CASSAVA/MAIZE COMPOSITE AS SUBSTITUTE FOR POUNDED YAM FLOUR

BY

BELLO DOLAPO JAMIU
2003/14787EA

DEPARTMENT OF AGRICULTURAL AND BIORESOURCES ENGINEERING
FEDERAL UNIVERSITY OF TECHNOLOGY,
MINNA, NIGER STATE.

NOVEMBER, 2008

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A PROJECT REPORT SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL AND BIORESOURCES ENGINEERING FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG.) AGRICULTURAL AND BIORESOURCES ENGINEERING FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA.

NOVEMBER, 2008

CERTIFICATION

This project entitled "Cassava/Maize Composite as Substitute for Pounded Yam Flour" by Bello Dolapo Jamiu meets the regulations governing the award of the degree of Bachelor of Engineering (B.ENG) of the Federal University of Technology, Minna and it is approved for its contribution to scientific knowledge and literary presentation and human development.

Engr. Prof E.S.A Agisegiri
Project Supervisor

Date

Dr. (Mrs) Z.D. Osunde
Head, Department of Agricultural Bioresources Engineering

28/11/2008
Date

External Examiner

1/8/11
Date

DECLARATION

I hereby declare that this project is a record of a research work that was undertaken and written by me. It has not been presented before for any degree or diploma or certificate at any university of institution. Information derived from personal communication. Published and unpublished works of others were duly referenced in the text.

--------------------------------- 24/11/2008.

Bello Dolapo Jamiu Date

2003/14787EA

DEDICATION

I solemnly dedicate this project to God Almighty, the giver of life. And to my parents Alhaji Mohammed Olaiya Bello and Alhaja Faridat Bello and my entire family.

ACKNOWLEDGEMENT

My acknowledgement goes first to the almighty God for giving me sufficient grace, strength, knowledge and understanding throughout my stay in school even at unbearable conditions

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ABSTRACT

The proximate composition (moisture content, carbohydrate content, fat content, crude protein, crude fibre and the Ash content,) and the physicochemical properties (PH,water absorbing capacity, Bulk density) of the pounded yam-like flour(Cca composite flour)were determine as functions of a composite flour from Corn and Cassava,with the blend of the two flour from corn and cassava, varing in the percentage composition such as a blend of 70% corn flour with 30% cassava flour,80%corn flour with 20% cassava flour. The result obtained showed that while the pounded yam-like flour showed significantly(P=0.05)higher amount of carbohydrate fat and Energy value,It's protein value were significantly lower to that of the control(pounded yam flour).The physicochemical properties also showed no significant difference between the flour produced and the control..However there was significant (p=0.05) difference in the flour in terms of general acceptability,texture,colour and appearance compared to that of the control.Neverhthless two out of the seven sample (Cca80:20) and (Cca70:30) of flour produced show no Significant difference compared to the control(pounded yam flour). tent,)

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CHAPTER ONE

1.0 Introduction

1.1 Cassava/maize composite as substitute to pounded yam flour

Pounded yam is a product made from yam which is a common name for some species in the Genus Dioscorea (Family: Dioscoreaceae). These are perennial herbaceous vine cultivated for consumption of their starchy tubers in Africa, Asia, Latin America and Oceania.

The world production of yam was estimated at 28.1 million tones out of this production 95.6% came from Africa, the main producer being Nigeria with 74.7% of the world production, Cote D'Ivoire 8.6%, Benin 3.4% and Ghana 2.4% in the humid tropical countries of West Africa (FAO, 1991).

Yams are one of the most highly regarded food products in most part of "Nigeria" because of it closely integrated into the social cultural, Economic and religious aspect of life. They are considered second to cassava as the most important tropical root crop Pounded yam also plays a significant role in the socio cultural lives of some producing region of yam for example, through the famous "Yam Festival" In West Africa. In some parts of southeastern Nigeria, boiled and mashed yam (pounded yam) is often the principal meal offered to the god and ancestors until recently newly married couples in yam zone of West Africa were presented with good quality yam tubers for planting to assist them in raising their family.

This family of Dioscorea contains a wide range of species used as food, of which only two of these species can be used for pounded yam preparation. Which are

1. White yam (Dioscorea rothndata)
2. Yellow yam (Dioscorea layenensis)

Yams usually are marketed as fresh product. However, tubers also are processed into several food products that are released in many parts of the tropics. In general, yam is made edible when boiled, roasted, baked, and fried which can be eaten with vegetable sauce or red palm oil. Yam can also be boiled, mashed or pounded into a smooth dough of mashed yam know as pounded yam. It is some time called Iyan in Yoruba language while in the Hausa language it is called saukura. The importance of pounded yam flour to the nutrition of million of people around the world is widely recognized, because they make up such a large part of the diet in developing countries. Pounded yam flour can not be considered only as a source of energy as they produce significant amount of protein as well. That is why the physicochemical properties of pounded yam flour is been considered from cassava and maize.

The cereal grain maize also known as corn (Zea mays) is the second most abundantly produced cereal grain crop in the world its grown in every continent except Antarctica. Corn (Zea. mays) is cultivated in region that experience periods of at least 90 days of frost-free conditions. The rainfall where it is grown may vary from 25 to 500 cm/year but suitable types are available for these varying condition. The crop originated in America where it is widely grown and it was been taken to Africa, India, Australia and the warmer part of Europe. Maize grain may be white, yellow or Reddish in colour.

Some verities of maize include;

The principle types of maize or corn are: Dent (Z. mays indentata). Flint (Z. mays indurata) the varieties of commerce are Pod (Z. mays tunicate) Pop (Z. mays everta) Soft or flour (Z.mays amylacca) (Berger 1962). Of the major cereal grain, maize is generally the most economical source of starch. The ease with which maize can be dried, stored and transported has made it a major source of energy for animal feeds and stable raw material for the production of starch and starch based industrial products. Maize is also a primary food source in many areas in the world, where they are converted directly into food products via grinding, boiling or cooking or fermentation e.g. manufacture of syrup and sugar, beer, industrials spirit and whisky. The product of milling include maize grits, corn steep floured and derived products protein (gluten fed) liquor. The ready to eat break fast cereal cornflakes is made from maize grits. The grain of maize is such larger than those of other cereals the basal part is narrow, the apex broad. The grain of maize kernel. It is the endosperm that is most important for the production of flour from maize. Although maize flour serves as a source of energy and they provide significant amount of protein and vitamins as well but they are low in protein concentrate and their protein quality is limited by deficiencies in some essential amino acid, mainly lysine. Through not all that appreciated, it is a fact that maize flour contains an excess of certain essential amino acid that influence the efficiency of protein utilization (Bressani et al 1989).

The other composite which will be used for the production of pounded yam flour like product is cassava flour. Cassava (Manihot Spp) plant is a highly efficient producer of carbohydrate, mainly in the form of starch. It is the fourth most important source of calories in the human diet in tropical regions of the world and it is consumed in a wide variety of forms. Cassava (Manihot Spp) originated from Americas, although the exact center of origin is still disputed, Northern Brazil, Northern Colombia/Venezuela, Paraguay and South-Mexico have been suggested. Cassava was taken by Spanish and Portuguese traders to Africa, India and Southeast Asia in the sixteenth and seventeenth centuries but did not become wide-spread in Africa until the late nineteenth century. It is currently cultivated in almost all tropical and sub-tropical countries, the major producers being Nigeria, Thailand, Indonesia, India, Brazil and Zaire. The cassava root is anatomically a true root, not a tuberous root. Root size and shape depends on variety and environmental condition. Variability in size within a variety is greater than that found in other root crops. The root is composed of three (3) distinct tissues, the Bark (peri-derm), Peel and Parenchyma. The parenchyma is the edible portion of the fresh root and comprises approximately 85% of total weight. It is the parenchyma that is used for the production of cassava flour. The parenchyma are chopped into pieces, sun dried and then pounded into a coarse meal or flour. The process for the production of high-quality cassava flour requires the use of cleaned roots with the bark removed, dried in an artificial air dryer and milled to produce good quality cassava flour which is white in colour with good smell (cooke, 1985). Although all known cassava (Manihot Spp) contain cyanide which is toxic to human when consumed or eaten. The quantity of cyanogens depends on the cassava cultivars and growing conditions, it is best to use cassava cultivars which contain a low level of cyanide compounds, since these are potentially toxic. However, the cyanide content of fresh root is not a serious problem in cassava flour production, since it is almost entirely eliminated during flour processing (Oyenaga, 1988). Cassava can be processed into Garri, starch, and flour. The flour is used for a variety of other food supplements such as wheat flour in some product, although the quality of the product will be different but a suitable ratio can be derived which consumers find acceptable depending on the kind of food (Cook and Coursey, 1981).

1.2 The Objectives of the Study

1. To determine the nutritional properties of cassava / maize composite flour

2. To compare the Nutritional qualities of cassava/maize composite flour to pounded yam flour (dehydrated)

3. To determine the appropriate mixing ration of cassava to maize flour.

1.3 Justification of the Study

Throughout the country, it has been observed that every individual in Nigeria is in love with pounded yam which has been attributed to be one of the most staple food in this country. It is therefore important to get a substitute for yam flour used for the preparation of pounded yam with a view of making pounded yam more available and to further reduce the high cost of yam in the market. In this lies the justification of this study.

1.4 Statement of the Problem

Consequently the recent mass production of cassava mostly around the middle belt of Nigeria, it has become important for us to maximize the effective use of this product to satisfy the nutritional need of the people of this country. Hence "cassava / maize composite as substitute to pounded yam flour" will make the cassava / maize composite flour always available at reduced cost.

1.5 Scope of the Study

The scope of this study is to find a substitute for pounded yam flour using cassava/maize composite flour.

CHAPTER TWO

2.0 LITERATURE REVIEW

Since the origin of mankind, there have been some ingredients necessary for sustaining life. Food is right on top of that list. Human started as hunters, taking what they could from nature. Eventually humans started raising their own livestock and growing their crops for food, having animals or food plant directly in their backyard which was a tremendous advantage over having to find food which is the result of insufficient naturally exiting food plants in our environment. One of the crops that became popular is yam which can be consumed by human and the residue from sifting as well as peels represent losses in the energy value of tuber, but they n be used as animal feed.

2.1 Production of Pounded Yam Flour from Yam.

This was started early even before civilization where by (injured tubers) due to diseases and pest are sliced, dried and milled into flour form. Traditionally processed yam products are made in most yam growing areas, usually as a way of utilizing tubers that are not fit for storage. Usually fresh yam is peeled, boiled and pounded until sticky elastic dough is produced. This is called pounded yam or yam fufu. The only processed yam product traditionally made at village levels is yam flour. Except by the Yoruba people in Nigeria, yam flour is regarded as an inferior substitute for freshly pounded yam because it is often made from damaged tubers, yam flour is favoured in the Yoruba area where the reconstituted food is know as amala. To a limited extent, yam flour is also manufactured in Ghana where it is know as kokonte. The nutritional value of yam flour is the same as that of pounded yam.

Pounded yam flour: The tubers are sliced to a thickness of about 10mm, more or less depending on the dryness of weather. The slices are then parboiled and allowed to cool in the cooking water. The parboiled slices are peeled and dried in the sun to reduce the moisture content. The dried slices are then ground to flour in a wooden mortar and repeated sieved to produce a uniform texture. Today small, hand-operated or engine-driven corn mills or flour mills are increasingly used. Treatment with sodium bisulphate is often used to prevent phenolic oxidation during drying which darkens the colour of the product (especially with white guinea yam, D. rotundata). The yam flour is rehydrated and reconstituted into pounded yam and eaten with a soup containing fish, meat and some times with vegetables soup.

2.2.1 Nutritional Properties of Pounded Yam.

The nutritional content of yam varies with species (Table below). In processed product, the nutritional value is affected by the method of preparations. Yam tubers have high moisture and dry matter content ranging between 60% and 75% and 25% and 40% respectively [Alakali. S.E Obeta, and O.Ijabo. 1995].

In general, yams have a high starch (30%) and potassium contents but the vitamin A content is low. Yams contain about 5 to 10mg. 100g vitamin C, and the limiting essential amino acids are isolencine and those containing sulphur. Yams contain a steroid sapogenin compound called diosgenin that can be extracted and used as a base for drugs such as cortisone and hormonal drugs some species contain alkaloids (e.g dioscorine $C_{13}H_{19}O_2N$)

2.3.0 Physicochemical Properties of Pounded Yam Flour.

2.3.1 Functional Properties of Pounded Yam Flour

Functional properties can be defined as those physicochemical properties, such as solubility, viscosity, water and oil absorption (retention), emulsification and foaming that affects the processing and behavior of protein in the food systems judged by the quality of final products (kinsella, 1979,kinsella 1981, Hayb, eta, al, 2002) these properties are often affected by the conditions under which the ingredient is applied such as concentration medium (fat or water) and the presence of any other ingredients acidity, ion strength, temperature and processing time is particular. In food products such as flour, solubility, water holding content, although the carbohydrates also play a role in water binding, swelling and viscosity. The basic functionality the various ingredients can be used to obtain an indication of their performance in the end products but in most cases a final test under practical condition is unavoidable (Visser and Thomas, 1987).

2.3.2 Water Absorption Capacity of Pounded Yam Flour

Water absorption capacity is considered as an important function and is a term frequently employed to describe the ability of a matrix of molecules (flour), usually macro-molecules to entrap large amount of water in a manner such that exudation is prevented. (Chemical hiu, 2002). The water absorption capacity of product varies with protein source, composition, the presences of carbohydrates and lipids, and salts.

$$\text{Water absorption} = \frac{\text{Volume of water } (\text{cm})^3 \times 100}{\text{Weight of flour (g)}}$$

2.3.3 Swelling Power of Pounded Yam Flour

The swelling power of a sample is the amount of water the macro-molecules can imbibe on heating. This functional property is important in determining amount of water sufficient to cook a sample and the amount of the constituents of the composition that goes into solution when heat is applied (Cynder ankwon, 1987).

Swelling power = weight of sediment - solubility

Weight of sample

2.3.4 Bulk Density of Pounded Yam Flour

Bulk density is widely used functional property. It is usually affected by starch content; which increases it. Bulk density refers to weight of the same measured in g/m3.Bulk density measures the bulk density before being condensed while packed bulk density measures the weight of the sample after condensing it usually by tapping the cylinder (Wang and Kinsella, 1976; Iwe and Ohuh, 1992). When mixing, transporting, storing and packaging particular materials such as flour, it is important to know the properties of the bulk materials. When such solids are poured into a container the total volume occupied will contain a substantial proportion of air. If the container is tapped, the total volume and hence the porosity will decrease until eventually the system reaches an equilibrium (Okaka and Pother, 1979).

$$\text{Bulk density} = \frac{\text{Mass of material}}{\text{Vol. of material after tapping}}$$

2.3.5 Foam Capacity and Stability of Pounded Yam Flour

Foaming is also known as aerating, leaving powder or whipping pro-properties of food. It means the ability to take in air by itself or in a mixture with other ingredients and to hold the aerated structures long enough so that it can be set by heat or other means. Foam is a two phase-system consisting of a mass of gas bubbles dispersed in a liquid or solid with the gas bubbles being separated form each other by thin films of liquid or solid. (Narasinga Rao and Narayana, 1982).

2.3.6 Wet ability of Pounded Yam Flour

This term describes the ability of the powder (flour) particles to absorb water on its surface thus initiating reconstitutions. The property largely depends on the particular size. (Armstrong and Maurice, 1979).

2.3.7 pH Value of Pounded Yam Flour

The pH value is the common logarithms of the number of hetres of solution that contain one tuber equivalent of hydrogen ion. Thus pH = $10g_{10}$ (H). The pH scale ranges from 0-14, a value below 7 representing an acidic solution 7 a neutral solution and above 7 and alkaline solution (Pearson, 1973).

2.3.8 Total Titratable Acid (TTA) of Pounded Yam Flour

Although the pH value is the most important factor in relation to preparation and setting a gel. The total titratable acid can be described as the amount of acid present in food sample which can be neutralized by a alkali to form salt and water it is most often determined by titrating a known weight of the sample with 0.1m or 0.5m sodium hydroxide (NADH) using phenolphpthline (ph 8.3-10) or bromothmol blue (ph 6.0-0.6) as indicator (Pearson, 1973).

2.4.0 Cassava (Manihot Spp)

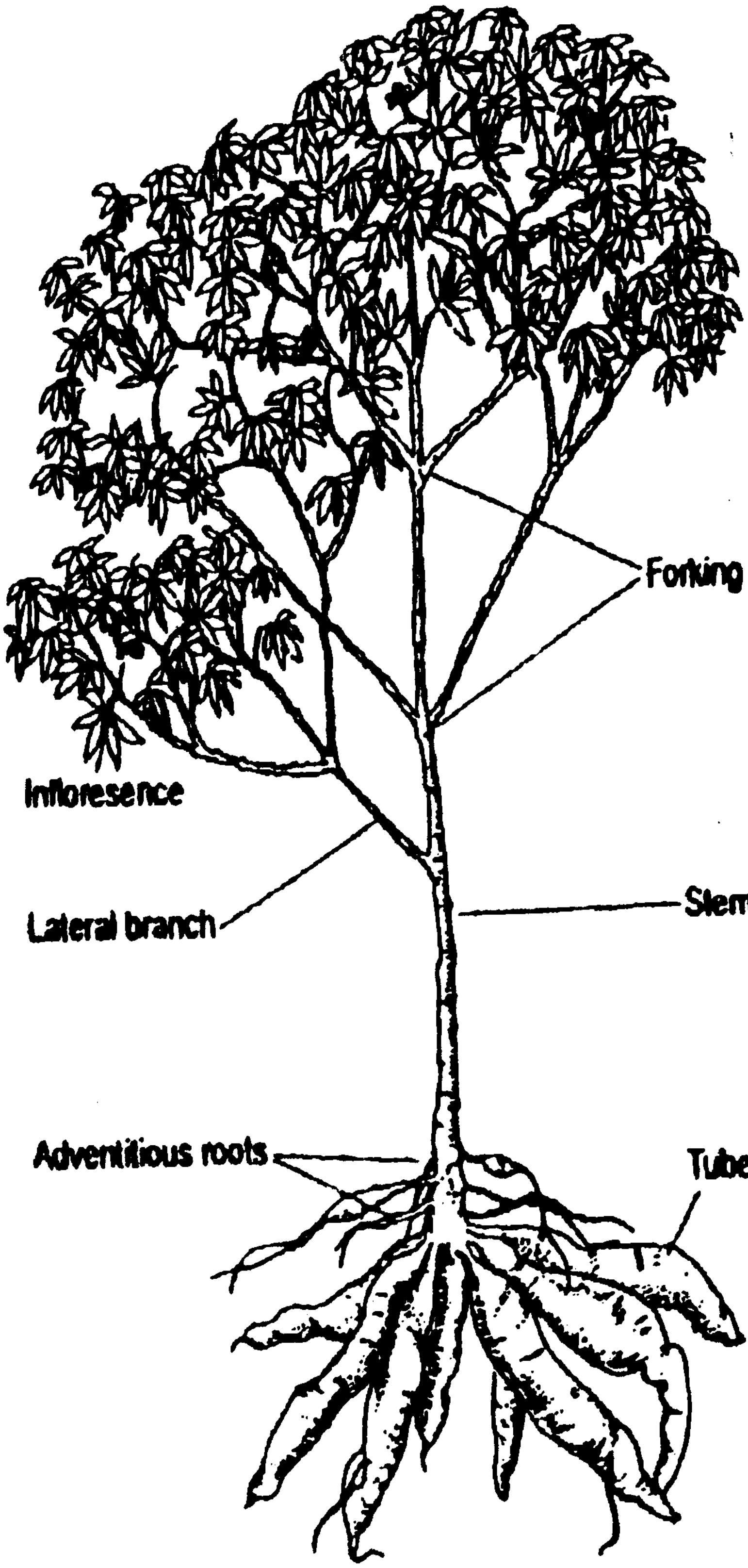


Fig 2.1 Cassava plant morphology showing tubers

The cassava plant is a highly efficient producer of carbohydrate, mainly in the form of starch. It is the fourth most important source of calories in the human diet in tropical regions of the world and is consumed in a wise variety of forms.

Cassava originated in the American, although the exact centre of origin is disputed: northern Brazil, northern Colombia/Venezuela, Paraguay and southern Mexico has been suggested.

The crop was widely grown in the Amazon basin by 2000 BC cassava was taken by Spanish and Portuguese traders to Africa, India and Southern Asia in the sixteenth and Seventeenth centuries, but did not become widespread in Africa until the have nineteenth century. (Cock 1985). It is currently cultivated in almost all tropical and subtropical countries, the major producer being Thailand, Indonesia, India, Brazil, Zaire and Nigeria. Total world production in 1989 reached 149x1066, of which Americas, Africa and Asia counted for 22%, 42% and 36% respectively. (Wheatley and best, 1991)

Cassava has found acceptance over a diverse range of agricultural and food systems due to its tolerance of poor soil and harsh climate conditions. Yield in excess of 10.6 per haper year are achieved with minimal inputs under conditions of paid soil (pH and 4) low rainfall (<1000mm per year) and nutrient deficiency.

Cassava has thus gained a reputation as a food security and famine reserve crop, and as such has become especially important to small farmers living in marginal areas of the tropics.

The cassava root (Manchot Spp) is automatically a true root not a tuberous root. The root cannot serve for vegetative propagation. Root size and shape depend on variety and environmental conditions. Variability in size within a variety is grater than that found in other root crops. Cassava roots are generally from 15-100 cm long and 3-15% wide. They are cylindrical, conial or oval, with a coffee, pink or cream- coloured peel which is covered by a thin brown bark. The parenchyma is generally white, cream or yellow plants. Produce 5-10 roots weighing 0.5-2.5kg each. The root is composed of three (3) distinct tissues: bark. (periderm) peel and parenchyma. The parenchyma is edible portion of the fresh root and comprises approximately 85% of total weight (Coursely, 1973).

Freshly harvested cassava roots have the shortest post harvest life of any of the major staple food crops. Roots become inedible within 24-72 after harvest due to a rapid physiological deterioration process. This deterioration is the major constraint for industrial processing of the fresh roots, and for marketing them to distance urban centres. Traditionally, cassava roots are preserved in the fresh state by reburying them in soil moist and. Field clams, using straw and roots in layers below a soil covered mound, with adequate ventilation, were developed in the 1970's

In particular, the two types of cassava recognized are the "sweet" variety with a small amount of glucedises, and the "bitter" cassava with a larger amount. Cassava varieties differ in their total cyanide distinct type can be discerned in many regions of the world. Low and high cyanide varieties. Low-cyanide varieties are often called sweet, although confusion with elevated free sugar contents in some condition may occur. These are grown for fresh consumption, or for simple processing. High cyanide varieties are called, biter, although the phonetic compounds involved in root physiological deterioration can also produce a bitter taste. These are variety grown for processing, especially for farinha in Brazil and gari in Africa.

(Rickard and Coursey, 1981). It is interesting that low cyanide for high-cyanide varieties is unclear. Contrary to anecdotal evidence, high-cyanide varieties do not yield more than low cyanide ones. These is some evidence that cyanide may protect against rodent pests and robbery, and also that their may be a link between end- product quality (i.g) Tarinha texture) and cyanide content. Cyanide is concentrated in the root peel, especially in low-cyanide varieties where peel root rations of 40:1 are found. In high cyanide varieties ration of 1.6.1 are common. These of whole or peel roots for processing may therefore result in great differences in end-product cyanide content.

2.4.1 Chemical Composition and Nutritional Value of Cassava

The chemical composition of cassava roots (peel and parenchyma) is different. The peel has more protein, fibre, sugars and cyanide than their parenchyma, and less dry mater and starch. A wide range of value is reported in the deterature for each root component. Report of whole root dry matter contents. Vary from 20% 60% 40% and between 70% and 90% and dry matters is composed of starch, with average values between 80% and 85%. Total of parenchyma dry weight. Protein content is uniformly low (below 2% or a fresh weight basis) as are fats and ash content. The roots contain significant amount of vitamin C about 30mg per 100g fresh weight (ownwueme, 1978).

The main amino-acids present in cassava protein are arginine, histidine, isolevene, leucine and lysine. Sulphur amino-acids are deficient.

Cassava is a starchy staple, whose roots are very rich in carbohydrates, a major source of energy, in fact the cassava plant is the highest producers of carbohydrates among crop plant with perhaps the exception of sugarcane. It has been reported that cassava can produce 250 x 10 calories /ha/day.

Although cassava roots are rich in calories, they are grossly deficient in protein, fat and some of the minerals and vitamins. Consequently, cassava is of lower nutritional value than are cereals legumes and even some other root and tuber crops such as yam. The cassava roots contain or are reasonable rich in calcium and vitamin C, but the thiamine, Riboflavin and niacin content are not as high. Large proportions of these nutrients have been reported to be lost during processing. All of this should be taken in to consideration or account in cassava processing in order to retain as much as possible of these nutrients (Oyenaga, 2002).

2.4.1.1 Chemical Composition of Cassava

2.4.1.2 Moisture Content of Cassava

The hot oven method proposed by Pearson (1976) was used. Petri dishes were thoroughly washed and dried in the oven at 100oc for 30mins and allowed to cool inside desiccators. The Petri dishes were weighed using electronic weighing balance. 5g of the gari sample was weighed into the petridish and placed inside the oven at 105oc for 4hrs. Thereafter, the sample was cooled in a dessicator and weighted. They were placed back into the oven, dried for further 30mins, cooled and re-weighed. The drying was continued and weighed repeatedly until a constant weight was achieved. The percentage moisture content was calculated from the weight loss of the sample, as follows;

Moisture content, % (wb)

$$= \frac{(\text{wt of dish + wet sample}) - (\text{wt of dish + dry sample}) \times 100}{\text{Wt of wet sample}} \quad \ldots\ldots(1)$$

2.4.1.3 Fat Content of Cassava

Soxhlet extractor as used. The extraction flask was thoroughly washed and dried in hot oven for 30mins. It was placed in a desiccators to cool and the weight taken. 5g of the sample was accurately weighed and transferred into ashless filter paper, placed inside the extractor thimble. The thimble was placed into the soxtractor. Some quantities of petroleum either of about three quarter of the volume of the flask was poured into the extraction flask. The soxhlet extractor was connected to the flask and the heater switched on. It was allowed to run for 4hrs, the ether was recovered before the thimble was removed.

Finally, the oil collected in the flask was dried at 100oC in the oven. The extracted oil was weighed. The difference in the weight of empty flask and the flask with the oil gives the oil content of the sample.

$$\% \text{ Fat content} = \frac{C - A}{B} \times \frac{100}{1} \quad \ldots\ldots\ldots\ldots (2)$$

Where A – Weight of empty flask

B – Weight of the sample

C – Weight of flask + oil after drying

2.4.1.4 Ash Content of Cassava

The AOAC (1980) method was used for this determination. The crucibles were washed thoroughly and dried in the oven at 100°C, it was cooled in the disiccator and weighed. 5g of the sample was weighed into the crucibles and placed inside the furnance at 600oC for 3hrs to produce the ash. After ashing, the furnance was switched off and the temperature allowed to drop before the crucible was removed. The crucible were put inside a desiccator and cooled. After cooling, the were weighed. The ash content was calculated from:

$$\% \text{ Ash content} = \frac{W - Z}{N} \times \frac{100}{1} \quad \ldots\ldots\ldots\ldots (3)$$

Where Z – Weight of empty crucible

N – Weight of sample

W – Weight of crucible + ash

2.4.1.5 Protein Content of Cassava

The microkjeldahl method as described by Pearson (1976) was used for the protein content determination. The following methods were used for this determination.

a. Digestion

b. Distillation

c. Titration

2.4.1.6 Digestion of Cassava in Human

1g of sample was placed inside 100ml digestion flask.

The following were added.

2g anhydrous sodium sulphate

1g hydrated cupric sulphate

A pinch of selenium powder

10ml conc. Sulphric acid

The flask was placed on an electric coil heater and gently boiled at first until blacking occurs; heat was then increased until the solution becomes clear. Heating is continued for at least one hour after solution has cleared. If black specks persist in the neck of flask, it is an indication of incompletion digestion. After heating distilled water was introduced into the flask to make up to 100ml mark. The flask was then thoroughly shaken.

2.4.1.7 Distillation and Filtration of Cassava

Steam was passed through microkjeldahl distillation apparatus for about 10mins. 5ml of boric acid was placed into 250ml conical flask and two drops of indicator added. The conical flask was placed under the condenser such that the condenser tip was on the surface of the liquid. 5ml of the diluted digest and 5ml of 40% NaoH was placed in the distillation apparatus and was rinsed down with distilled water. Steam was then let through for about 5mins until the amount of liquid in the conical flask was about twice what it was in the beginning of distillation. The boric acid indicator was titrated with 0.01m Hcl to the end point, which is pinkish colour. The titre volume was recorded.

The protein content was calculated from:

$$\% \text{ Protein} = \frac{0.000141 \times \text{titre} \times 6.25 \times 5 \times 100}{\text{Wt of sample}} \quad \ldots\ldots(4)$$

2.4.1.8 Carbohydrate Content of Cassava

This was obtained by the addition of other components (moisture, fat, protein and ash) and then subtracting their sum from 100%.

2.4.2 Processing of Cassava

Processing of cassava has several objectives: to produce a more stable product capable of being stored in tropical environments with extended periods with no decrease in quality or deterioration to reduce the content of cynide to innocuous level, to reduce bulk and hence lower transport costs, to diversify the food and other uses of cassava, leading to market expansion and to provide food and other industries with a low-cost raw materials for further processing. Cassava maybe processed into flour, Garri, Farinha and Fufu.

2.4.3. Economic Importance of Cassava

2.5.0 Maize (Zea Mays)

Corn (Zea mays l) originated in the western hemisphere. It was the only cereal systematically cultivated by the American Indians, although some other grains where harvested from the wild state. Columbus found corn being cultivated on Haiti, where it was called mahiz. The name maize is used in Europe to distinguish this cereal from other grains which are called (corn).

Corn (also referred to as maize) is the second most abundantly produced cereal grain crop (in the world, grown in every continent except Antarctica. It is one of the most important cereal crops in the countries of west and central Africa. The crop was introduced to Africa via two major routes.

The first route was from Central America to Portugal, to Egypt and then to West African through the Sahara by the Arab traders (that is the yellow seeded maize)

The second route of maize entry into West Africa was from South America through Soa Tome (that is the white seeded maize) (Normal, et. Al. 1984).Maize had rapidly gained popularity as a major food item. Among the world cereal crops maize production contribute to the development of the state .In developing economies, it rank first in Latin America and third after Rice and Wheat in Asia. seventy counties including 53 developing countries plan maize on more than 100,000 hectares (FAO, 1993) and is one of the five major crops accounting for / to 70% of the total cereal production in 11 countries of west and Central Africa.(CIMMYT,1994).In the past few decades, the crops had spread rapidly replacing the traditional cereal, like sorghum and millet particularly in areas with good access to fertilizer inputs and market (Alabi, et, al. 2003). Fakrorede et al,. (2003), indicated that the ratio of land to cultivate maize, to that used to cultivate sorghum and millet were about equal from 1990 to 1995 but the average annual, increase from 1980 to 2001 in total production for maize (0.43 million tons) was much longer than the annual increase from millet and sorghum (0.23 and 0.30million tons), respectively. The average grain yield of maize in the sub-region increased of 0.02 tons per hectare. The importance of maize in human diet, livestock feed and as a raw material for some industries has increased rapidly in the last two decade of the twentieth century of west central Africa. Zea mays is a member of the grass family and is one of the most diverse species of plants. Maize plants contain both male and female reproductive structures and reproduce by both cross-pollination and self pollination (Wolf et al 1952). Ears of maize may range in size from about 2.3 to over 45cm long. Kernel size shape and colour also very widely. Although there are hundreds of "races" of maize most of the economically grown hybrids emanated form only a few major races. The commercial importance of the crop, maize types can be sub divided into four categories not related to race.

2.5.1 Types of Maize (Corn)

i. Dent maize (Z. mays indentala) is the primary types of maize grown in the US Corn Belt, Europe, South Africa and China. Dent varieties of maize are identifiable by the dent in the crown end the kernel.

ii. Flint maize (Z.mays indurate) it is genetically different in ancestry from dent maize and is characterized by hard, round kernels.

iii. Popcorn Z. may tunicala) it is a flint-type maize which has been genetically selected for its ability to expand or "pop" when heated. Popping occurs when the kernels are rapidly hated to approximately 243^{0}C

iv. Sweet corn Z. may saccharranlao is a dent – type maize that is harvested while still immatuce for canning, freezing and direct consumption as a vegetable. A sweet corn hybrid contains a gene which records the conversion of glucose to starch in the endosperm (Berger 1962).

a. The grain of maize is much larger than those of other cereals. The basal part is narrow, the apex bread. The embryo, relatively large seuteclum (10-13% of the grain) and the endosperm are within the pericarp and testa, which are fused to form a so-called "hull" (corresponding morphologically with the brain of other cereals). The part of the "hull" overlying the germ is called the tip cap. There is no ventral furrow or crease in maize. The grain of maize is made up of four (4) part the germ 12% endosperm 82% pericarp, 5.2% and the tip cap 0.8%. Each of these four (4) sections has distinct compositional characteristics which are important for utilization of maize kernel. (Wolf et al. 1972).

2.5.2 Uses of Maize

As indicated previously, maize has three (3) uses: as food, as feed for livestock and as raw material fore industrial used.

As food, the whole grain, either matured or immature, may be used or processed by dry milling techniques, to give a relatively large number of intermediary product such as maize grifts of different sizes, maize meal flour and flaking grits. The materials in term have a great number of applications in a large variety of foods. Maize grown in subsistence agriculture can continue to be sued to compound feeds for poultry, pigs and ruminants. In recent years, even in developing countries in which maize is a staple food, more of it is being used as animal feed ingredient (FAD, 1997)

Earll, et al (1988) and Beirge and Duensing, (1989) reported that high moisture maize had been paid much attention recently as an animal feed because of its lower cost and its capacity to improve efficiency in feed conversion. The by – products of dry milling include the germ and the seed coat. The former is used as a source of edibles oil of high quality. The seed coat or pericarp is used mainly as a feed, although in recent years, interest had developed and by products such as maize gluten used as a fed ingredient.

Wet milling is also a process applicable, morally in the industrial use maize although the alkaline cooking processes used in manufacturing fortillas (a thin flat bread of Mexico and other central American countries) is also wet milling operation that removes the pericarp (Bressani 1990)

2.5.3. Chemical Composition and Nutritional Value of Maize

2.5.3.1 Chemical Composition of Maize

There are important differences in the chemical composition of the maize kernel. The seed coat or the pericarp is characterized by a high crude fibre content of about 87% of which starch is 7.3%, protein 3.7% oil 1.0%, sugar 0.3% and ash 0.8%. On the other hand, the endosperm contains a high level of starch 87.6% protein 8.0%, sugar 0.6% ash 0.3%, and oil [illegible] 8% and crude fibre 2.7%. The germ is characterized by a high crude fat content averaging 78.6%, starch 5.3%, protein 9.1%, oil 3.8%, sugar 1.6% and ash 1.6%. For the nitrogen distribution, endosperm contributed the largest amount 80.5%, followed by the germ with 14.9% and the seed coat 4.6% (Burge and Duensing 1989). It is evident that the carbohydrate and protein contain contents of maize kernel depend to a large content on the endosperm and crude fibre on the germ. The crude fibre in the kernel comes mainly form the seed coat. The weight distribution among part of the maize kernel and their particular chemical composition and nutritive value are of great importance when maize is processed for consumption. In this regards there are two important matters from the nutritive point of view. Germ oil provides relatively high levels of fatty acid (Weber 1987). Where there are high intakes of maize as in certain population, those who consume the degermed grain will obtain less fatty acid than those who eat processed whole maize. This difference is probably equally important with respect to protein, since the amino acid content of germ problem is quite different from that of the endosperm protein (Bressani et al, 1990)

2.5.3.2 Starch

The major chemical component of the maize kernel is starch which provides up to 72 or 73% of the kernel weight, other carbohydrates are simple sugar present as glucose, sucrose and fructose in amounts that vary from 1-3% of the kernel. The starch in maize is made up of two (2) glucose polymers: amylase on essentially linear molecule and amylopectin a branched (Boyer and Shanne, 1987).

2.5.3.4 Protein

After starch the next largest chemical component of the kernel is protein. Protein content varies on common varieties form 8-11% of the kernel weight. Most of it is found in the endosperm. The protein in maize kernel has been studied extensively. It is made up of at least five (5) different fractions, according to landry and oureaux (1982). In their scheme, albumins, globulins and non-protein nitrogen amount to about 18% of the total nitrogen in a distribution of 7%, 5% and 6% respectively.

2.5.3.4. Oil and Fatty Acids.

The oil content of maize kernel comes mainly from the germ. Oil content is genetically controlled with values ranging from 3-18% (Bressani at al, 1990)

2.5.3.5 Dietary Fibre

After carbohydrates, protein and fats, dietary fibre is the chemical component found in the greatest amounts. The complex carbohydrate content of the maize kernel comes from the pericarp and the tapcap. Although it is also provided by the endosperm cell walls and to a smaller extent the germ cell walls (Bressani et al, 1990)

2.5.3.6 Minerals,

The concentration of ash in the maize kernel is about 1.3% only slightly lower than the crude fibre content. The germ provides about 78% of the whole kernel minerals. The most abundant minerals is phosphorus, found as phytate of potassium and magnesium. All the phosphorus is found in the embryo. As with most grains maize is low in calcium content and also low in trace mineral.

2.5.3.7 Fat Soluble Vitamins.

The maize kernel contains two fat- soluble vitamins; pro-vitamin A or carotenoid and vitamin E. caroteneiods are found mainly in yellow maize, in amounts that may be genetically controlled. While white maize has little or no carotenoid content.

Most of the carotenoids are found in the hard endosperm of the kernel and only small amounts in the germ. The carotenoid in yellow maize is susceptible to destruction after storage (Waston

1962). The other fat soluble vitamin E which is subject to some genetic control is found mainly in the germ.

2.5.3.8. Water Soluble Vitamins of Maize.

Water soluble vitamins are found mainly in the aleuronic layer of the maize kernel, followed by the germ and endosperm. The water soluble vitamin E monotonic acid has attracted much research because of its association with niacin deficiency or pellagra, which is common in populations consuming high amount of maize Christianson et al 1968). A feature peculiar to niacin is that it is bound and therefore not available to the animal organism.

Some processing techniques hydrolyses niacin thereby making it available. The association of maize intake and pellagra is a result of the law levels of niacin in the gram, although experimentally, evidence has shown that amino acid in balances, such as the ratio of leveine to isoleuine and the availability of tryptophan are also important (Patterson, et al 1975, Goplan and Rao 1980) maize has no vitamin biz (cyanocabalamim) and the nature kernel contains only small amounts of aseorbic and if any. Yen et al, (1976) reported a content of about 2.69mg/kg of available pyridoxine. Other vitamins such as choline, folic acid and pantotheme acid are found in very low concentration.

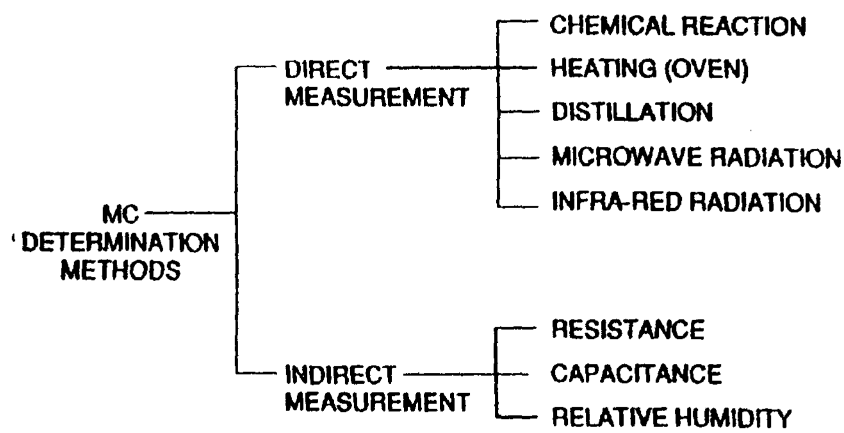


Fig 2.2 Classiffication of grain moisture content (MC) determination methods.

2.5.4 Nutritional Value of Maize

The importance of cereals in the nutrition of people around the world is widely recognized because, they make up such as large part of diets in developing countries, cerealsm grains cannot be considered only as a source of energy, as they provide significant amounts of protein as well. It is also recognized that ceral grain have a low protein concentration and that protein quality is limited by deficiencies in some essential amino acid mainly lysine. The protein quality of maize is similar to that of other cereal except rice.

The reasons for the low quality of maize protein have been studied extensively by a number of researchers. Mitchell and Smut (1932) observed a definite improvement in human growth when 8% maize protein diets were supplemented with 0.25% lysine.

These results have been confirmed over the years by several authors (Howe, et al, 1965; Bressani, et al, 1986) has shown that the addition of lysine to maize caused only a small improvement in protein quality. These different results might be explained by variations in the improvement in protein quality. These different result might be explained by variations in the lysine content of maize varieties which led to the discovery of Mertz, et al, (1964) of the high lysine maize called opaque – 2..

However, some researcher (Hogan et, al 1995) had reported that tryptophan rather than lysine is the first limiting amino-acid in maize, which might be true for some varieties with a high lysine concentration or for maize products modified by some kind of processing. Improvement in quality obtained after an addition of lysine and tryptophan has been small in some studies and higher in others when other amino acid has been added. Apparently the limiting amino acid after lysine and ryptophan is isoleusine as detected from researchers who reported such findings indicated that the effect of isoleusine addition resulted from an excess of leucine which interfered with the absorption and utilization of isoleusine (Haper et al, 1955; Benton et al; 1956). They also reported that high consumption of leucine along with the protein of maize increased niacid requirement and this amino acid could be partly responsible for pellagra

2.5.5 Processing of Maize

Maize processing essentially begins with soaking the grain and then grinding it between stones or pounding it in a mortar and nestle arrangement. During pounding or grinding the brain is removed. The grain is unlimited as intervals to remove the brain from the kernels. The dehulled grain is then pulverized into flour by further grounding or pounding. Processing of maize into desirable and products usually involves primary processing (cleaning, grading, soaking, dehulling, grinding and sieving) ad secondary processing (blending, cooking, frying and baking)

2.5.6 Maize Milling

The process of milling maize can either be dry or wet. Dry milling may or may not include determining as a preliminary step. Both processes involve the separation of the germ oil. After germ removal, dry milling employs roller mills to provide grits, meal and flour, whereas wet milling involves a steeping stage and the complete disintegration of the endosperm, to enable the recovery of the starch and protein as separate products.

2.5.6.1 Dry Milling (Production of Maize Four)

Maize is dry milled by two general systems de-germing or non-degerming. The non-degerming method produces a meal with little or no removal of germ. The resulting product has a rich, only flavor because of it high fat content.

The de-germing method frees the kernei of its hull and germ and recovers these as well as one endosperm fraction or several. In the conventional de-germing system moisture is added to the corn under controlled conditions before degerming take place. With the dry degerming process, on the other hand corn having no more than 15 or 16% moisture is degermed without prior addition of moisture to produce grits meals and flour (Kent et al, 1983).

CHAPTER THREE

The analysis was conducted at Food Science and Nutrition laboratory of the Department of Food Science and Nutrition School of Agricultural and Agricultural Technology, Minna, Niger State, Nigeria between June and August 2007. The analysis conduct was to determine the physicochemical properties of pounded yam flour from cassava and corn, also considering the chemical composition with nutritional value of the flour produced from the raw material.

3.1 Materials for the Cassava/Maize Composite

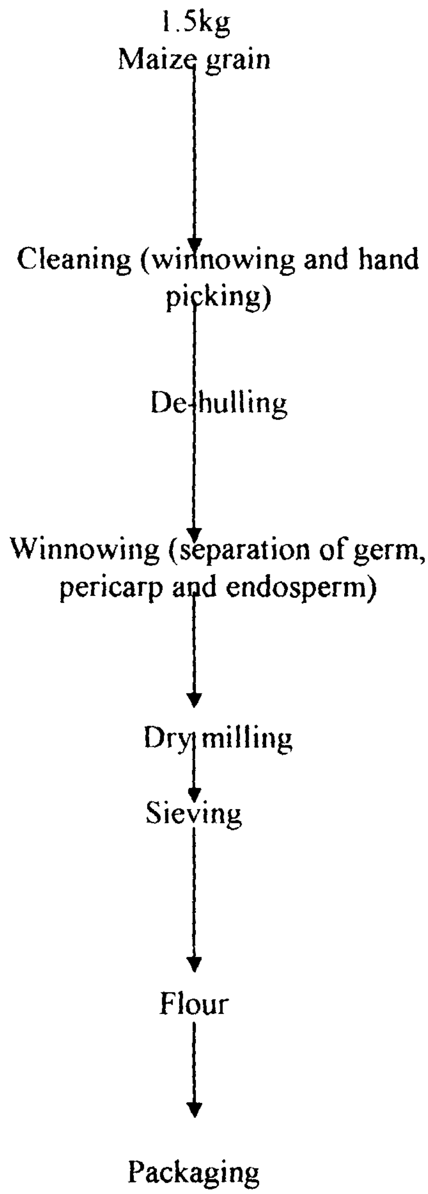
The raw materials, maize grain (white) and cassava which were use for this study were purchased at Mobil, market, Minna central market, Niger state.

3.2 Cleaning and Sorting of the Composite Material

The maize grains and cassava tuber were annually cleaned to remove stones, damaged grains and coloured grains from the maize grains and sands, rust cassava and unwanted tubers from the raw materials (cassava)

3.2.1 Production of Maize into Flour

1500g of lean maize grains was dried milled into grits using a disc attrition mill after de-hulling the grains. The maize grains was tempered with water to a moisture level of 18-24% to toughen the germ and to induce differential swelling to the germ, endosperm and pericap for ease of separation. The degerminator used, is mechanically to break loose the germ and pericap from the endosperm. The degerminator used, is mechanically to break loose the germ and pericap from the endosperm,. The resulting material is then winnowed, separating the pericap, the germ and endosperm. The endosperm was then collected, dried milled and then sieved to obtain desired maize flour depending on its particle size, the flour was then packaged.



Flow chart of maize processing into flour

3.2 Production Of Cassava Into Flour

15kg of cassava tuber where cleaned removing the sand and stone particles from the cassava tubers by washing it with water. The cassava tubers were then peeled removing the peels or back from the parenchyma. The parenchymas were washed in a clean water, chopped into flakes or chips and dried. The drying process may be done either in the sun or in hot air oven dryer. The moisture content of the cassava chips were reduced to 8% before milling into flour, sieved and packaged.

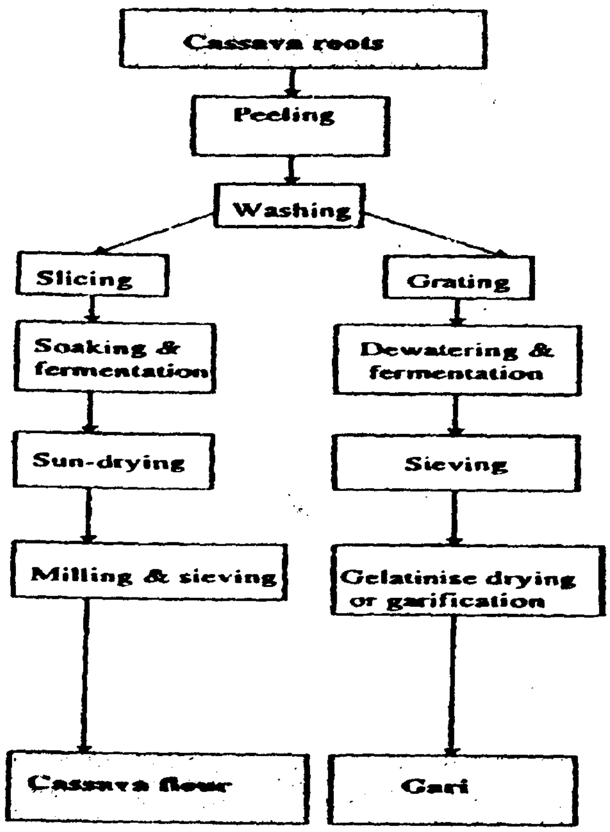


Fig 3.1 Tradition process for production of cassava flour and gari.

3.2.3 Formulation of blends

In formulating the blends, the following samples were obtained by weighing them using a Mattle balance pm 2000.

Seven (7) different samples were derived varying the percentage composition of the maize to cassava flour.

i. 200g of the first sample consisting about 90% of maize flour and 10% of cassava flour.

ii. The second 80% of maize flour and 20% of cassava flour.

iii. 70% of maize flour and 30% of cassava flour obtaining a ratio blend of maize flour to cassava flour.

iv. 70% of cassava flour blending with 30% of maize flour.

v. 60% of cassava flour blending 40% of maize flour

vi. 60% of maize flour blended with 40% of cassava flour.

vii. 50% of maize flour blended with 50% of cassava flour.

The composition of all these samples blended together are just parameters that will be used so as to know the right proportion that will give a good and better blend.

3.3 Physico- chemical analysis Of Cassava/Maize Composite

3.3.1 Determination of water Absorbing capacity Of the Composite Flour

The water absorption capacity (WAC) was determined using Susulski method (1962). 15ml of distilled water was added to 1g each of the sample in a preweighed centrifuge tube. The tube and their content were agitated on an orbital shaker for 2 minutes. The supernatant was discarded and the centrifuge tube weighed with the sediment. The amount of water bounded by the samples were determined by the difference and expressed as the weight of water bounded by 100g of the sample.

3.3.2 Determination of pH Of The Composite Flour

The pH of the samples were determined using the AOAC (1990) method. 1g of samples each was weighed into a beaker contains 9ml of distilled water. The samples were allowed to stand for 30 minutes with constant stirring. The pH was then determined with the aid of a pH meter.

3.3.3 Determination of bulk density Of The Composite Flour.

The bulk density was determined according to the method described by Okaka and Dotter (1979). 50g of the sample were put into a 100ml graduated cylinder. The cylinders were tapped 50 times and the bulk density was calculated as weight per unit value.

$$\text{Bulk Density} = \frac{\text{loss volume x initial weight of sample}}{\text{Packed volume.}} \quad = \text{g/cm}$$

3.3.4 Swelling Power and Solubility Determination

This was determined by the Tanlkashi and Seil (1988) method. It involves weighing 1g of each of the samples into different 50ml centrifuge tube.50ml of distilled water was then added and mixed gently. The slurry was heated in a water bath at 70, 80, 90 and 100 respectively for 15 minutes. During the heating process the slurry were stirred gently to prevent lumping. After 15 minutes the tubes containing the paste was centrifuged at 3000rpm for 10 minutes after which the supernatants were decanted immediately and the weight of the sediment taken and recorded. The moisture content of the sediment gel was then determined to get the matter content of the samples.

$$\text{Swelling power} = \frac{\text{weight of sediment} - \text{solubility}}{\text{Weight of sample}}$$

$$\text{\% Solubility index} = \frac{\text{weight of soluble sample}}{\text{Weight of sample}}$$

3.4 Chemical analysis Of the Composite Flour

3.4.1 Determination of Moisture Content.

The moisture content was determined by an air oven method as described by AOAC (2002). 2g of the test samples were weighted in duplicates in the already weighed, dried Petri dishes. These were transferred in an air oven at about 105°C for about 24 hours. The samples were covered in the oven before being transferred to the desiccators and allowed to cool for about one hour and weighed. The dishes were returned to the oven and again reweighed until constant weights were obtained and expressed in percentages

$$\text{Percentage moisture} = \frac{\text{loss in weight x 100}}{\text{Weight of sample before drying}}$$

3.4.2 Determination of Fat content Of the Composite Flour

The soxhlet extraction method outlined by AOAC (2000) was used in determining the fat content of the samples. 2g of the samples were weighed and the weigh of the flat bottom flask was taken with the extractor mounded on it. The thimble was held half way in to the extractor and the weighed samples were carefully transferred into the thimble.

Extraction was carried out using petroleum ether (boiling point 40 – 60), the thimble was plugged with cotton wool, fully dropped into the extractor and extraction was carried out continuously for 8 hours. After extraction the solvent were removed by evaporation on a water bath and the remaining part of the flask were dried to 80 for 30 minutes in the air oven to dry the solvent and then cooled in a desiccators. The flask were reweighed and the percentage fat calculated as

$$\text{Percentage fat} = \frac{\text{Weight of Extracted fat x 100}}{\text{Weight of sample}}$$

3.4.3 Determination of ash content.

The ash content of the samples was determined using the procedure outlined by AOAC (2000). the weight of the crucible dish was taken, 2g of the sample was added to each of the crucible and placed in a furnaces rack and the temperature was set 500 for 16 hours until the sample was completely ashed. The ash in crucible dishes were removed and kept in a desiccators to cool, before they were weighed the percentage calculated as

$$\text{Percentage Ash} = \frac{\text{Total weight of extracted Ash} \times 100}{\text{Weight of sample}}$$

3.4.4 Determination of carbohydrate Content

The procedure outlined in AOAC (2000) was used in determining the carbohydrate content of the samples. This were calculated by difference of the moisture, fat, protein and ash contents subtracted from 100, given as

Carbohydrate content = 100 – (% protein + % moisture + % Ash + % Fat).

3.4.5 Determination of Energy value

The food energy value of the sample was determined according to the method described by Osbrone and Voogt (1978). The energy value is calculated in kilocalories.

Energy Value = (4 x protein)+ (9x fat) + (4 x carbohydrate)

3.4.6 Determination of protein Content

The macro Kjeidahls method described by AOAC (2000) method was used. 2g of the sample were weighed into 500ml Kjeldahl flask and tow tablet of selenium were added. To this 20ml of concentrated sulphuric acid (H_2SO_4) was added down the side of the flask stopper and swirled. The flask and its content were heated gently in a fume cupboard in an inclined position and swirled occasionally until the liquid were clear and free from black or brown colouration. The content of the flask were allowed to cool and diluted with 75ml of distilled water, 25ml of boric acid was put into a 250ml collection flask and placed under the collection spigot of the distilled apparatus. The digested samples were dissolved with 80ml of 40% sodium hydroxide solution (NaOH) and placed under the stoopered portion of the condenser. The solution were allowed to distill for 7 minutes or when the volume of ammoniacollected in boric acid in the receiever flask is 50ml and when the purple solution had truned green. The distillate was then titrated against 0.1m hydrocholoride (HC) acid to a greenish blue colour. A blank titration were also carried out. Percentage of protein was calculated as

$$\text{Nitrogen content} = \frac{A - B \times \text{Molarity of titre} \times 0.014 \text{ dilution faction} \times 100}{\text{Weight of sample}}$$

Percentage protein content = nitrogen content value x 6.25

Where A = volume of titre

B = Volume of blank

3.5 Sensory Evaluation of the Composite Flour

All samples were evaluated by sensory panelists. The panelists helps to describd the sensory characteristics of the product such as the taste, aroma, flavour and the mouth feel of the product. 100g each of the following samples were evaluated, the samples has a composition variation from two (2) raw materials cassava and maize flour, the variation differ from each samples in their percentage value. 100% of maize and cassava flour were mixed together at a ratio of 70:30 for sample one (1) the second sample also have a mixture of cassava and maize with ratio of 30: 70, like wise the third and fourth samples, to the last sample making seven (7) samples in all.

The samples were made into paste with water and cooked in boiling water for 20 to 25 minutes, stirring to avoid lumping until the flour gelatinized, after gelatilation the paste are cooked covered for another 5 minutes to a soft textured mountain like edible morse.

The product were judged organoleptically by ten (10) panelists drawn from various departments of federal university of technology Minna, Niger state, using a 5-point hedonic scale test an example of a preference test as described by ihekoronye and Ngoddy (1985). The term hedonic is defined as 'having ti do with pleasure'. It was carried out in connection with a questionnaire which consist of scales in which panelist expressed their degree of like or dislike of the product's colour, taste, appearance and overall acceptance. The rating for the seven (7) samples were given numerical values, ranging from extremely desirable to undesirable. The product samples were randomly coded and analyzed using the analysis of variance (ANOVA)

3.6 Statistical Analysis

The data obtained were statistically analyzed using the one way analysis of variance (ANOVA). Duncan's new multiple range test was used to obtain the significant difference between means of the proximate and the physicochemical analysis using the Statistica Package for Social Scientist (SPSS) version.

CHAPTER FOUR

4.0 Results and Discussion

4.1 Proximate Composition

The proximate analysis conducted for seven (7) samples from pounded yam-like product from corn and cassava are shown in the table 4.1 below. The results show that sample produced from a blend of corn and cassava in a ratio of 50 : 50 (cca 50:50) has moisture content 12.20 ± 2.00, ash value 2.10 ±0.50%, crude fibre content 3.10 ±1.00, with protein value of 2.40 ±0.50, fat content of 8.15± 1.50, and carbohydrate value of 84.25 ±1.25. The second sample which is a blend of 80% corn to 20% cassava (cca,80:20) has moisture content of6.47± 0.50, ash value of 2.67 ± 0.50, crude fibre value of 5.04 ± 1.00, however the protein value is high ranging from 2.63 ±0.50 compared to the other samples. The fat content of 8.47 ±1.00 and the carbohydrate content of 81.19 ±1.00.

The third sample a blend of 90% corn and 10% cassava, produced a moisture content of 7.20±0.10, ash content of 4.69± 1.00,crude fibre value of 2.63 ±1.00, crude protein from 2.63± 0.50,fat content of 7.27 ±1.00 and the carbohydrate content a little bit higher 82.79 ±1.50

However the fourth sample which was produced from a blend of corn and cassava 60:40 (cca,60:40) has a minimum moisture content of 6.60 ± 0.50, having higher ash content of 5.30 ±1.00, crude fibre of 4.20 ±1.00, crude protein of 1.75± 0.50 been low in value and one of the highest fat value of 9.45 ±2.00 and carbohydrate value of 79.30 ±1.00

The fifth sample (cca 40:60) has a moisture content of 9.60± 1.50,ash content of4.05±1.00, crude fibre of 4.72± 1.00, crude protein of 1.75±0.50 and lowest fat content of 6.77 ±0.50 and one of the highest carbohydrate content of 82.71±1.00.

Sample six which was a blend of (cca 70:30), it has one of the lowest moisture content of 7.00± 1.00, ash content of 5.00±1.00, crude fibre of 4.38±1.00, crude protein value of 2.63±0.50, highest fat content of 8.75±1.25 and with carbohydrate value of79.25±1.00.

However the last sample produced from a blend of corn and cassava in a ratio of 30:70 (cca 30:70) has a moisture content of 6.60±0.50, ash content of 6.08±1.50, with crude fibre of 2.14± 1.00, a little higher crude protein 1.90±0.50, minimum fat value of 10.57±2.00 and carbohydrate content ranging from 79.31±1.00 respectively.

Table 4.1 Proximate composition of Pounded yam-like Flour

Parameter	Cca (50:50)	Cca (80:20)	Cca (90:10)	Cca (60:40)	Cca (40:60)	Cca (70:30)	Cca (30:70)	Cc
CHO %	84.25±1.25	81.19±1.00	82.79±1.50	79.30±1.00	82.71±1.00	79.25±1.00	79.31±1.00	72.18±1.50
Protein%	2.40±0.50	2.63±0.50	2.63±0.50	1.75±0.50	1.75±0.50	1.90±0.50	2.63±0.50	12.61±1.50
Fat %	8.15±1.50	8.47±1.00	7.27±1.00	9.45±2.00	6.77±0.50	8.75±1.25	10.57±2.00	1.54±0.50
Ash %	2.10±0.50	2.67±0.50	4.69±1.00	5.30±1.00	4.05±1.00	5.00±1.00	6.08±1.50	0.75±0.10
E. V %	419.95±2.25	411.51±2.00	407.11±2.00	409.24±2.5	0398.77±1.00	406.27±1.50	419.97±1.05	369.50±2.50

4.2. Physicochemical properties of pounded yam-like flour

The physiochemical properties of pounded yam-like flour was also determined such as bulk density, water absorption capacity etc, so as to know the future use of the flour. The results of the analysis shown in table 4.1 the results revealed that (Cca 50:50) has a swelling capacity of 4.2± 0.50,water absorbing capacity of 1.43± 0.50 however its bulk density 12.78±1.50,its total titratable acidity was 0.41 0.01 and its pH is 6.59±0.15. The (Cca 80:20) has swelling capacity of3.85 0.50, its water absorbing capacity value is 1.66±0.45, Bulk density value is 7.93±1.00, Total titratable acidity 0.39 0.01 however it's pH value was 6.38 0.02.The third blen (Cca 90:10) showed swelling capacity of 4.30 0.50, water absorbing capacity Of 1.59±0.50, Bulk density of 13.33±2.00 however it's total titratable acidity was 0.41 0.50 and it's pH value was 6.19±0.05. The fourth sample (Cca 60:40) has swelling capacity of 3.96 ±0.50, water absorbing capacity of 1.56±0.50,Bulk density value 13.52 ±1.00 however it's Total titratable acidity was 0.54 0.05 and lastly its pH value was 6.62 ±0.50. The fifth sample (Cca 40:60) has swelling capacity of 3.42±0.40, water absorbing capacity of 1.50 ±0.05,Bulk density value of 17.38 0.50 the highest of them all with it's total titratable acidity value of 0.50 0.05 and pH value of 6.70±0.05.

The sixth sample (Cca 70:30) has one of the highest swelling capacity of 4.24±0.50, it's water absorbing capacity value of 1.41±0.50, it's bulk density of 9.67±0.50, however its total titratable acidity value was 0.50 0.05 and lastly is pH value was 6.74±0.50. Lastly the last sample (Cca 30:70) has swelling capacity of 3.85±0.50, water absorbing capacity of 1.60±0.040, bulk density of 11.45±1.00, its total titratable acidity of 0.45 0.05 and lastly it's pH value was 6.40±0.05 respectively.

Table 4.2 Physicochemical Properties of the pounded yam flour

Parameter	Cca (50:50)	Cca (80:20)	Cca (90:10)	Cca (60:40)	Cca (40:60)	Cca (70:30)	Cca (30:70)	Cc
B.D g/ml	12.78±1.50	7.93 ±1.00	13.33±2.00	13.52±1.00	17.28±0.50	9.67±0.50	11.45±1.00	0.31±0.05
S.C g/ml	4.28 ± 0.50	3.85 ± 0.50	4.30 ± 0.50	3.96 ± 0.50	3.42 ± 0.50	4.24 ± 0.50	3.85 ± 0.50	4.76±0.05
pH	6.59 ± 0.15	6.38 ± 0.02	6.19 ± 0.05	6.62 ± 0.50	6.70 ± 0.50	6.74 ± 0.50	6.40 ± 0.50	5.92±0.05
T.T.A	0.41 ± 0.01	0.39±0.01	0.41±0.05	0.54±0.05	0.50±0.05	0.50±0.05	0.45±0.05	0.42±0.01
WAC %	1.43 ± 0.50	1.66 ± 0.50	1.59 ± 0.50	1.56 ± 0.50	1.50 ± 0.50	1.41 ± 0.30	1.60 ± 0.40	1.00±0.50
Mc %	12.20±2.00	6.47±0.50	7.20±1.00	6.60±0.50	9.60±1.50	7.00±1.00	5.60±0.50	10.32±2.50
C F %	3.10±1.00	5.04±1.00	2.63±1.00	4.20±1.00	4.72±1.00	4.36±1.00	2.14±1.00	2.70±0.50

Key for table 4.1

CHO	Carbohydrate
E. V	Energy value
B. D	Bulk density
S. C	Swelling capacity
T. T. A	Total titratable acid
WAC	Water absorbing capacity
Mc	Moisture content
Cca 50:50	Ratio of corn to cassava 50:50
Cca 80:20	Ratio of corn to cassava 80:20
Cca 90:10	Ratio of corn to cassava 90:10
Cca 60:40	Ratio of corn to cassava 60:40
Cca 40:60	Ratio of corn to cassava 40:60
Cca 70:30	Ratio of corn to cassava 70:30
Cca 30:70	Ratio of corn to cassava 30:70
Cc	Control

4.3. Sensory evaluation of poundedyam-like flour

The sensory evaluation score of poundedyam-like flour is shown given in table 4.3 using 5% of significance for the six parameters considered such as external appearance, colour, taste, texture, mouthfeel, aroma and general acceptability.

All the seven samples where organoleptically evaluate by ten panelists with the control (poundedyam flour) making eight samples in all. Considering the level of significance the flour produced especially (Cca 70:30) and Cca 80:20) has highest value for colour, external appearance and aroma while the control (poundedyam) has the highest value for texture, mouthfeel and general acceptability, although ranking from the control, the other two samples (Cca 70:30 and Cca 80:20) come second with the third samples being (Cca 90:10) the rest of the samples showed significant difference in colour and aroma but were not significantly different in other parameters considered most especially mouthfeel.

Table 4.2 Sensory Evaluation for poundedyam- like Flour samples

Parameter%	Cca50:50	Cca80:20	Cca90:10	Cca60:40	Cca40:60	Cca70:30	Cca30:70	CC
Flavour	2.50±0.5	2.60±0.50	2.50±0.25	1.90±0.30	2.20±0.30	2.20±0.30	2.10±0.25	2.10±0.40
Texture	3.6± 0.50	2.00±0.20	3.00±0.30	2.70±0.30	3.70±.30	3.70±0.30	2.20±0.20	1.80±0.20
Aroma	2.50±0.20	2.50±0.20	2.80±0.20	2.30±0.30	2.10±0.40	2.40±0.2	2.10±0.40	2.40±0.20
Ext. App	3.20±0.20	1.80±0.20	1.90±0.20	1.90±0.20	2.20±0.30	2.40±0.30	1.80±0.20	1.90±0.20
Colour	2.60±0.30	1.80±0.20	1.90±0.10	2.00±0.02	2.10±0.30	2.20±0.30	1.60±0.30	1.90±0.10
Acct	3.40±0.10	2.00±0.30	2.60±0.30	2.40±0.03	3.10±0.30	3.50±0.30	2.30±0.20	2.30±0.20

Key

EXT. APP	External Appearance
Acct	General Acceptability
Cca 50:50	Ratio of corn to cassava 50:50
Cca 80:20	Ratio of corn to cassava 80:20
Cca 90:10	Ratio of corn to cassava 90:10
Cca 60:40	Ratio of corn to cassava 60:40
Cca 40:60	Ratio of corn to cassava 40:60
Cca 70:30	Ratio of corn to cassava 70:30
Cca 30:70	Ratio of corn to cassava 30:70
CC	Control
Cf	Crude fibre

4.4 Discussion of Result

The result from the proximate composition shows that the carbohydrate content of poundedyam-like flour produced was higher than that of poundedyam flour. This suggests that the flour produced (composite flour) has higher calorific value than pounded yam. Although the protein value of flour produced was lower compared to that of poundedyam flour, but the protein content was still above the recommended daily allowance which has been standardized by WHO/FAO to be 0.82 and 0.81g protein /kg/day (Okaka et al, 2002). The fat content of the flour produced was higher than that of poundedyam flour indicating that the product will give more calories. The ash content of the flour produced has higher value, if compared to that of poundedyam. This may be because the flour is higher in fibre and also in food value.

The energy value was also observed to be higher in flour produced. This could be due to the high fat and carbohydrate content of the flour, further more the flour produced has more starch which indicated that if well stored could stay for longer time.

The results of the physicochemical properties of the flour produced (ca,c composite) was also compared with that of poundedyam flour (control). The swelling capacity of the samples, is higher than that of the control, but are relatively close in terms of variation, may be as a result of size distribution, degree of association of amylase, amylopectin and surfactants absorbed to the surface of starch granules (Collison 1968; Sathe and Salunkhe, 1981). The water absorbing capacity of the samples are higher than the control this could be because of the higher starch content of the sample, which on heating induced crystalline melting which combine to cause overall changes in the starch granules allowing absorption of water (Sapade and Grys, 1991).The pH and total titratable acidity of the samples are comparable to the control. The pH value shows that the sample and the control are both slightly acidic (weak acid).

The sensory evaluation result revealed that there were differences between samples and the control, while some of the samples were significantly different, some were not, such as (Cca 80:20) (Cca 70:30), having a closer value in terms of general acceptability, appearance, texture and colour. However I discovered that as the ratio of cassava to corn increases the aroma are more pronounced but the texture, colour and general acceptability decreases.

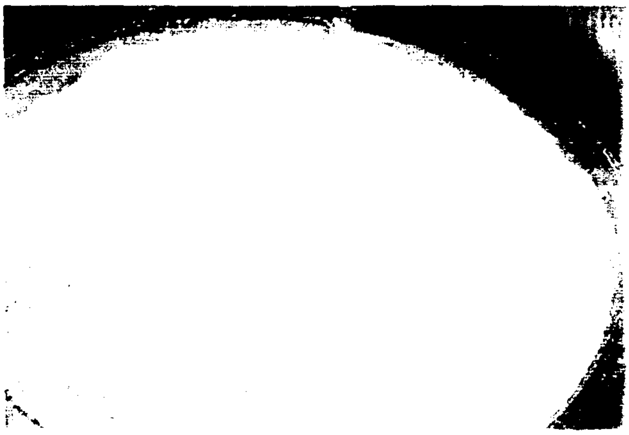
Peeling and cutting of cassava into chip

Bitter cassava in bags

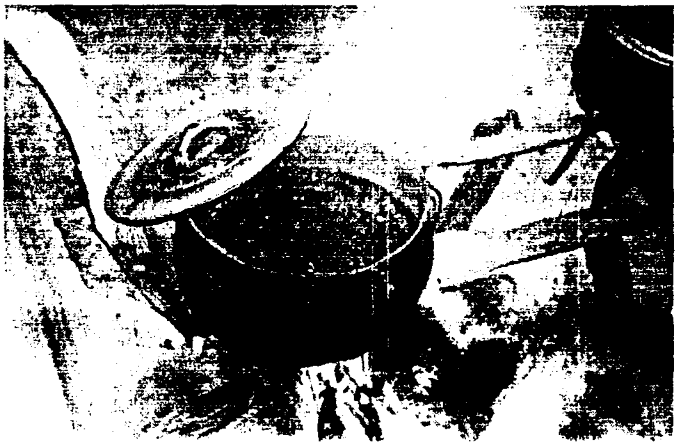
Hydraulic Screw jack method of extraction of the Hydrogen cynide

Gari production process

Processed Maize flour



Processed Cassava flour



Boiling water at 100°C

The Maize paste

Cassava/Maize composite ready to eaten

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Based on the analysis conducted with respect to the chemical composition and physicochemical properties of poundedyam-like flour produced from corn and cassava in respect to the control(pounded yam flour), it could be deducted that the flour produced is of high economy value considering its carbohydrate, fats and energy value, which are higher than that of poundedyam. Although the physicochemical properties such as swelling capasity (g/ml), total titratable acid, water absorbing capacity(g/ml) and the pH shows no significant (p=0.05) difference compared to the flour produced. However the sensory evaluation conducted revealed that there is differences between samples and the control(poundedyam flour), while the samples have no significant (p=0.05) difference in terms of flavour and mouthfeel compared to the control, some were significantly different in terms of general acceptability, appearance, texture and colour. Although out of the seven (7) samples produced ,two (2) samples showed some level of significance to the control (poundedyam flour).

Based on these results it is concluded that three samples (Cca 80:20, Cca70:30,) has no significant (p=0.05) difference compared to the control (poundedyam flour) and are more organoleptically accepted.

5.2 Recommendation

There is the need for further study and research into the following areas;

1. The effect of fortification on the quality of the flour.

2. Improvement on the nutritional composition and standardization of the flour produced so as to meet both local and international standards.

3. Storage stability of the flour.

4. Usage of the flour for the production of snack.

REFERENCES

Alabi, S.O King, J.G, Ado D.D, Yurbiser, E.O Ajala S.O; shyouemimo , Tatfa, (2003). Progress in breeding for low nitrogen stress on moue in the Northern guinea savanna in: maize revolution in West &Central Africa. Proc.of a regional maize Workshop.

Berger,J.(1962) Maize production and the manuring of maize,centre d' etude de l' Azote, Geneva.

Boyer, C.D and Shannon, J.C (1987) carbohydrate of the Kernel. In S.A Wabson and P.E Ramstad, eds, corn chemistry and technology 253 – 272. St paul minn, USA America Associ. Cereal chem.

Bradbury J.H and Hollowy W. D (1988) chemistry of forpical reatf crops:signicance for nutrition and agriculture in the pacific crops: significances for nutrition and agriculture in the pecific lustration centre for inter5national Agricultural research monograph

Bressani, R.(1962) Effect of acid inbalance Nitrogen retention. 1, Effect of a relative deficiency of tryptophan in dogs J.Nutrition.(78) ;365- 370.

Bressani, R,(1963) Effected of Amend acid imbalance on ention ii interrelationships between method mine, value, isolueine and threonine as supplements to corn protean for doges j.Nutrition (79): 389- 394.

Bressani, R.(1971) Effect of Amimo Acid supplementation of cereal grain flours tested in children. In N.S. Sehrimshaw and A.N. AltseHUL, eds, Amino acid fortification of protein feeds 184204. Corn bridge, mass, USA, mit process.

Bressani, R (1990). Chemistry, technology and nutritive of maize fortihas. Food Revo/nt,6:275-264

Chritianson, D.D, Wall, J.S Dimler,R.J and Booth,A.N (1980). Nutritionally available niacin in corn, isolatead and biological activity.J .Agric. food chem, 16:100 -104

CIMMYT (1994) maize facts and trends report two an analysis changes in third world food and feed uses of maize

Cock J.H (1985) Cassava,New potential for a neglected crop,Bould, Colorado:Westview press.

Knowles E.J Venneslannd B. Westley E and Wissung F (eds) Cyainde in biology P.193 New York.

Collison,R. (1968). In: Sarch and it's derivatives (j:A Randley ed) Chapman and Hill London.4th ed.,p.182.

Elton G.A.H and Fisher, N (1970) flour and bread BNF inf. Bull. No 4, March:17.

Fakoreder M.A.B,Badu-Apraku, B, Kamara, A, Mallkir A. and Ajala, S.O (2003) maize revolution in west and central Africa an over view in maize revolution in west central Africa proc of regional maize

F A O- (1989) utilization of tropical foods: cereals food and nutrition paper 47/1 rome.

F A O , (1997).maize in Human N utrition. Rome.

Hogan, A.G,Gillesple G.T, Kocturk,O,Odell B.L and Flynni L.M. (1955). The percentage of protein in corn and its nutritional properties. J. Nutrition, (577:225-239)

Howe, G.E. Janson G.R. and Ginfillan, G.w. (1965). Amino acid supplementation of cereal drains as related to the world food supply. American.J. Clinical nutrition (16) 315-320.

Kent, N.L. (1975) Technology of cereal, 2nd edition, pergamon press Oxord.

Kinsella, J.C and Samson,S.A and Abel B.C (1979) Funtional properties or Novel properties of Flour. Journal of Food Science (41) 268-289.

Landry, J.and Moureaux T. (1982) Distribution and amino acid composition of protein fraction in opaque- 2 maize grain phytochemistry (21): 1865-1869.

L.M (1955).The percentage of protein in corn and it's nutritional properties.. Nutrition (577:225-239)

Merzy E.F Batis, L.S. and Nelson, O.E (1964) Mulant gene that changes protein composition and increase lysine content of maize endosperm. Science; 149-280.

Nelson, J.A., Glass,R.L and Geddes, W.F (1963) The tryglycerides and fatty acids of wheat. Cerent chem..40:343.

OSBORNE,J.B.(1907) the protein of the wheat. Carnegie inst. Wash., Pub. No. 84.

Paul, A.A and Southgate, D.A .T (1978) Mc Cance and Widdowson's .The composition of foods' 4th edition H.M.S, London.

Sapade,P.A and Le Grys G.A (1991). An investigation into the effect of extrusion cooking on the properties of maize starch extrudate. Nigeria Food Journal.9: 49-66.

Sathe,S.K and Salunkhe. D.K (1981). Funtional properties of the great Northern bean (Phaseolus Vulgaris L) proteins, emulsion, Foaming, Viscosity and Gelatinization properties. Journal of food science 44, 564-573.

Shoilenberger, J.H and Jaeger, C.M (1943) Wheat it'sproduct and uses. Northern Regional Research Laboratory proria. 111 U.S.A.

dietary fibre. F. hum. Nutr: 30:30.

Waston,S.A (1962) The yellow carteniod pigments of corn in W. Hechendorn and J.J. suther land. Eds proceeds of corn Resourse conference (17th washinglon, D.C USA, Am, seed trade

Waston.S.A, Ramstad, P.E (eds) (1987) Corn, chemistry aand Technology American.

Wheatley C.C and Best, R (1991) How ca traditional forms of nutrition e maintained in uran centers: the case of cassava Entwicklung and Landlicher Raun 1: 13-16

Yen, J.T, Jensen, A.H and Baker, D.H (1976) Assessment of the concentration of biologically available vitamin B6 corn meal.J. Animal Science, (42) 866-870.

FAO 1992, production yearbook for 1991 Rome: Author

Dorosh, P. 1988. The economics of root and tuber crops in Africa, RCMP Research Monograph. Ibadan, Nigeria: IITA.

Appendix

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	Upper Bound	Minimum	Maximu
EXTERNAL	CA7CO3	10	2.4000	1.17379	.37118	1.5603	3.2397	1.00	4.0
	CA3CO7	10	1.8000	.42164	.13333	1.4984	2.1016	1.00	2.0
	CA8CO2	10	1.8000	1.03280	.32660	1.0612	2.5388	1.00	4.0
	CA6CO4	10	2.2000	.91894	.29059	1.5426	2.8574	1.00	4.
	CO6CA4	10	1.9000	.56765	.17951	1.4939	2.3061	1.00	3.0
	CAO1	10	1.9000	.99443	.31447	1.1886	2.6114	1.00	4.0
	C5O1	10	3.2000	1.31656	.41633	2.2582	4.1418	1.00	5.0
	COCA	10	1.9000	.99443	.31447	1.1886	2.6114	1.00	4.0
	Total	80	2.1375	1.02801	.11493	1.9087	2.3663	1.00	5.0
COLOUR	CA7CO3	10	2.2000	1.03280	.32660	1.4612	2.9388	1.00	4.0
	CA3CO7	10	1.6000	.51640	.16330	1.2306	1.9694	1.00	2.0
	CA8CO2	10	1.8000	.78881	.24944	1.2357	2.3643	1.00	3.0
	CA6CO4	10	2.1000	.56765	.17951	1.6939	2.5061	1.00	3.0
	CO6CA4	10	2.0000	.47140	.14907	1.6628	2.3372	1.00	3.

	CAO1	10	1.9000	.73786	.23333	1.3722	2.4278	1.00	3.00
	C5O1	10	2.6000	1.07497	.33993	1.8310	3.3690	1.00	5.00
	COCA	10	1.9000	.73786	.23333	1.3722	2.4278	1.00	3.00
	Total	80	2.0125	.78746	.08804	1.8373	2.1877	1.00	5.00
TEXTURE	CA7CO3	10	3.7000	.67495	.21344	3.2172	4.1828	2.00	4.00
	CA3CO7	10	2.2000	.78881	.24944	1.6357	2.7643	1.00	3.00
	CA8CO2	10	2.0000	.81650	.25820	1.4159	2.5841	1.00	4.00
	CA6CO4	10	3.7000	.48305	.15275	3.3544	4.0456	3.00	4.00
	CO6CA4	10	2.7000	.48305	.15275	2.3544	3.0456	2.00	3.00
	CAO1	10	3.0000	1.05409	.33333	2.2459	3.7541	1.00	4.00
	C5O1	10	3.6000	.96609	.30551	2.9089	4.2911	2.00	5.00
	COCA	10	1.8000	.63246	.20000	1.3476	2.2524	1.00	3.00
	Total	80	2.8375	1.03659	.11589	2.6068	3.0682	1.00	5.00
AROMA	CA7CO3	10	2.4000	.84327	.26667	1.7968	3.0032	1.00	4.00
	CA3CO7	10	2.1000	.73786	.23333	1.5722	2.6278	1.00	3.00
	CA8CO2	10	2.5000	.84984	.26874	1.8921	3.1079	1.00	4.00
	CA6CO4	10	2.1000	.56765	.17951	1.6939	2.5061	1.00	3.00
	CO6CA4	10	2.3000	.48305	.15275	1.9544	2.6456	2.00	3.00
	CAO1	10	2.8000	.91894	.29059	2.1426	3.4574	2.00	4.00
	C5O1	10	2.5000	.97183	.30732	1.8048	3.1952	1.00	4.00
	COCA	10	2.4000	.84327	.26667	1.7968	3.0032	1.00	4.00
	Total	80	2.3875	.78746	.08804	2.2123	2.5627	1.00	4.00

FLAVOUR	CA7CO3	10	2.2000	.78881	.24944	1.6357	2.7643	1.00	3.00
	CA3CO7	10	2.1000	.56765	.17951	1.6939	2.5061	1.00	3.00
	CA8CO2	10	2.6000	.69921	.22111	2.0998	3.1002	2.00	4.00
	CA6CO4	10	2.2000	.63246	.20000	1.7476	2.6524	1.00	3.00
	CO6CA4	10	1.9000	.56765	.17951	1.4939	2.3061	1.00	3.00
	CAO1	10	2.5000	.70711	.22361	1.9942	3.0058	2.00	4.00
	C5O1	10	2.5000	.70711	.22361	1.9942	3.0058	2.00	4.00
	COCA	10	2.1000	.56765	.17951	1.6939	2.5061	1.00	3.00
	Total	80	2.2625	.67023	.07493	2.1133	2.4117	1.00	4.00
ACCEPT	CA7CO3	10	3.5000	.52705	.16667	3.1230	3.8770	3.00	4.00
	CA3CO7	10	2.3000	48305	.15275	1.9544	2.6456	2.00	3.00
	CA8CO2	10	2.0000	.47140	.14907	1.6628	2.3372	1.00	3.00
	CA6CO4	10	3.1000	.31623	.10000	2.8738	3.3262	3.00	4.00
	CO6CA4	10	2.4000	.51640	.16330	2.0306	2.7694	2.00	3.00
	CAO1	10	2.6000	.96609	.30551	1.9089	3.2911	1.00	4.00
	C5O1	10	3.4000	.84327	.26667	2.7968	4.0032	2.00	4.00
	COCA	10	2.3000	.67495	.21344	1.8172	2.7828	2.00	4.00
	Total	80	2.7000	.80190	.08965	2.5215	2.8785	1.00	4.00

Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.

EXTERNAL	2.134	7	72	.051
COLOUR	2.138	7	72	.050
TEXTURE	1.341	7	72	.244
AROMA	1.599	7	72	.150
FLAVOUR	1.096	7	72	.375
ACCEPT	4.481	7	72	.000

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
EXTERNAL	Between Groups	15.988	7	2.284	2.436	.027
	Within Groups	67.500	72	.938		
	Total	83.488	79			
COLOUR	Between Groups	6.288	7	.898	1.515	.176
	Within Groups	42.700	72	.593		
	Total	48.988	79			

TEXTURE	Between Groups	42.988	7	6.141	10.553	.000
	Within Groups	41.900	72	.582		
	Total	84.888	79			
AROMA	Between Groups	3.687	7	.527	.837	.560
	Within Groups	45.300	72	.629		
	Total	48.988	79			
FLAVOUR	Between Groups	4.188	7	.598	1.376	.229
	Within Groups	31.300	72	.435		
	Total	35.488	79			
ACCEPT	Between Groups	22.000	7	3.143	7.857	.000
	Within Groups	28.800	72	.400		
	Total	50.800	79			

Post Hoc Tests

Homogeneous Subsets

EXTERNAL APPEARANCE

Duncan

TRT	N	Subset for alpha = .05	
		1	2
CA3CO7	10	1.8000	
CA8CO2	10	1.8000	
CO6CA4	10	1.9000	
CAO1	10	1.9000	
COCA	10	1.9000	
CA6CO4	10	2.2000	
CA7CO3	10	2.4000	2.4000
C5O1	10		3.2000
Sig.		.240	.069

Means for groups in homogeneous subsets are displayed.

a Uses Harmonic Mean Sample Size = 10.000.

COLOUR

Duncan

N Subset for

alpha =

		.05	
TRT		1	2
CA3CO7	10	1.6000	
CA8CO2	10	1.8000	
CAO1	10	1.9000	1.9000
COCA	10	1.9000	1.9000
CO6CA4	10	2.0000	2.0000
CA6CO4	10	2.1000	2.1000
CA7CO3	10	2.2000	2.2000
C5O1	10		2.6000
Sig.		.138	.078

Means for groups in homogeneous subsets are displayed.

a Uses Harmonic Mean Sample Size = 10.000.

TEXTURE

Duncan

	N	Subset for alpha = .05			
TRT		1	2	3	4
COCA	10	1.8000			
CA8CO2	10	2.0000	2.0000		
CA3CO7	10	2.2000	2.2000		

CO6CA4	10		2.7000	2.7000	
CAO1	10			3.0000	3.0000
C5O1	10				3.6000
CA7CO3	10				3.7000
CA6CO4	10				3.7000
Sig.		.274	.055	.382	.064

Means for groups in homogeneous subsets are displayed.

a Uses Harmonic Mean Sample Size = 10.000.

AROMA

Duncan

TRT	N	Subset for alpha = .05
		1
CA3CO7	10	2.1000
CA6CO4	10	2.1000
CO6CA4	10	2.3000
CA7CO3	10	2.4000
COCA	10	2.4000
CA8CO2	10	2.5000
C5O1	10	2.5000
CAO1	10	2.8000
Sig.		.096

Means for groups in homogeneous subsets are displayed.

a Uses Harmonic Mean Sample Size = 10.000.

FLAVOUR

Duncan

TRT	N	Subset for alpha = .05	
		1	2
CO6CA4	10	1.9000	
CA3CO7	10	2.1000	2.1000
COCA	10	2.1000	2.1000
CA7CO3	10	2.2000	2.2000
CA6CO4	10	2.2000	2.2000
CAO1	10	2.5000	2.5000
C5O1	10	2.5000	2.5000
CO8CA2	10		2.6000
Sig.		.082	.149

Means for groups in homogeneous subsets are displayed.

a Uses Harmonic Mean Sample Size = 10.000.

ACCEPTABILITY

Duncan

TRT	N	Subset for alpha = .05 1	2	3
CA8CO2	10	2.0000		
CA3CO7	10	2.3000		
COCA	10	2.3000		
CO6CA4	10	2.4000		
CAO1	10	2.6000	2.6000	
CA6CO4	10		3.1000	3.1000
C5O1	10			3.4000
CA7CO3	10			3.5000
Sig.		.061	.081	.187

Means for groups in homogeneous subsets are displayed.

a Uses Harmonic Mean Sample Size = 10.000.