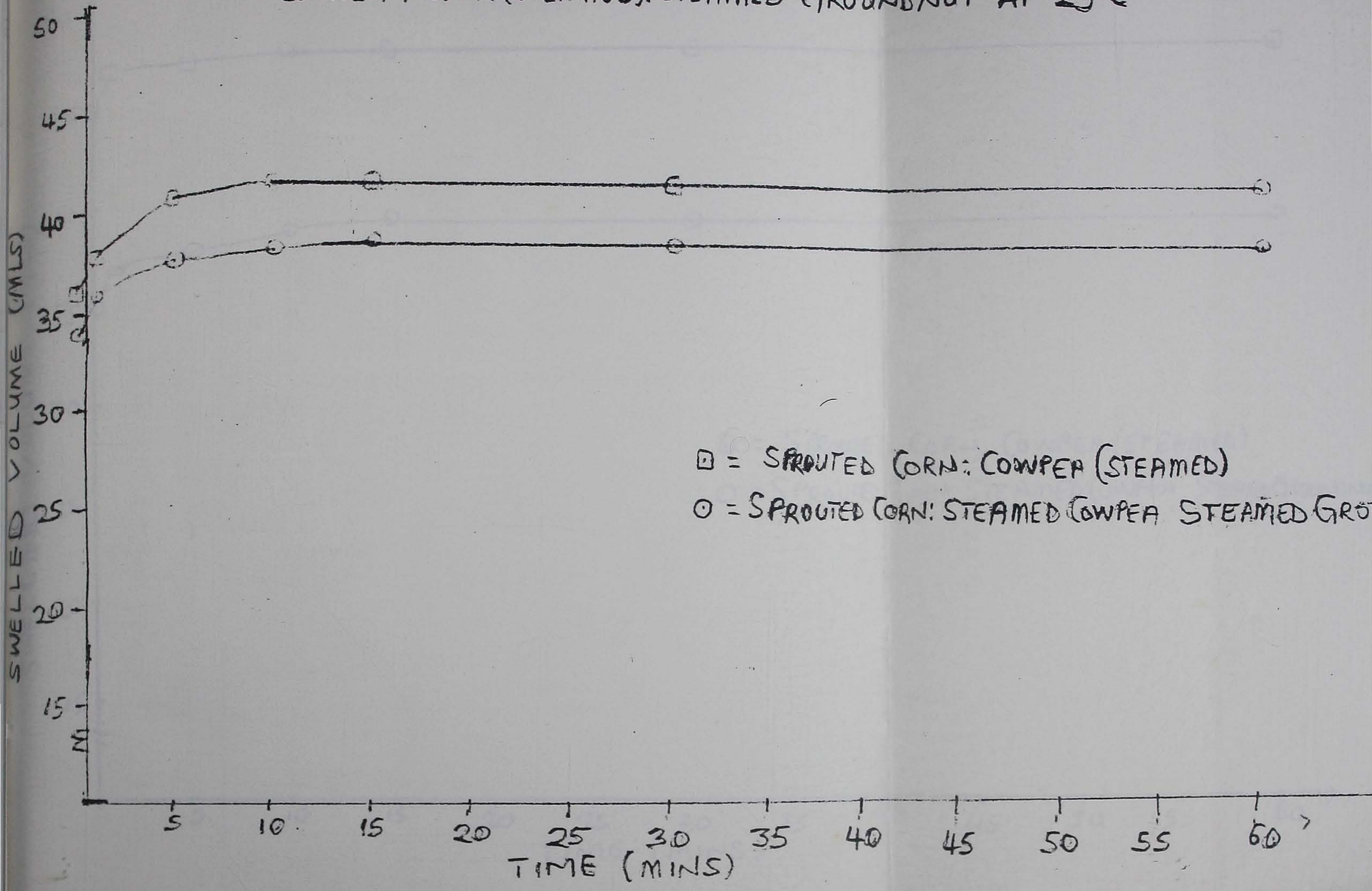
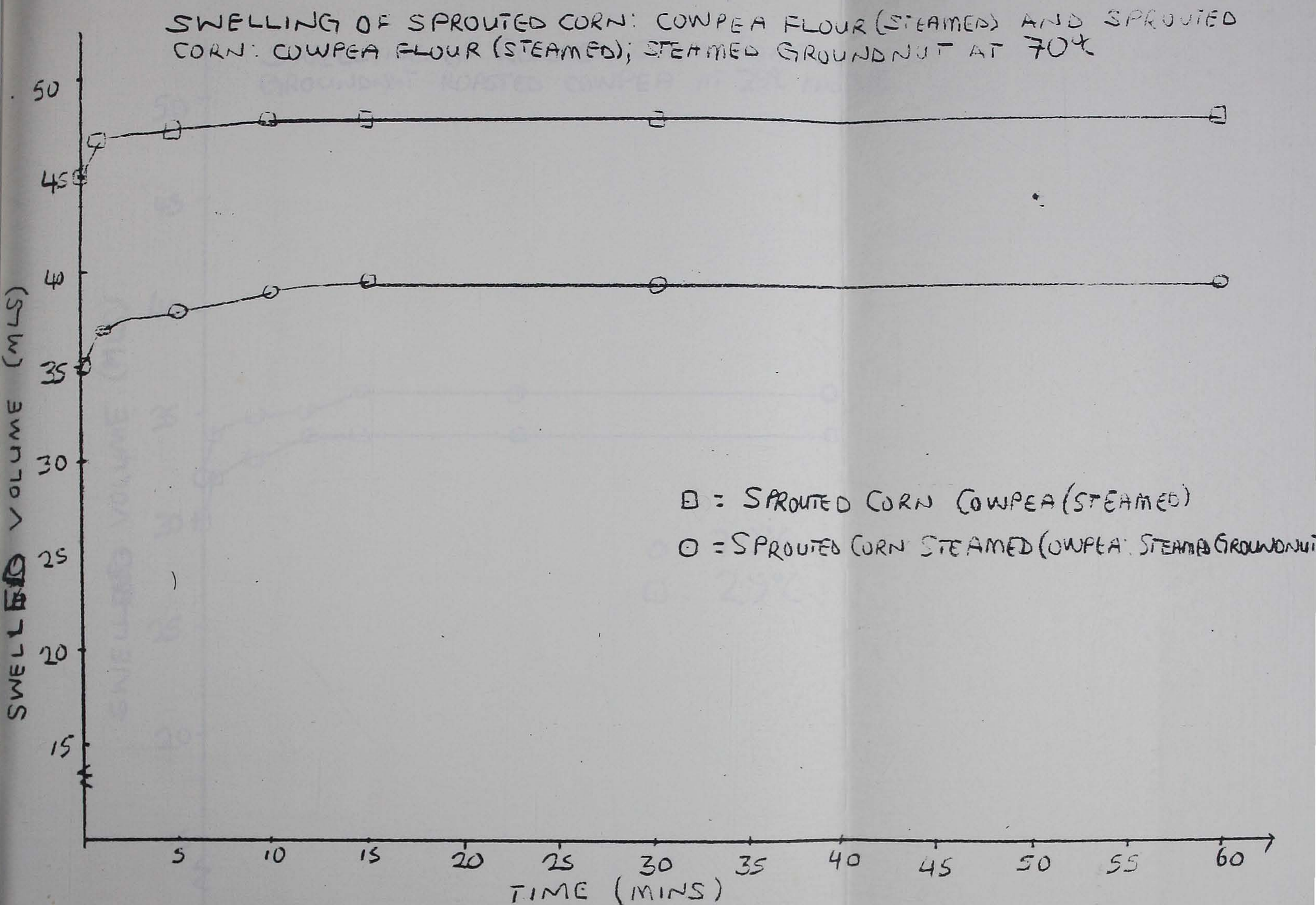
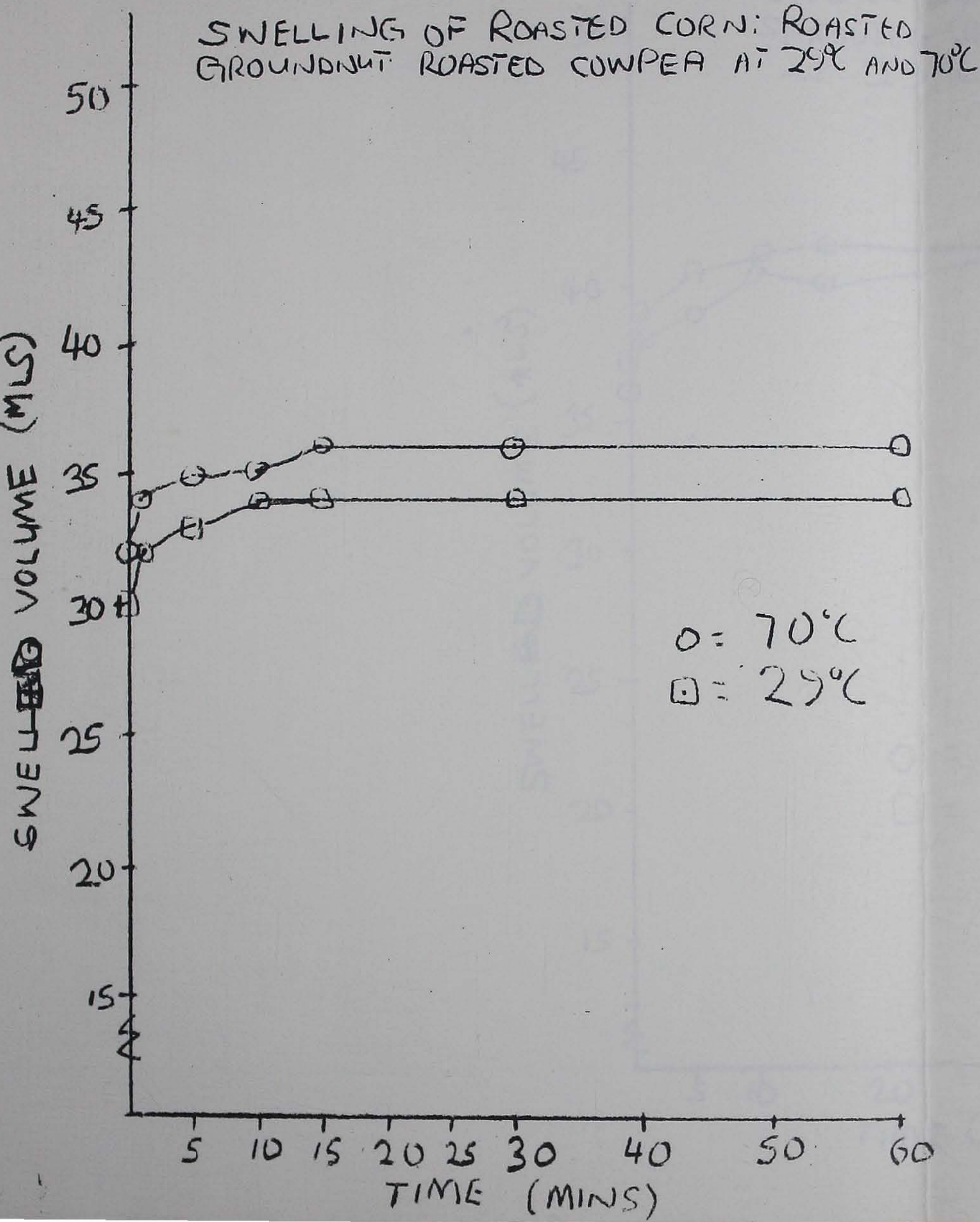


Fig 7



SWELLING OF SPROUTED CORN: COWPEA FLOUR (STEAMED) AND SPROUTED CORN: COWPEA FLOUR (STEAMED); STEAMED GROUNDNUT AT 70%
SWELLED VOLUME (MLS)
TIME (MINS)
50
45
40
35
30
25
20
15
5
10
15
20
25
30
35
40
45
50
55
60
□ = SPROUTED CORN COWPEA (STEAMED)
O = SPROUTED CORN STEAMED COWPEA: STEAMED GROUNDNUT


SWELLING OF ROASTED CORN: ROASTED GROUNDNUT ROASTED COWPEA AT 29°C AND 70°C
50
45
40
35
30
25
20
15
SWELLED VOLUME (MLS)
5
10
15
20
25
30
40
50
60
TIME (MINS)
O = 70°C
⊡ = 29°C

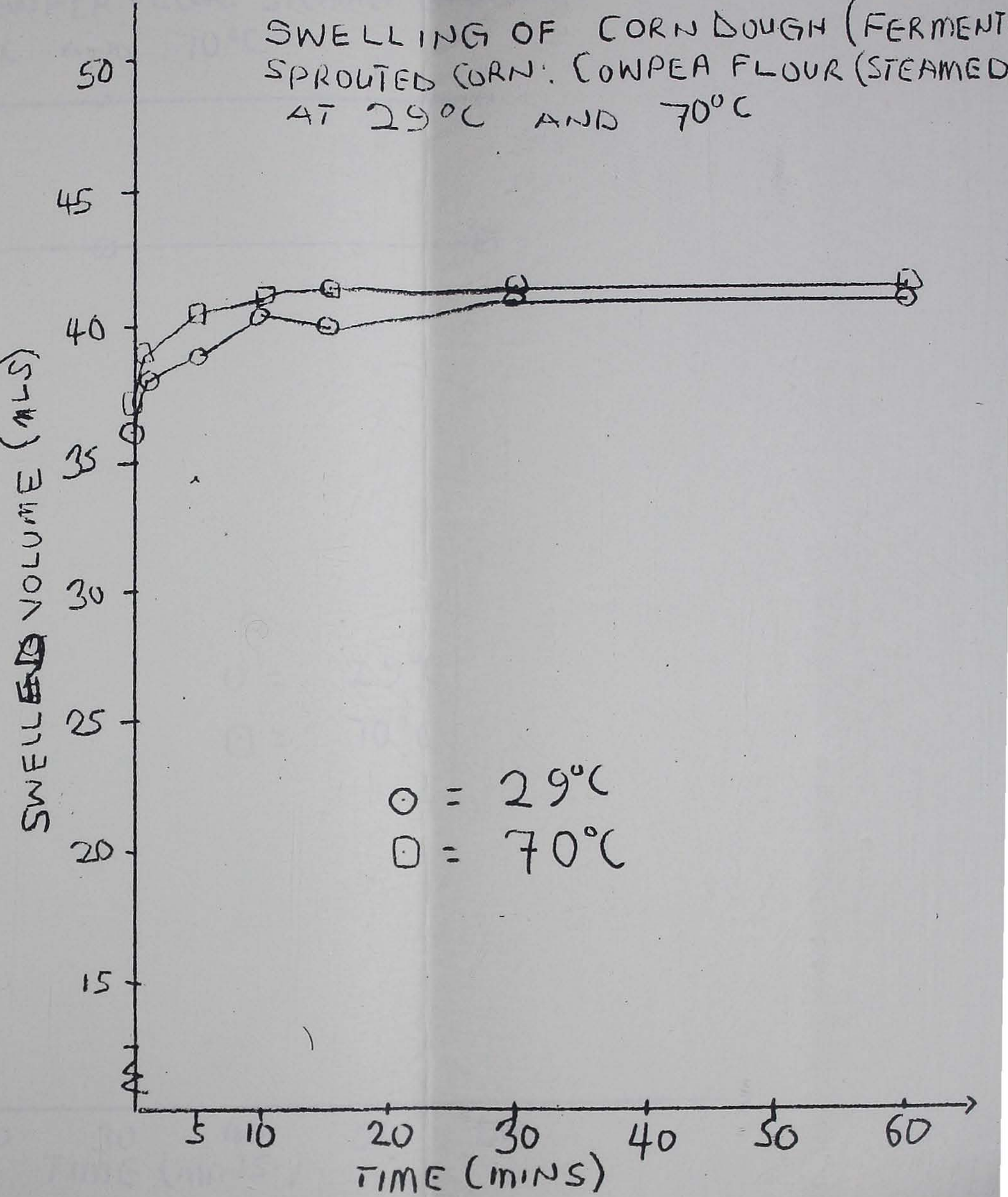
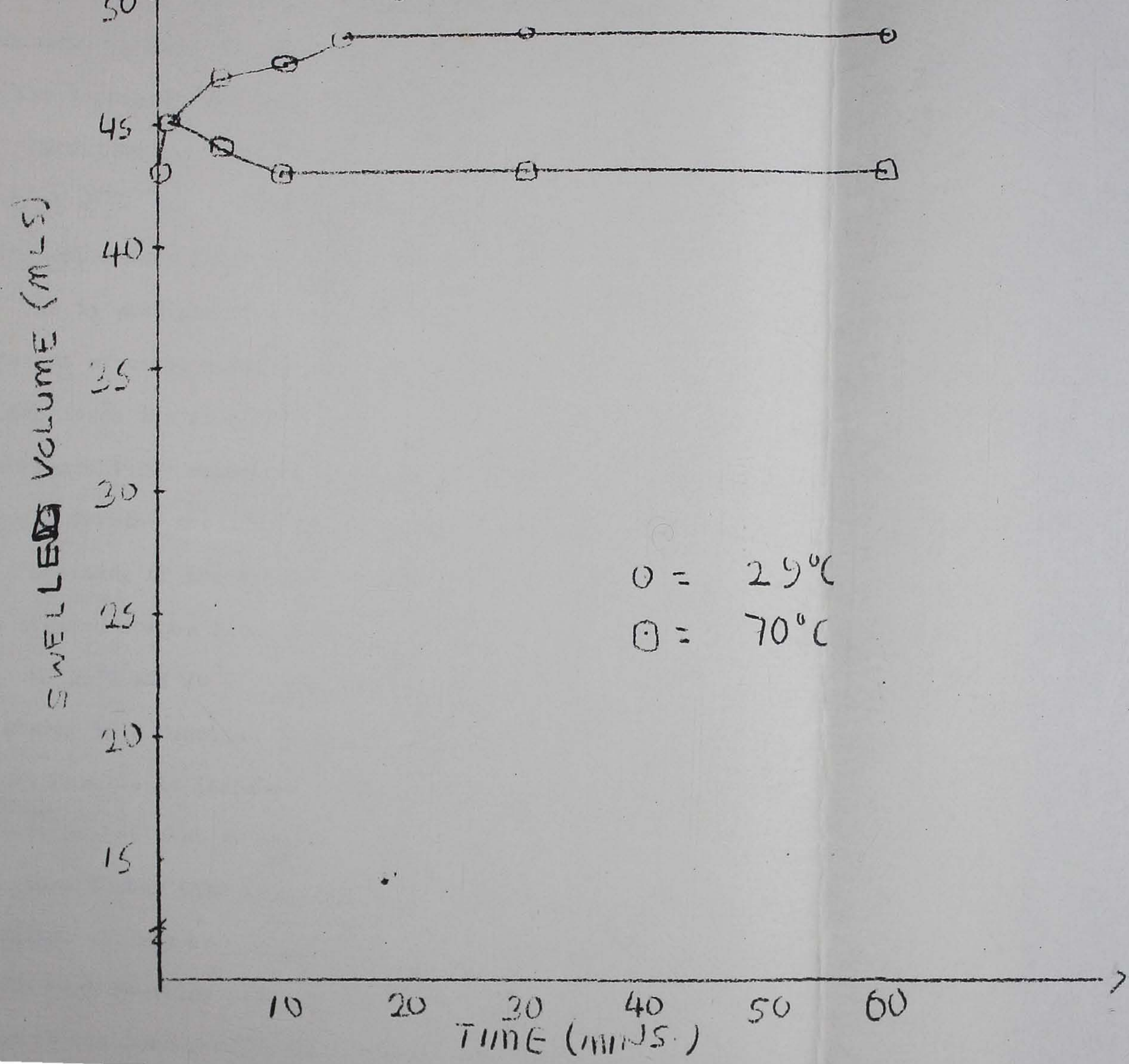

SWELLING OF CORN DOUGH (FERMENT
SPROUTED CORN: COWPEA FLOUR (STEAMED
AT 29°C AND 70°C
SWELLED VOLUME (MLS)
50
45
40
35
30
25
20
15
5
10
20
30
40
50
60
TIME (MINS)
⊙ = 29°C
⊡ = 70°C

Fig 7

SWELLING OF CORN DOUGH (FERMENTED): STEAMED COWPEA FLOUR: STEAMED GROUNDNUT AT 29°C AND 70°C



In exception of corn dough (fermented) cowpea flour and steamed groundnut blends, the swelling at 70°C is more than at 29 °C. This is due to the increased swelling of the starch granules.

Swelling was also found to be higher for each of the blends at 70°C than at 29 °C due to increase in imbibition of water by the starch granules with temperature (Deghpande, 1982).

It is also generally observed that swelling of the blends remained constant after 10 minutes at both 29 °C and 70°C. At high temperatures starch loses its glandular stfucture faster than would raw starch (Deshpande 1982) resulting in lessened swelling capacity. This can account for the swelling of the blends remaining constant after 10 minutes.

Swelling of the blends containing roasted corn, roasted groundnut and steamed cowpea flour decrease as the roasting time of the corn increases at both 29°C and 70°C. Deshpande et al 1982 reported that swelling capacity of starch is a function of modification proceeding such treatment. This effect results in increase in swelling characteristics of the starch, but he also stated that at high temperatures, starch loses its glandular structure foster than would raw starch resulting in lessened swelling capacity. It may be possible that this effect may have been facilitated by the high roasting time treatment as well as high temperature drum drying given to the corn leading to decreased swelling. However the increase swelling of the blends at 70°C than 29 °C may be due to increase imbibition of water by the starch granules with increase temperature.

For the blends containing sprouted corn, it has been observed that the blend containing sprouted corn and cowpea flour (steamed) has higher swelling capacity both at 29°C and 70°C than the blend containing sprouted

TABLE 6a

SWELLING : AT 29 °C

PRODUCTS	BULK VOLUME (cm^3)	TIME 0 MINS.	1	5	10	15	30	60
Roasted Corn (10 minutes) : Roasted Groundnut : Cowpea flour (Steamed)	15.0	39.0	41.0	42.5	43.0	43.0	43.0	43.0
Roasted Corn (15 minutes) : Roasted Groundnut : Cowpea flour (Steamed)	15.0	30.5	32.5	35.0	35.5	35.5	35.0	35.5
Roasted Corn (120 minutes) : Roasted Groundnut : Cowpea flour (Steamed)	13.5	30.0	32.0	34.5	35.0	35.0	35.0	35.0
Sprouted Corn : Cowpea flour (Steamed)	14.0	36.0	38.0	41.0	42.0	42.0	42.0	42.0
Sprouted Corn : Steamed Groundnut : Cowpea flour (Steamed)	12.5	34.0	36.0	38.0	38.5	39.0	39.0	39.0
Roasted Corn (10 mins. : Roasted Groundnut : Roasted Cowpea	14.0	30.0	32.0	33.0	34.0	34.0	34.0	34.0
Corn dough (fermented) : Sprounted Corn : Cowpea flour (Setemed)	14.0	36.0	38.0	39.0	40.5	4.0	41.0	41.0
Corn dough (fermented) : steamed Groundnut : Cowpea flour (Steamed)	17.5	43.0	45.0	47.0	47.0	48.0	58.0	48.0

SWELLING AT 70^{o}C

TABLE 6b

PRODUCTS	BULK VOLUME (cm^3)	TIME 0 MINS.	1	5	10	15	30	60
Roasted : Roasted : Cowpea flour Corn(10 minutes) Groundnut (Steamed)	17.0	42.0	44.0	45.0	46.0	4.0	46.0	46.0
Roasted : Roasted : Cowpea flour corn(10 minutes) Groundnut (Steamed)	17.0	40.0	42.0	43.0	44.0	44.5	44.5	44.5
Roasted : Roasted : Cowpea flour Corn(15 minutes) Groundnut (Steamed)	17.0	36.0	38.0	38.5	40.0	41.0	41.0	41.0
Sporuted : Cowpea flour Corn (Steamed)	16.0	45.0	47.0	47.5	48.0	48.9	48.0	48.0
Sprouted : Steamed : Cowpea flour Corn Groundnut (Steamed)	12.5	35.0	37.0	38.5	39	39.5	39.5	39.5
Roasted : Roasted : Roasted Corn(10 minuties) Groundnut Cowpea	14.0	32.0	34.0	35.0	35.0	36.0	36.0	36.0
Corn dough : Sprouted : Cowpea flour (fermented) Corn (steamed)	13.0	37.0	39.0	40.5	41.0	41.5	41.5	41.5
Corn dough : Steamed : Cowpea flour (fermented) Groundnut (steamed)	16.5	43.0	45.0	44.0	43.0	43.0	43.0	43.0

corn, cowpea flour and steamed groundnut. This difference is due to groundnut which has high fat. Fats and surfactants are known to slow down the uptake of water by starches. Fats and fatty acids are known to affect gelatinization of starch. Heckman 1977 (cited by Deshpande 1982) reported that slow rate of water penetration into starch granule may be due to the formation of a fatty layer around the starch granule leading to the formation of amylose-fatty acid complex which is insoluble and restrict swelling of starch by stabilizing the granule structure. This may account for the low swelling of sprouted corn, steamed cowpea and steamed groundnut.

The swelling of the blend containing roasted corn, roasted groundnut and roasted cowpea is lower than that of roasted corn at 10 minutes, roasted groundnut and steamed cowpea. Here the cowpea is roasted. The roasting of the cowpea may have resulted in decrease swelling of this blend. The cowep cowpea starch might have lost its glandular structure than the raw starch in steamed cowpea. Increase imbibition of water by the starch granules may account for the increase swelling at 70°C than 29°C for this blend. The high heat treatment by using drum dryer may further account for the less swelling of the blend.

It is interesting that the swelling of the blend containing corn dough (fermented), cowpea flour and steamed groundnut has it swelling at 29°C higher than at 70°C. The microbial action on starch during fermentation results in formation of certain compounds as carboxylic acids. There is also lowering of pH usually below 4.0 for 36 hours fermentation. These can expose the starch granules and they can readily be affected by heat. Deshpande (1982) reported that at high temperatures, starch loses its glandular.structure resulting in lessened swelling capacity. This may probably account for the slow swelling capacity of corn dough, steamed cowpea and steamed groundnut blend at 70°C than at 29°C. At 29°C the modification by the drum dryer might have favoured the water imbibition capacity of the starch. Further modification of the starch by heat treatment at 70°C results in the loss of glandular structure of the starch. This is significant becuase when we take a close look at the swelling curve at 70°C, it increases initially and started decreasing. The decreacing swelling time is when the starch lost its glandular structure.

Generally, the blend containing corn dough, steamed cowpea and strea steamed groundnut has the highest swelling capacity. This can be due to the favourable modification of the starch granules during the drum drying. The lowest swelling was observed in blend containing roasted corn roasted groundnut and roasted cowpea.

4.3 PASTING PROPERTIES OF BLENDS

The result is given in Table 7.

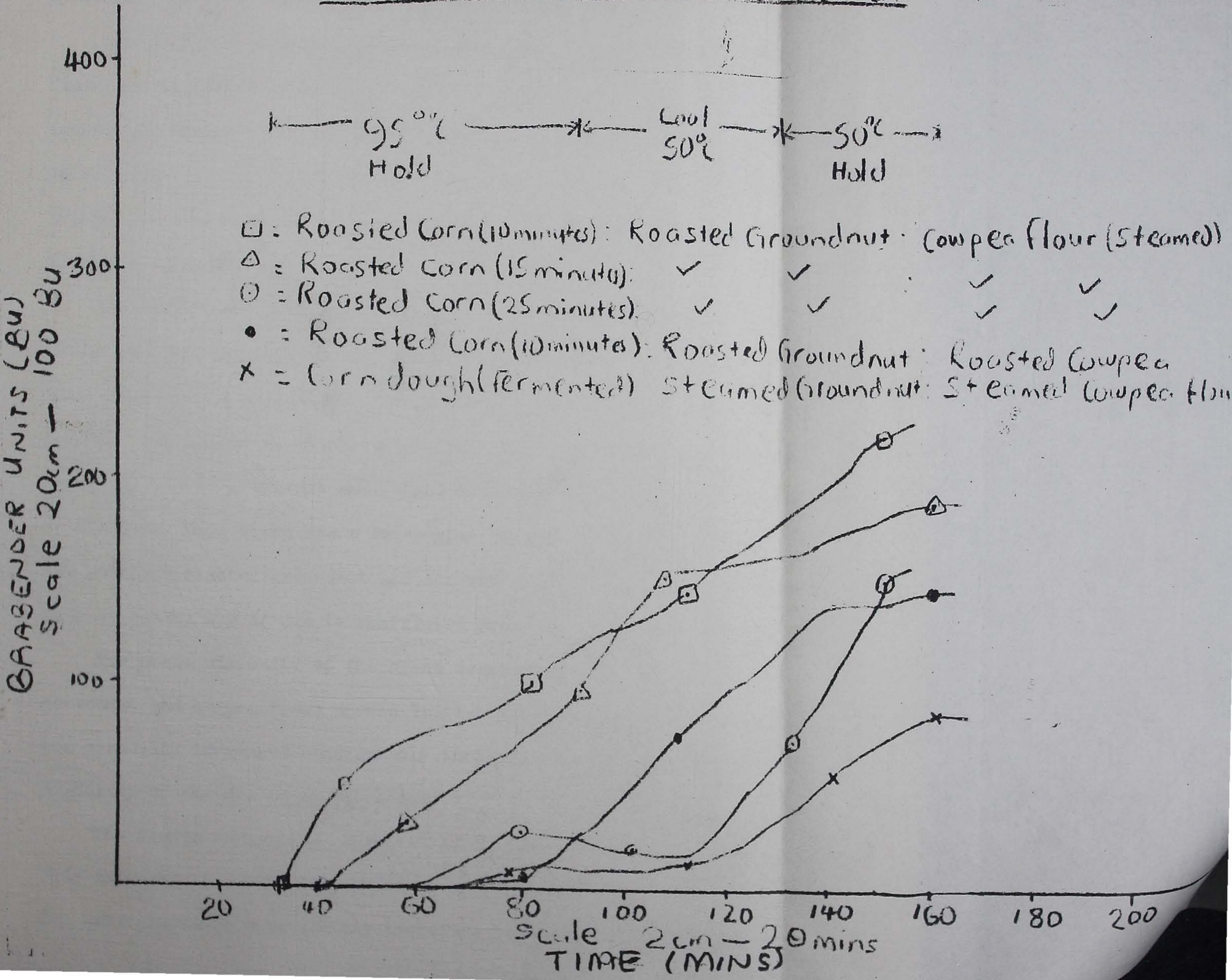
The data on amylograph shows considerable increase in viscocity during cooling. It shows that the starch granules have ability to associate when cooled.

Blends containing roasted corn, roasted groundnut and cowpea flour (steamed) show considerable decrease in initial pasting temperature with increasing temperature. This is due to delay in beginning of swelling due to changes caused by the roasting. There is restricted swelling characteristic of roasting corn for a long time (cited by Ampadu, 1989). The restricted swelling may in turn decrease the ease of cooking.

One of the indices of amylograph is the maximum peak viscosity. The

Fig 8

AMYLOGRAPH CHARACTERISTICS



highest peak viscosity was recorded with the blend containing roasted corn at 10 minutes. Increasing the roasting time to 15 minutes decreased the viscosity by 50 Brabender units. Further increase in roasting time to 25 minutes decreased the peak viscosity by 70 Brabender units.

The peak viscosity is an important characteristic of any starch or flour and is concentration dependent. The viscosity at a particular concentration reflects the ability of the starch granule to swell freely before physical breakdown. When the starch solution is cooled, the viscosity showed a considerable increase indicating a tendency toward association of starch molcules.

The blend containing roasted corn (10 minutes) roasted groundnut and roasted cowpea had the highest intial paste viscosity of 93°C. Like the other blends, its viscosity increased moderately throughout the cooking period. This blend is identical to the blend containing roasted corn (10 minutes) roasted groundnut and cowpea flour steamed excppt that the cowpea is roasted. This blend has a lower peak viscosity than the roasted corn (10 minutes) roasted groundnut and steamed cowpea flour. The decrease in peak viscosity may be due to restricted swelling of roasted cowpea.

The paste viscosity of the blend containing corn dough, steamed groundnut and cowpea flour showed initial pasting temperature of 85°C. Its viscosity increased considerably throughout the period indicating the stability of the starch in the blend.

The blends containing sprouted corn showed no viscosity rise or increase. This is probably due to the action of x- and B-amylases in the corn malt. The zero viscosity observed may therefore be due to the action of

PASTING PROPERTIES OF BLENDS

AMYLOGRAPH SENSITIVITY CATRIDGE = 500cmg

composition of slurry = 12%

TABLE 7

BLENDS	PASTE TEMP. °C	PEAK	95°C	95°C HOLD	50°C	50°C HOLD
Roasted Corn : Roasted : Cowpea Flour (10 minutes) Groundnut (Steamed)	78	220	50	100	150	220
Roasted Corn : Roasted : Cowpea flour (15 minutes) Groundnut (Steamed)	82	170	30	90	160	170
Roasted Corn : Roasted : Cowpea flour (25 minutes) Groundnut (Steamed)	92	150	0	30	10	150
Sprouted : Cowpea Corn flour	0	0	0	0	0	0
Sprouted : Steamed : Cowpea flour Corn Groundnut (Steamed)	0	0	0	0	0	0
Corn dough : Sprouted : Cowpea flour (Fermented) Corn (Steamed)	0	0	0	0	0	0
Corn dough : Steamed : Cowpea flour (Fermented) : Groundnut (Steamed)	85	70	0	10	30	70
Roasted Corn : Roasted: Roasted (10 minutes) Groundnut Cowpea	93	140	0	20	40	140

these enzymes which hydrolyse the starch during cooking to dextrin and sugar resulting in less swelling. In view of this, if a product which thickens upon cooking is desired, one will need to use a minimum of 12% slurry composition. The energy density is therefore increased as a result of reduction in bulk density.

Through the action of x- and B-amylases, the starch in sprouted corn was broken down to maltose, dextrin and other oligosoccharides. Through their superior water binding capacity sugars preferentially tie up H_2O molecules and withhold them from starch. Presence of sugar therefore inhibit binding of water by starch hence prevent gelatinization (Meyer 1974).

4:4 SUMMARY OF RESULTS ON SENSORY EVALUATION ~~TASTE~~

Table 8: ANOVA SUMMARY TABLE FOR TASTE

Source of Variation	df	ss	ms	F-value	F-tab.
Panelists	9	42.75	4.75	1.696	2.10
Treatments	2	14.475	7.24	2.59	3.75
Error	68	190.78	2.8		
Total	79	248			

F-tabulated value at 5% level of significance

COLOUR

Table 9: ANOVA SUMMARY TABLE FOR COLOUR

Source of Variation	df	ss	ms	f-value	F-tab.
Panelists	9	15.7625	1.7514	0.6680	2.10
Treatments	2	13.3375	6.6687	2.5435	3.75
Error	68	178.2875	2.6219		
Total	79	207.3875			

FLAVOUR

Table 10: ANOVA SUMMARY TABLE FOR FLAVOUR

Source of Variation	df	ss	ms	F-value	F-tab
Panelists	9	21.1125	2.3458	0.7390	2.10
Treatments	2	4.5375	2.2687	0.7147	3.75
Error	68	215.8375	3.1741		
Total	79	241.4875			

CONSISTENCY

Table 11: ANOVA SUMMARY TABLE FOR CONSISTENCY

Source of Variation	df	ss	ms	F-value	F-tab
Panelists	9	36.8625	3.9847	1.4292	2.10
Treatments	2	25.0375	12.5187	4.4902	3.75
Error	68	189.5875	2.7880		
Total	79	250.4875			

F-tabulated value of 5% level of significance.

GENERAL ACCEPTABILITY

Table 12: ANOVA SUMMARY TABEL FOR GENERAL ACCEPTABILITY

Source of Variation	df	ss	ms	F-value	F-tab
Panelists	9	50.7	5.6333	2.130	2.10
Treatments	2	11.425	5.7125	2.1601	3.75
Error	68	179.825	2.6445		
Total	79	241.95			

F-tabulated value of 5% level of significance

Refer to raw data on appendix 2 to 6.

4:4,1 DISCUSSION ON SENSORY EVALUATION

TASTE

ANOVA summary for taste is given on table 8. The F-value tabulated is higher than the calculated value which shows that there is no difference in the panelists acceptability of the product. The F-values for treatment also showed that there is no significant difference in the treatment given to the products to affect the taste. This is expected since all the products were swwetened with sugar before presented to the paneliists. All the products were fairly accepted and the product containing sprouted corn, steamed cowpea and steamed groundnut was best accepted.

COLOUR

Results presented on Table 9.

Colour is an index in acceptance of products. Some of our weaning foods have different colours. For example 'tombrown' is brown in colour while 'koko' or 'akasa' is white in appearance. Hence it is significant that the panelists did not show any difference since they all exposed colours of the products. Treatments given to the products also did not show any variation in colour acceptability. Sprouted corn, corn dough (fermented), steamed cowpea flour product was highly accepted in terms of colour.

FLAVOUR

The results are in Table 9. The ANOVA summary shows that, there is no variation in neither panelists nor treatments given to the products in terms of flavour. This can be explained that, the panelists consume fermented, malted and roasting foods. The roasted foods consumed are roasted groundnut and maize hence they are used to the flavour. Fermented foods consumed included Kenkey, 'koko', Fante Kenkey etc. Therefore the consumers are used to the flavour of these treatments given to the products. This is also in line with the aim of the project i.e. to develop product not quite different from what is locally consumed. In terms of flavour the roasted corn (25 minutes), roasted groundnut, steamed cowpea flour was highly accepted. The acceptability can be due to changes occuring to develop flavour.

CONSISTENCY

The ANOVA summary on consistency is given on Table 10. The analysis shows that there is significant difference in the treatment given to the products. The panelists did not show any significant difference at 5% level. When least significance difference tests (LSD) was conducted, it showed that the difference between sprouted corn and roasted was not significant. Also the difference between fermented corn dough and roasted corn was not significant at all to affect consistency. However, the difference between sprouted corn and fermented corn dough was found to be significant. This difference is expected because the microorganisms acting on corn dough make the nutrients more available and the starch when cooked, gelled. The sprouted corn had x- and B-amyloses acting on the starch to low molecular weight compounds e.g. maltose, dextrin etc. These compounds do not absorp much water hence reduce bulk. The fermented dough however absorbs a lot of water. Hence the consistency was not expected to be the same. This is in line with the comment one of the panelists made that "some of the products are too watery hence made them unattractive". This shows that the consistencies were not the same for all products though the same amount of water was added to them. Fermented corn dough, steamed cowpea and steamed groundnut product was however the most accepted product in terms of consistency.

GENERAL ACCEPTABILTY

The ANOVA summary is presented on Table 11. Itt shows that all the products were accepted by the panelists. The panelists did not show any significant difference in general acceptability of the products. The treatmant given to the products also did not affect the overall acceptability of the products to any appreciable extent. The highly acceptability of these products will make them good weaning foods. But it must be stated here that, all the potential consumers were represented during the sensory evaluation. Most of them are not potential consumers of x weaning foods

Therefore the highly acceptability of these products shown by the panelists does not guarantee the product to be highly marketable. It is possible that the panelist belong to certain community who like the type of treatments given to the products. The product containing sprouted corn, steamed cowpea, steamed groundut was the most acceptable product.

CONCLUSION

Chemical and functional properties of the cereal-legume products showed that, pretreatments of the corn, cowpea and groundnut prior to blending significantly influence the properties of the products. Processing treatments such as roasting, sprouting, fermentation, steaming and drum drying greatly determined the moisture, protein, fat, calcium and Crude fibre contents of the products. The products generally have high protein and fat content and hence qualified to be used as weaning food. The drum drying af the pre-gelatinized products makes the products more convenient for ignorant mothers especially illiterate mothers and those who are always occupied with their daily business and don't have time to cook for their infants. These products can be used to alleviate some of the protein-energy nutrition problems facing some communities.

The moisture content of the blends was generally low due to the use of drum drier. This indicates that the products have good storage stability when packaged properly. Lower moisture was observed in product containing fermented corn dough. Increasing roasting time decrease moisture content of the products. 5 sprouted corn products showed higher moisture content.

Water observation was found to be higher at 70°C than at 29°C except product containing fermented corn dough. The observed decrease in water absorption of the corn dough product at 70°C was due to damage of the starch granules due to the high heat treatment of the drum drier. This product therefore can be best used with cold water. The water absorption of the roasted blends decreased with increasing roasting time. Swelling of the products was higher at 70°C than 29 °C except corn dough products. This decreased in swelling was due to damage to the starch grains. However, the corn dough product showed highest swelling capacity at 29 °C due to favourable changes induced on the starch granules. The swelling of roasted corn products decreases with increasing time of roasting. The sprouted corn, cowpea flour product show the highest swelling at 70°C. In general the products swelled moderately. As a weaning food, high swelling will lead to thick viscosity of products hence less will be consumed at a meal.

Cooked paste viscosity characteristics shows that increasing roasting time of corn in the blend may increase the pasting temperature and decrease peak viscosity. No viscosity change during cooking was formed in products containing sprouted corn. This is possibly due to amylose activity on starch. This shows that germinated grains can decrease the bulkiness of weaning food. By adding germinated cereal flour to gruels or porridges prepared from ungerminated at suitable temperature, mothers can attain liquid and semi-liquid or free flouring consistencies adequate for feeding their infants. The energy density may also increase by such application. Nutrients are also concentrated and made available when germinated seeds are used.

The calcium content of the products is very low compared to the recommended daily allowance issued by FAO/WHO. The products therefore needs calcium substitution. Fish with bones can be used to fortify the products to raise their calcium level. Also prior to drum drying, $CaCO_3$ can be added to increase the calcium content.

The fibre content of the products are generally low hence will not interfere with the absorption of the nutrients.

From the sensory evaluation, all the products were highly accepted in terms of colour, flavour, taste and general acceptability. The consistency of the products only showed variations and this was expected. With the variations in consistency the products can serve different purposes as weaning food.

RECOMMENDATIONS

1. The weaning foods prepared should be fed to laboratory animals to determine the biological value of the products.
2. Nutritional evaluation of the products to determine amino acid composition and digestibility since the heat treatment by drum drying is high to deplete some essential amino acids. Therefore available lysine should be determined on the products.
3. Studies on trypson inhibitor activity in the cowpea and aflatoxin in the groundnuts before processing and after drum drying.
4. Supplementation of the products with high calcium product is recommended.

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APPENDIX I

QUESTIONNAIRE FOR HEDONIC SCALE

Name: .... Date ....

Evaluate these food samples for colour, flavour, taste, consistency and general acceptability using Hedonic scale on the terms provided. Use the codes on the samples for the evaluation.

	Colour	Flavour	Consistency	Taste	General Acceptability
Like extremely					
Like very much					
Like much					
Like moderately					
Neither like nor dislike					
Dislike moderately					
Dislike much					
Dislike extremely					

Comments ....

....

....

....

....

APPENDIX 2

COLOUR PANELISTS/SCORE

SAMPLE	1	2	3	4	5	6	7	8	9	10	Total
A	7	5	6	7	4	6	5	4	9	7	60
B	5	6	5	9	6	8	4	6	6	4	59
C	6	4	5	7	9	5	4	5	8	6	59
D	5	5	6	2	6	8	5	4	6	5	52
E	5	7	4	5	5	7	6	5	4	5	53
F	4	7	3	6	8	5	3	3	7	6	52
G	9	8	7	3	5	7	8	6	5	8	66
H	5	8	7	9	4	6	7	7	4	5	62

A = Roasted Corn: Roasted Groundnut: Cowpea Flour (steamed)

B = Roasted Corn (10 minutes): Roasted Groundnut: Cowpea (steamed)

C = Roasted Corn (20 minutes): Roasted Groundnut: Cowpea Four (steamed)

D = Sprouted Corn: Cowpea Flour (steamed)

E = Sprouted Corn: Steamed Groundnut: Cowpea Flour (steamed)

F = Roasted Corn (5 minutes): Roasted Groundnut: Roasted Cowpea

G = Corn dough (fermented): Sprouted Corn: Cowpea Flour (Steamed)

H = Corn dough Steamed Groundnut: Cowpea Flour (steamed)

APPENDIX 3

FLAVOUR

SAMPLE	PANELISTS/SCORE										
	1	2	3	4	5	6	7	8	9	10	Total
A	8	5	5	3	6	7	7	6	4	9	60
B	6	8	4	7	7	8	4	5	5	6	60
C	5	7	7	9	9	8	6	5	9	5	70
D	7	5	5	8	8	4	3	4	6	7	57
E	7	4	3	6	6	4	5	3	6	8	52
F	4	7	7	4	5	4	6	4	5	4	50
G	8	6	6	9	3	5	5	6	8	8	64
H	6	8	4	2	3	5	8	7	7	6	56

APPENDIX 4

TASTE

SAMPLE	PANELISTS/SCORE										
	1	2	3	4	5	6	7	8	9	10	Total
A	7	8	6	3	4	7	8	5	5	8	61
B	6	7	4	7	7	8	3	3	7	6	58
C	5	6	7	9	7	9	6	4	6	4	63
D	9	6	5	8	8	6	4	5	7	9	66
E	7	8	7	4	9	6	5	6	9	7	68
F	4	5	4	6	9	5	4	3	8	5	53
G	8	6	5	9	6	4	7	4	4	7	60
H	6	4	6	2	6	4	7	4	6	6	51

APPENDIX 5

CONSISTENCY

SAMPLE	PANELISTS/SCORE										
	1	2	3	4	5	6	7	8	9	10	Total
A	9	8	7	6	4	9	6	5	6	8	68
B	4	6	4	9	3	8	3	3	5	4	49
C	5	4	4	8	7	5	5	4	8	5	55
D	7	6	5	6	4	9	3	5	5	6	56
E	4	5	4	3	3	4	4	6	6	7	46
F	6	5	5	4	7	5	5	4	8	5	54
G	8	7	6	3	8	6	4	5	9	6	62
H	6	8	8	9	9	5	6	7	8	5	71

APPENDIX 6

GENERAL ACCEPTABILITY

SAMPLE	PANELISTS/SCORE										
	1	2	3	4	5	6	7	8	9	10	Total
A	8	6	3	7	4	5	6	5	5	9	58
B	6	5	3	9	5	7	3	4	6	7	55
C	5	9	4	7	6	5	5	5	4	5	53
D	9	8	5	3	8	7	3	5	6	9	63
E	7	8	6	7	7	3	7	6	9	5	65
F	4	7	4	4	7	4	4	4	8	7	53
G	8	6	5	2	6	6	4	4	8	8	57
H	6	5	6	9	4	4	8	6	5	5	58