THE EFFECT OF COOKING ON PROXIMATE AND PHYSICOCHEMICAL PROPERTIES OF MAIZE (*Zea mays*)

BY

KOLADE RISIKAT BECKY

2003/14824EA

DEPARTMENT OF AGRICULTURAL AND BIORESOURCES ENGINEERING

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGER STATE

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BEING A FINAL YEAR PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B. ENG.) DEGREE IN AGRICULTURAL AND BIORESOURCES ENGINEERING,

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE.

NOVEMBER, 2008

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, diploma or certificate at any University or Institution. Information derived from personal communications, published and unpublished works of others were duly referenced in the text.

_____ _____

Kolade Risikat Becky **Date**

2003/14824EA

CERTIFICATION

This is to certify that this research work "The Effect of Cooking on Proximate and Physicochemical Properties of Maize (*Zea mays*)" carried out by Kolade Risikat Becky of the Department of Agricultural and Bio-Resources Engineering, Federal University of Technology, Minna, Niger State, meets the regulations governing the award of the degree of Bachelor of Engineering (B. ENG.), and it is approved for its contribution to scientific knowledge and literary presentation.

Engr. Dr. O Chukwu	**Date**
(Project Supervisor)	
	26/11/2008
Dr. (mrs) Z.D OSUNDE	**Date**
(H.O.D)	
	19-11-08
External Examiner	**Date**

DEDICATION

I dedicate this project to the most magnificent God and my best friend Shomoye Kehinde.

ACKNOWLEDGEMENTS

All my sincere gratitude goes to the most Magnificent, Awesome, the Trinity, God Almighty for giving me the strength, grace, knowledge and guidance to overcome all the difficulties encountered during my undergraduate study. I hereby say "Glory be to God".

My special thanks and sincere gratitude also go to Engr. Dr. O. Chukwu, my supervisor for his professional guidance, leadership and kind interaction during the course of this project work. I acknowledge the effort and knowledge imparted on me by my HOD, Engr. Dr. (Mrs.) Z.D. Osunde, my level adviser Engr. Peter Adeoye, Engr. Adamu and all the Lecturers of Agricultural and Bioresources Engineering Department, Federal University of Technology, minna. May GOD bless you all (Amen).

My sincere gratitude goes to my mother, Mrs. S. Kolade, and my precious Heroine Mrs. N. Orowa, Miss H Ossai; there is no one like you all. Words cannot express my gratitude and appreciation, you have been the best things that have happened to me, you took great care of me right from the onset to my present stage. I pray that God Almighty grants you all long live, and prosperity throughout your existence, (Amen). Also to my brothers, Mr. Nasir B. Kolade, Mr. Abiodun M. Kolade. Mr. Idowu V. Kolade, Mr. Alaba G. Kolade, and to my loving sisters Oluwayemsi K. Kolade, and Oluwatoyin F. Kolade, and to my precious cousins the (Walnik) Orowa's family. Mere words cannot explain what you all mean to me. Things have not been easy without you all; I appreciate you all, as you have continued to be my company in all my life endeavours. Thank you for being there for me.

My sincere gratitude goes to my friend Mr. K. Shomoye for his wonderful supports. May God never forsake you in the time that matters most (Amen). I also appreciate the contribution of Adegbuyi Salau, Musa Jubril aka (MJ), and those that appear to be good for their immense contribution and to all my fellowship members of Redeemed Christian

Fellowship and colleagues that I cannot mention, I say a big thank you for being there when I needed you most and for standing by me through the years.

Finally, I am grateful to the school authority for giving me the opportunity to study this course. May God bless you all (Amen).

ABSTRACT

The effect of cooking on proximate and physicochemical properties of maize (white and yellow) was extensively carried out to determine the physical and chemical components as it relates to their nutritional value. The analysis of maize was carried out under some laboratory tests to determine the moisture content, carbohydrate, crude protein, crude fibre, lipid, ash, minerals and vitamins. It was discovered that there were some differences in the physicochemical properties of the two different varieties of maize i.e. white and yellow. White maize contains 12% of moisture content, 65.79% of carbohydrate, 11.87% crude protein, 14.62% of crude fibre, 6.22% of lipid, 4.1% of ash, 7.80% of vitamin A and Vitamin C 10.40%.

Yellow maize however contains 11.92% of moisture content, 61.30% of carbohydrate, 11.56% crude protein, 15.29% of crude fibre, 6.66% of lipid, 5.21% of ash, 7.14% of vitamin A and vitamin C 14.29%.

Yellow maize has more composition of vitamin A than white maize, while white maize has more composition of vitamin C than yellow maize. From the analysis carried out in this work, it was found that maize irrespective of its varieties contains high nutritional value, so people should concentrate on both varieties rather than concentrating their consumption on white variety only.

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CHARPTER ONE

1.0 INTRODUCTUION

1.1 Background to the Study

Maize (*Zea mays*) is the American-Indian word for Corn, It means "that which sustains life". It is one of the most important cereal staple foods in the world today after wheat and rice. It is a source of nutrients for both humans and animals and a source of basic raw material for the production of starch, oil and protein, alcoholic beverages, food sweeteners and bio-fuel. Maize belongs to the grass family, *Gramineae*, and is a tall annual plant with an extensive fibrous root system. It is a cross pollinating specie, with female (ear) and male (tassel) flowers in separate places on the plant. The grain develops in the ears, or cobs, often one on each stalk. The green plant, made into silage, has been used with much success in the dairy and beef industries. Maize harvesting is highly mechanical in developed countries of the world, while it is still done manually in developing countries. The mechanized system removes not only the ear from the plant but also the grain from the cob, while manually harvesting requires initial removal of the ear which is shelled at a later stage. Maize is always harvested when the moisture content is in the range of 18 to 24 percent. Moisture content of maize during harvest have much impact, as the lower the moisture content the less the damage to the kernels. After harvest of the grain, the dried leaves and upper part, including the flowers, are still used today to provide relatively good forage for ruminant animals owned by many small farmers in the developing countries (Deobley *et al.*, 1996).

The erect stalks, which in some varieties are strong, have been used as long- lasting fences and walls. Grains make up about 42 percent of the dry weight of the plant. The grains or

kernels are often white or yellow in colour, although black, red and mixtures of colours are also found. There are a number of grain types, distinguished by differences in the chemical compounds deposited or stored in the grain or kernel. Maize constitutes an important source of carbohydrates, proteins, vitamins and minerals. As an energy source, it compares favorably with root and tuber crops. Maize kernels develop through accumulation of the products of photosynthesis, root absorption and metabolism of the maize plant on the female inflorescence called the ear. This structure may hold from 300 to 1000 single kernels depending on the number of rows, diameter and length of the cob (Galinat, 1977).

Maize is an important staple food in sub-African region. It is important to study the proximate composition and physicochemical properties of cooked maize to determine its nutritive value. The nutritive value of maize grain may increase or decrease depending upon the method in which it is processed. Cooking of maize has been reported to reduce the concentration of protein, lipids, and crude fibre. In most regions of the tropics and sub tropics, maize is a staple crop and the method of processing ought to be such that it will preserve the nutritional value of the agricultural material. During harvest the ears of maize are removed from the maize plant either by hand or mechanically. The husks covering the ear are first stripped off, and then the kernels are separated by hand or more often, by machine. Maize is processed into different forms of food for large numbers of people in the developing world, providing significant amounts of nutrients, in particular calories and proteins. An intake of 226g of tortillas (processed maize) by weaned three-year-old children, provide about 47 percent of their calories *(Garcia et al., 1978).*

F.A.O. (1984) showed that 22 of 145 countries had a maize consumption of more than 100g per person per day. However, the chemical components and nutritive value of maize do not lose their susceptibility to change when the grain / kernel is harvested. Subsequent links in the

food chain such as storage and processing, may also cause the nutritional quality of maize to decrease significantly or even worse, make it unfit for either human and animal consumption or industrial use.

The major chemical component of the maize kernel is Starch. Starch provides up to 72-73 percent of the kernel weight (*Boyer et al.,* 1987). Other Carbohydrates are simple sugars present as glucose, sucrose and fructose.

Another important chemical component of maize is protein. It's vary in common varieties from 8 to 11 percent of the kernel weight and is found in the endosperm. The protein in maize kernels is made up of at least five different fractions (*Landry et al.,* 1982) they are albumins, globulins and non protein nitrogen amount to about 18 percent of total nitrogen, in a distribution of 7 percent, 5 percent and 6 percent respectively. Oil and fatty acids are next chemical components found in maize kernel and come mainly from the germ. They are genetically controlled, with values ranging from 3 to 18 percent. The high consumption of maize by the human population in a number of countries in Africa and the well-established lysine and tryptophan deficiencies in maize protein motivated the search for a maize kernel with higher concentrations of these essential amino acids in its protein.

After carbohydrate, protein and fats, dietry fiber is the next chemical component found in the greatest amounts. It is found in the pericarp and the tip cap and slightly provided by the endosperm cell walls and germ cell walls. Other minute chemical components found are carbohydrates other than starch in small amount in form of total sugars and some minerals slightly lower than the crude fibres which are found in the germ of the kernel. They are fat soluble and water soluble vitamins. Maize kernel contains two fat-soluble vitamins. Provitamin A or Carotenoids, and vitamin E. Carotenoids are found mainly in yellow maize in amount that

may be genetically controlled while white maize has little or no carotenoids. The beta–carotene content is an important source of vitamin A, but unfortunately yellow maize is not consumed by humans as much as white maize (*Fussell,* 1992). Water soluble vitamins are found mainly in the aleurone layer of the maize kernel, followed by the germ and endosperm. This distribution analysis is important towards the preparation of this research work.

1.2 Statement of the Problem

Despite the fact that maize consumption has been accepted world wide as a staple food, people do not know the effects of cooking on its proximate composition and physicochemical properties.

1.3 Objectives of the Study

1. To determine the effect of cooking on proximate composition of maize.
2. To determine the effect of cooking on the physicochemical properties of maize.

1.4 Justification of the Study

In most regions of the tropics and sub tropics, maize is a staple crop and the methods of processing ought to be such that will preserve the nutritional value of the agricultural material. Poor knowledge of the effect of cooking on maize may be responsible for cooking maize to the point of depletion of its nutrients.

Therefore the study of the effect of cooking on proximate and physicochemical properties of maize is an attempt to provide objective measurements resulting in meaningful data on maize when subjected to cooking.

These data will generally aid food industries to select appropriate methods of cooking and processing maize that would result in the preservation of its nutrients, hence, the need for this study.

1.5 Scope of the Study

The scope of this work is limited to the determination of the proximate composition and physicochemical properties of maize (white and yellow maize).

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Historical Evolution of maize.

Maize is a cereal plant of the *Gramineae* family of grasses that constitutes the most wildly distributed food plant in the world. Maize is grown in diverse regions and climates but most probably originated from Central America, particularly in Mexico from where it spread northward to Canada and southward to Argentina. The oldest maize, about 7000 years old, was found by Archeologists in Teotihuacan, a valley near Puebla in Mexico. It has been established that modern maize evolved from *teosinte* (God's corn), or *Zea mays* (Deobley *et al., 1990*)

In spite of its great diversity of form, all main parts of maize known today were apparently already being produced by the native populations when it was discovered. Furthermore, evidence from botany, genetics and cytology has pointed to a common origin for every existing type of maize. The survival of the oldest maize and its distribution depended on humans who harvested the seed for planting. At the end of the fifteen century after the discovery of the American continent by Christopher Columbus, maize was introduced into Europe through Spain. It then spread through the warmer climates of the Mediterranean and later to northern Europe. (*Mangelsdorf et al.*, 1939), stated that the maize is grown in every suitable agricultural region of the world and that a crop of maize is being harvested somewhere around the globe every month of the year. Maize crop is harvested in regions below sea level the Caspian plain and at altitudes of more than 4000m in the Peruvian Andes of South America. Although it remains unclear who first introduced maize to Europe, Africa, and the Old world more generally, a number of scholars now argue that the Portuguese colonies of Africa served as the initial conduit to the diffusion of maize in that hemisphere. Maize, beans and peppers diffused into the

Balkans, or southeastern Europe, India, and the Ottoman Empire in the period following the voyages of Columbus. (*Andrew,* 1993*),* So profound was the impact of maize on the African economy that, like Mesoamerica, culture and society, subsistence and settlement, political economy and gender relations, and the respective cuisines and culinary technologies of each of these vast regions were rapidly transformed to accommodate the adoption of maize and those human diasporas with which it was associated.

The unique maize-based cultural complex of agricultural practices, extensive settlement patterns, and storage, distribution, and food processing technologies identified with maize cultivation in fact fueled much of the transformation in question. It has been acknowledged that the adoption of maize has been the primary engine driving the transformation of the African social, political, and economic landscape for the many societies that have been swept up in this new agricultural revolution (Derek, *et al.,* 1997).

However, it is becoming increasingly evidence that those agricultural practices identified with maize , such as Sweden cultivation (another method of harvesting maize), extensive or shifting settlement patterns that are, in turn, identified with Sweden systems(another method of harvesting maize), the processing of maize with basalt grinding slabs, the female domination of these labour-intensive food processing and storage traditions, and the emerging role of women in the maize dominated market place have all played significant roles in the transformation of the African political economy. Many African countries which initially centred their cultivation on such cereal crops like millet have been displaced by maize. This has much to do with the changing face of African cuisine at the most fundamental level of analysis, and more generally, at the interface of cultural change and transformation.

Maize is turned into many delicacies in Africa sub-regions. Africans prepare maize porridge – called *kpekple* in Ghana, *bidia* in Democratic Republic of Congo, *sadza* in Zimbabwe, *putu* in Zululand, *mealie* in South Africa, *posho or ugali* in East Africa, *agidi or eko* in Nigeria-consumed by millions. Maize is eaten and used in different forms e.g. the preparation of pap in some countries or solid food (in form of *moi-moi*) and maize meal *(tuwo masara).* A family of 7-10 can consume between 2-3kg a day. (*Byerlee, et al.,* 1997) tested various methods of cooking maize and sorghum as well as mixtures of the two grains. The methods tested included the traditional one, steam cooking as tested by *Khan et al.*, (1982), and a method using reflux (condensing) system. They found that the method of cooking affect the proximate composition and physicochemical properties of maize.

Virtually no African country has remained untouched by the diffusion and exchange of maize, and the agricultural practices on the African continent range from the simple sowing of maize kernels along rivers and streams to the cultivation of maize in household gardens (*Brandes et al.,* 1992). These traditional practices are primitive compared to the magnitude and intensity of agricultural business development and investment in commercially viable maize agricultural field systems.

2.2 Structure of Maize

Maize is described outside of the so-called Mesoamerica triumvirate of maize (culture area), beans and squash. Early Mesoamerican (culture area) peoples planted these crops together, often planting beans and squash adjacent to maize so as to provide the former plants stalks on which to extend their vines. Mesoamerican cuisine similarly combined the products of these plants in a culinary mix that reinforced and supplemented the otherwise niacin-poor composition of maize-dominant dietary practices. Without these supplements, or the lime processing inherent

in the production of maize flour (*masa)* used in the production of tortillas and related foodstuffs, maize-dominated diets have the potential to result in the spread of the skin disease pellagra (*Brandes et al.,* 1992). Pellagra spreads rapidly and in epidemic proportions throughout all the African and European countries that first adopted maize consumption without similarly adopting the critically important of production of lime-treated masa.

Maize environments in the third world have been classified into four major types: tropical, subtropical, temperate, and highlands. As of 1996, tropical environments accounted for 36.7 million hectares, or 45 percent of the total area under maize cultivation in developing countries; temperate environments accounted for 22.3 million hectares; or 27 percent of the total; sub tropical environments accounted for 17 million hectares, or 21 percent of the total; highland environments constituted 6.2 million hectares, or 8 percent of total area under maize cultivation in the developing world (*Dowswell et al.*, 1996).

Maize kernels develop through accumulation of the products of photosynthesis, root absorption and metabolism of the maize plant on the female inflorescence called the ear. This structure may hold from 300 to 1 000 single kernels depending on the number of rows, diameter and length of the cob. Kernel weight may be quite variable, ranging from about 19 to 40 g per 100 kernels. The weight distribution of main parts of maize kernel is shown in table 2.1 during harvest the ears of maize are removed from the maize plant either by hand or mechanically. The husks covering the ear are first stripped off and then the kernels are separated by.hand or, more often, by machine. (Deobley, *et al.,* 1990)

TABLE 2.1: Weight Distribution of Main Parts of the Maize Kernel

Structure	Percent weight distribution
Pericarp	5-6
Aleurone	2-3
Endosperm	80-85
Germ	10-12

Source: Bressani,*et al., (*1958*).*

The maize kernel is known botanically as caryopsis; a single grain contains the seed coat and the seed as shown in Table 2.1. The figure also shows the four major physical structures of the kernel: the pericarp, hull or bran; the germ or embryo; the endosperm; and the tip cap (dead tissue found where the kernel joins the cob). The gross anatomy and the microscopic structure of these anatomical components were well described by (*Wolf et al.,* 1952, 1969). They also studied the structure of the improved opaque-2 maize and found differences between its endosperm and that of common maize.

The protein matrix was thinner and there were fewer and smaller protein bodies, since there is a restriction in zein synthesis in opaque-2 maize. (*Robutti, et al.*, 1974) reported on the protein distribution, amino acid content and endosperm structure of opaque-2 maize. The weight distribution of the different parts of the maize kernel is shown in Table 2.1. The endosperm, the largest structure, provides about 83 percent of the kernel weight, while the germ averages 11 percent and the pericarp 5 percent. The remainder is the tip cap, a conical structure that together with the pedicel attaches the kernel to the ear of maize. Table 2.2 shows the distribution of weight and nitrogen among the anatomical parts of common and selected kernel varieties, such as high-oil and high-protein maize and three quality protein maize (QPM) selections (*Bressani et al.*, 1958).

The main difference in the high-oil variety is the size of the germ, which is about three times as large as the germ from common maize with a reduction in endosperm weight. Germ of the high-protein varieties is larger than that of common maize but about half the size of high-oil varieties.

There are also differences in the weight of the seed-coats. Table 2.2 also shows some data for teosinte (the closest relative to maize). The seed weight is much lower than that of maize seed and the endosperm weighs about half that of maize. The three QPM selections are similar to maize in weight per seed and in weight of the seed-coat, the endosperm and the germ. Similar data have been reported by other authors. Table 2.3 summarizes data for two common varieties and one opaque-2 maize (*Landry et al.*, 1980). The two common samples have the same general characteristics as those reported above; the opaque-2 sample, however, has a larger germ providing more nitrogen than the QPM selections in Table 2.2. With respect to the germ, the increase of weight and of nitrogen amounts in absolute as well as relative terms is consistent with other results (*Watson*, 1987).

Table 2.2. Distribution of weight and nitrogen among parts of maize kernel.

Maize Sample	Weight of 20 Seeds (g)	Weight Distribution (%)			Total N (%)	Nitrogen Distribution	
		Seedcoata	Endosperm	Germ		Seedcoat	Endosp
US 4251	5.62	6.3	86.3	7.4	1.31	3.3	81.2
US High Oil (HO)	5.72	6.4	71.2	22.4	1.99	2.4	68.4
US high protein	4.32	6.9	82.7	10.4	2.24	2.2	83.2
US high protein	4.97	7.4	78.9	13.7	2.14	2.7	78.2
US normal-Shi PT	4.88	6.7	78.9	13.7	2.14	2.7	78.2
US normal mutant-Shi PT	2.80	10.7	70.6	18.7	2.21	6.1	64.6
Tiquisate (TGY) (Guat)	8.24	4.9	83.9	11.2	1.37	2.8	75.2
San Sebastian (SSD)(Guat)	8.24	4.9	83.9	11,2	1.37	2.8	75.2
Guatemalan 142-48	6.91	6.9	82.1	11.0	1.83	2.6	81.0
Guatemalan Cuyuta	65.95	5.7	82.5	11.8	1.28	2.9	72.4
Guatemalan teosinte	1.56	55.6	44.4	-	1.81	8.2	91.8
Nutricta QPM	5.91	5.7	82.7	11.6	1.42	1.7	72.8
QPM white	5.11	5.9	82.4	1.6	1.36	1.4	72.8
QPM yellow	6.19	5.9	81.6	12.5	1.48	2.4	73.4

Source: Bressain *et al.*,(1958)

Table 2.3: Weight and Nitrogen distribution of part of common Maize

Part of Kernel	Dry Matter (%)			Nitrogen (%)		
	common	Common	Opaque-2	Common	common	Opaque-2
Germ	13.5	8.1	35	20.1	14.9	35.1
Endosperm	80.0	84.0	61	76.5	80.5	60.7
Seed coat	6.5	7.9	4	3.4	4.6	4.2

Source: Landry *et al.*, (1980)

2.3 Uses of Maize

As indicated in previous sections, maize has three possible uses: as food, as feed for livestock and as raw material for industry. As a food, the whole grain, either mature or immature, may be used; or the maize may be processed by dry milling techniques to give a relatively large number of intermediary products, such as maize grits of different particle sizes, maize meal, maize flour and flaking grits. These materials in turn have a great number of applications in a large variety of foods. Maize grown in subsistence agriculture continues to be used as a basic food crop (Earll *et al.*, 1988). In developed countries more than 60 percent of the production is used in compounded feeds for poultry, pigs and ruminant animals. In recent years, even in developing countries in which maize is a staple food, more of it has been used as an animal feed ingredient. "High moisture" maize has been paid much attention to 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 edible oil of high quality. The seed-coat or pericarp is used mainly as a feed, although in recent years interest has developed in it as a source of dietary fibre (*Burge et al.*, 1989).

Wet milling is a process applicable mainly in the industrial use of maize, although the alkaline cooking process used in manufacturing tortillas (the thin, flat bread of Mexico and other Central American countries) is also a wet milling operation that removes only the pericarp (*Bressani*, 1990). Wet milling yields maize starch and by-products such as maize gluten used as a feed ingredient. The maize germ processed to produce oil gives a by-product maize germ meal, used as an animal feedstuff. Some attempts have been made to use these by-products for humans in food mixes and formulations.

Although the technology has been available for a long time, the increase in fuel oil prices has resulted in much research on the fermentation of maize to produce alcohol, popular in some states of North America. Fermentation also provides some alcoholic beverages.

Finally, maize plant residues also have important uses, including animal feeds as well as a number of chemicals produced from the cobs, such as furfural (organic liquid aldehyde) and xylose (plant sugar). These residues are also important as soil conditioners. Maize remains vital to the food security of millions of African farmers who use maize in several ways;

- It is used for *Ukpoka* (inform of *Moi-Moi*).
- It is turned into swallow meal call Tuwonmasara.
- The husk is used to make fire for cooking.
- It is used to produce animal feeds.
- It can be cooked into various forms with meat and fish for man.

2.4 Physical Properties of Maize

The physical characteristics of maize became clear sometime ago when (Pazy *et al.*, 1958) showed that the yield of dry matter in the form of dried-maize dough or flour was affected by the maize cultivar. In their rural home studies, dry matter losses from white maize averaged 17.2 percent with a variability of 9.5 to 21.3 percent. Dry matter losses from yellow maize averaged 14.1 percent with a range from 8.9 to 16.7 percent. (*Cortez et al.*, 1972) conducted a series of measurements on 18 cultivars of maize produced in Mexico. These included kernel weight, colour and lime-cooking time using a standard cooking procedure with 1.5 perçent lime at 80°C and a steeping time of 12 hours. Cooking efficiency and time were measured by the ease with which the seed coat could be removed. Evaluations of the cooked maize included measurement of the volume of 1 kg of maize, the yield of dough from 1 kg of grain and the moisture content of

the dough. The dough was further evaluated by measuring its strength and water absorption. The dehydrated dough was then ground to 60-mesh size and evaluated for moisture, colour, specific volume and other physical characteristics using a mixograph. The tortillas made from the dough of each maize sample were further evaluated for extensibility, volume, plasticity, softness and roughness of the surface.

From this extensive study, the authors reached several conclusions. Maize varieties or cultivars of higher weight per volume, a harder endosperm, more moisture and high protein content produced the best tortillas. Two cultivars of popcorn maize were among the best types for tortillas. The Swanson mixograph was useful in establishing differences in maize types. The time required to cook the samples ranged from 30 to 75 minutes and dry matter losses ranged from 10 to 34 percent. (*Rooney et al.,* 1987) found that maize with hard or corneous endosperm required a longer cooking time. (*Bedolla et al., 1*984) stated that the texture of the dough was affected by the endosperm texture and type, drying, storage and soundness of the maize kernel. (*Martinez Herrera et al.,* 1979) established a relationship between kernel hardness and the time needed for cooking. They reported that within a maize variety, higher calcium hydroxide concentration slightly decreased cooking time. Furthermore, knowing the initial hardness of a variety made it possible to predict the time required to cook it. (*Khan et al.,* 1982) measured a parameter termed nixtamal shear force (NSF), an indication of kernel hardness. The measurement was related to both cooking time and processing method. These authors showed that the NSF measurement could reveal small differences in maize with similar endosperm texture and could be used to predict optimum cooking time.

2.5. Chemical Properties of Maize

There are significant amounts of data on the chemical composition of maize. Many studies have been conducted to understand and evaluate the effects of the genetic make-up of the relatively large number of available maize varieties on chemical composition, as well as the effects of environmental factors and agronomic practices on the chemical constituents and nutritive value of the kernel and its anatomical parts. Chemical composition after processing for consumption is an important aspect of nutritive value; it is affected by the physical structure of the kernel, by genetic and environmental factors, by processing and by other links in the food chain. In this chapter, the chemical nature of maize, of both common and quality protein types, is described as a basis for understanding the nutritive value of various maize products consumed throughout the world.

2.5.1 Moisture Content

The determination of moisture content is one of the most important and widely used measurements in samples that absorb and retain water. Chemical analyses are normally made on dry matter basis. Determination look very simple in concept, but in practice the accurate determination is complicated by number of factors which vary considerably from one sample to another. Air or vacuum oven drying at 80^0C is considered to be reliable methods provided that there is no chemical decomposition of the sample and water is the only volatile constituent removed. The samples were dried to a constant weight.

2.5.2 Crude Fibre

Crude fibre is a chemical entity. It is the remnant after plant material or more precisely plant has been treated with hot concentrated H_2SO_4, alkali and alcohol. It is the cellulose and lignin portion of the plant materials. In other words, crude fibre is a complex mixture of indigestible compounds derived mainly from plant cell walls. It consists mainly of polysaccharides, particularly cellulose fibres. There is evidence that fibre helps to reduce blood cholesterol levels and the risk of bowel cancer and gallstone (*Ranhotra et al.,* 1992).

2.5.3 Lipid

The lipid content of biological materials is a group of substances found in plant and animal tissues, insoluble in water but soluble in common organic solvents such as benzene, ether, petroleum ether and chloroform. Lipids include the fats and oils. Ether-extractable substances of 33 and 43 percent were reported by (*Bressani et al.,* 1953) from yellow and white maize respectively, as processed in Guatemalan rural homes. *Pflugfelder et al.,* (1988) found losses of 11.8 to 18.1 percent and suggested that these could be partly due to the vigorous handling of cooked maize at the industrial plant. Of the total masa lipid, 25 to 50 percent was free and partially emulsified. *Bedolla et al.*, (1983) found extract values of 5.0, 3.1 and 3.6 percent in raw maize, cooked maize and tortillas respectively, or about a 28 percent change in maize. This loss has not been fully explained; however, it may result from the loss of the seed-coat, the tip cap, the aleurone layer and possibly part of the germ, and also from ether soluble substances, not necessarily fat.

2.5.4 Protein

The word protein is derived from Greek word, proten' and means 'holding the first place'. Protein literally holds the first place in the architecture and machinery of all living things. Without them no life can exist, no plant can grow or tap sunlight. The protein can be plant protein or animal protein. There are different but all build up from the same 20 building blocks called essential amino acids. When amino acids combine to form protein they do so through the NH_2 group of one amino acid reacting with the OH of another. Amino acids are important in human diet.

After starch, the next largest chemical component of the maize kernel is protein. Protein content varies in common varieties from about 8 to 11 percent of the kernel weight. Most of it is found in the endosperm. The protein in maize kernels has been studied extensively. It is made up of at least five different fractions, according to (*Moureaux et al.*, 1982). In their studies, albumins, globulins and non-protein nitrogen amount to about 18 percent of total nitrogen, in a distribution of 7 percent, 5 percent and 6 percent, respectively. The prolamine fraction soluble in 55 percent isopropanol and isopropanol with mercaptoethanol (ME) contributes 52 percent of the nitrogen in the kernel. Prolamine 1 or zein 1 soluble in 55 percent isopropanol is found in the largest concentration, about 42 percent, with 10 percent provided by prolamine 2 or zein 2. An alkaline solution, pH 10 with 0.6 percent ME extracts the glutelin fraction 2, in amounts of about 8 percent, while glutelin 3 is extracted with the same buffer as above with 0.5 percent sodium dodecyl sulphate in amounts of 17 percent for a total globulin content of 25 percent of the protein in the kernel. Usually a small amount, about 5 percent, is residual nitrogen. (*Ortega et al.*,1986).

2.5.5 Ash

Changes in ash content have not received much attention from researchers. Most findings, however, have shown an increase in total ash content of maize. These are inorganic compounds which appear in food analysis. There are substances left behind, when the carbon, hydrogen and nitrogen (organic compounds) have all been burnt off by excess oxygen. Ash of a biological material is an analytical term for the inorganic residue that remained after the organic matter has been burnt off. An adult may have over 1kg of calcium in his body, whereas for chromium he has only 5-10mg and of copper 150mg (*Pflugfelder et al.*, 1996).

2.5.6 Carbohydrate

Carbohydrate is found in food either as sugars or as starches and glycogen. Maize contains significant amounts of soluble carbohydrate, but very little is known on how they change during alkaline processing. Starch losses of about 5 percent have been reported.

Starches are long straight or branched chain of the many sugar molecules joined together. The chemical nature of sugar determines their properties, their functions in living tissues and how starches are formed and broken down. The sugars include the monosaccharides and polysaccharides. Glucose and fructose are the monosaccharides that are nutritionally important. Sucrose, lactose and maltose are the disaccharides of nutritional importance. The only polysaccharides of major nutritional importance are starches and glycogen because they can easily be digested in human gut.

It is scarcely found free in plant materials, with grapes as the most significant exception. It is present in human blood, at about 80-120mg/100ml blood (5-6 mol/litres) and is the only sugar that plays a major role in human metabolism. Glucose is found in the liver and muscles of

animals. Among disaccharides, sucrose is widely distributed in plant, fruit and other tissues e.g. sugar cane. Maltose is found in the starch of grain seeds when they begin to germinate. Maize contains significant amounts of soluble carbohydrate, but very little is known on how they change during processing. (*Robbles et al.,* 1988)

2.5.7 Vitamins

There are organic substances needed in very small amounts in human body that perform a specific metabolic function and must be provided in the diet of man and animals. Plants can manufacture vitamins from the elements available to them from the soil. Water soluble vitamins are soluble in water and are heat labile. They include vitamin C, B1, B2, B3, B6, and B12. They are called Ascorbic acid, Thiamine, Riboflavin, Niacin, Pyridoxine, and Cobalamin respectively. Fat soluble vitamin is present in fats and is not heat labile. They include vitamin A (Retinol), vitamin D (Cholecalciferol), vitamin E (Tecophenols) and vitamin K (Naphthoquinones) (*Bressain et al.1961*).

2.6 Nutritional Evaluation of Maize Grains

The importance of cereal grains to the nutrition of millions of people around the world is widely recognized. Because they make up such a large part of diets in developing countries, cereal grains cannot be considered only as a source of energy, as they provide significant amounts of protein as well. It is also recognized that cereal grains have a low protein concentration and that protein quality is limited by deficiencies in some essential amino acids, mainly lysine Much less appreciated however, is the fact that some cereal grains contain an excess of certain essential amino acids that influence the efficiency of protein utilization. The classic example is maize. Other cereal grains have the same constraints but less obviously (Hogan *et al.,* 1955).

A comparison of the nutritional value of maize protein with the protein quality of eight other cereals is given in Table 2.4 expressed as percentages of casein. The protein quality of common maize is similar to that of the other cereals except rice. Both opaque-2 maize and the hard-endosperm QPM (*Nutricta*) have a protein quality not only higher than that of common maize, but also significantly higher than that of other cereal grains.

Reasons for the low quality of maize proteins have been extensively studied by numerous investigators. Among the first were *Mitchell et al.,* (1932) who obtained 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) while *Bressani* (1968) has shown that the addition of lysine to maize causes only a small improvement in protein quality. These differing results may be explained by variations in the lysine content of maize varieties. Work in this field led to the discovery by *Mertz, et al* (1964) of the high lysine maize called opaque-2. The protein quantity of maize and other cereal grains is shown in Table 2.4

Table 2.4: Protein Quality of Maize and other Cereal Grains

Cereal	Protein quality (% casein)
Common maize	32.1
Opaque-2 maize	96.8
QPM	82.1
Rice	79.3
Wheat	38.7
Oats	59.0
Sorghum	32.5
Barley	58.0
Pearl millet	46.4
Finger millet	35.7
Teff	56.2
Rye	64.8

Source: *Bressani et al,* 1985

Some researchers (*Hogan et al.*, 1955) have reported that tryptophan rather than lysine is the first limiting amino acid in maize, which may be true for some varieties with a high lysine concentration or for maize products modified by some kind of processing. All researchers have agreed that the simultaneous addition of both lysine and tryptophan improves the protein quality of maize significantly; this has been demonstrated in experimental work with animals.

The improvement in quality obtained after the addition of lysine and tryptophan has been small in some studies and higher in others when other amino acids have been added. Apparently, the limiting amino acid after lysine and tryptophan is isoleucine, as detected from animal feeding studies (*Benton et al.*, 1955). Most researchers who reported such findings indicated that the effect of *isoleucine* addition resulted from an excess of leucine which interfered with the absorption and utilization of *isoleucine* (*Harper et al.*, 1955). It has been reported that high consumption of *leucine* along with the protein in maize increases niacin requirements, and this amino acid could be partly responsible for *pellagra.* When a response to *threonine* addition has been observed, it has been attributed to this amino acid's correction of amino acid imbalances caused by the addition of *methionine.* A similar role can be ascribed to added isoleucine resulting in improved performance. Similarly, the addition of *valine*, which results in a decrease in protein quality, could be counteracted by the addition of either *isoleucine* or *threonine.*

In any case, *isoleucine* seems to be more effective than *threonine,* producing more consistent results. A possible explanation for these findings is that maize is not deficient in either *isoleucine* or *threonine*. However, some samples of maize may contain larger amounts of *leucine, methionine* and *valine*, and these require the addition of *isoleucine* and *threonine* besides lysine and tryptophan to improve protein quality. In any case, the addition of 0.30 percent L-lysine and 0.10 percent L-tryptophan easily increases the protein quality of maize by 150 percent (*Bressani, et al.*, 1968). Many of the results of the limiting amino acids in maize protein are influenced by the level of protein in the maize. As was indicated previously, protein content in maize is a genetic trait that is affected by nitrogen fertilization. The observed increase in protein content is highly correlated with zein, or the alcohol-soluble protein, which is low in lysine and tryptophan and contains excessive amounts of leucine. Frey (*1951*) found a high correlation

between protein content and zein in maize, a finding that has been confirmed by others. Using different animal species, various authors have concluded that the protein quality of low-protein maize is higher than that of high-protein maize when the protein in the diets used is the same. However, weight for weight, high-protein maize is slightly higher in quality than low-protein maize. The levels of dietary protein, then, affect the response observed upon amino acid supplementation with lysine and tryptophan in particular but with other amino acids as well, such as *isoleucine* and *threonine*.

The proximate composition of maize is shown in Table 2.5. The very low moisture content suggests that maize loses a considerable amount of water during storage resulting in a longer shelf life .The crude lipid value is higher than the reported value for millet and sorghum. The protein content of maize is low compared to rice, millet, and sorghum. The crude fibre content of maize is lower than that of sorghum but higher than that of millet and rice. The calorie value of maize compare well with the values reported for most cereals maize is richest in calcium, magnesium, iron and copper than most cereals (FAO, 1968).

Table 2.5: Proximate Composition of Maize (mean of three different determinations± SD)

Product	*Moisture (%)*	*Protein (%)*	*Fat (%)*	*Ash (%)*	*Crude fibre (%)*	*Carbohydrate (%)*	Calories per 100g
Maize							
White	15.9	8.1	4.8	1.3	1.1	70.0	356
Yellow	12.2	8.4	4.5	1.1	1.3	73.9	370
Tortillas							
White	47.8	5.4	1.0	0.8	0.7	44.5	204
Yellow	47.8	5.6	1.3	0.8	0.7	44.4	212
Industrial	40.5	5.8	0.9	1.1	1.4	50.3	226
Industrial	44.0	5.3	3.4	1.2	0.7	42.8	215
Industrial	45.2	5.2	3.1	1.4	1.1	41.1	206

Sources: *Bressani et al.*, (1985)

2.6.1. Forms of Maize Consumption

Maize is consumed in many forms in different parts of the world, from maize grits, polenta and corn bread to popcorn and products such as maize flakes (*Rooney s*, 1987). The grain is fermented to give ogi in Nigeria (*Oke*, 1967) and other countries in Africa (*Hesseltine*, 1979) and is decorticated, degermed and precooked to be made into arepas in Colombia and Venezuela (*Instituto* de *Investigaciones Tecnológicas*, 1971; *Rodriguez*, 1972).

In Egypt maize flat bread, aish merahra, is widely produced. Maize flour is used to make soft dough spiced with 5 percent ground fenugreek seeds, which is believed to increase the protein content, improve digestibility and extend the storage life of the bread. The dough is fermented all night with a sour dough starter. In the morning the dough is shaped into small, soft, round loaves, which are left for 30 minutes to "prove". Before baking, the loaves are made into wide, flat discs. Aish merahra keeps fresh for seven to ten days if it is stored in airtight containers. A similar product called markouk is eaten in Lebanon. (FAO 1989).

Maize is also widely used to make beer. In Benin, for example, malt is obtained by germinating the grain for about five days. The malt is then exposed to the sun to stop germination. The grains are lightly crushed in a mortar or on a grinding stone. The malt is cooked and the extract is strained off, cooled and allowed to stand. After three days of fermentation it is ready to be drunk as beer (FAO, 1989).

The lime-cooking process for maize is particular to Mexico and Central America (*Bressani*, 1990), although today the technology has been exported to other countries such as the United States. A dough prepared from limecooked maize is the main ingredient for many popular dishes such as atole, a beverage with a great variety of flavours, and tamalitos, made by

wrapping the dough in maize husks and steam-cooking it for 20 to 30 minutes to gelatinize the starch. This form is usually prepared with young chipilín leaves (*Crotalaria longirostrata*), the flowers of loroco (*Fernaldia pandurata*) or cooked beans mixed with the dough, thus improving the nutritional quality of the product and its flavour (*Bressani*, 1983). The dough is also used for tamales, a more complex preparation because of the number of ingredients it contains, in most cases with chicken or pork meat added to the gelatinized dough. It is also used to provide support for enchiladas, tacos (folded tortillas containing meat) and *pupusas,* the latter made with fresh cheese placed between two layers of dough and baked like tortillas. When the dough is fried and flavoured, it yields foods such as chips and *chilaquiles*. If the dough is allowed to ferment for two days, wrapped in banana or plantain leaves, it provides a food named *pozol* from which a number of drinks can be made. It has been claimed that this preparation is of high nutritional quality.

There are many ways to convert maize into interesting and acceptable forms which, if presented in attractive and easily prepared products could to some extent counteract the trend toward greater consumption of wheat derived foods in arepa- and tortilla-eating countries and elsewhere.

CHAPTER THREE

3.0 Materials and Methods

3.1 Materials

The samples of maize (White and Yellow) were purchased from Minna Main Market in Niger State, Nigeria.

The two samples were used as they were obtained. The analyses were carried out in Animal Production Laboratory and Biochemistry Laboratory, both in the Federal University of Technology, Minna, under the supervision of Mr. A. Yohanna, Mr. Dauda, and Mr Zegi between May 19th to June 2 2008.

3.2. Regents and Instruments

The regents and instrument used for the practical work of this study are;

3.2.1 Reagents

Tetraoxosulphate (VI) acid,(H_2SO_4).

Sodium hydroxide (NaOH)

Methyl orange indicator/ Bromocresol green (BCG)

Boric acid (H_3BO_3)

Petroleum ether.

3.2.2 Instruments/Apparatuses

Petri dish

Desiccators

Weighing balance (Manufactured in Switzerland – Metler, Sensitivity = 0.000, Serial No. 1+52764)

Oven (Manufactured in England - Gallenkamp, Serial no. 2062P 19N)

Filter paper.

Soxhlet extractor

Flat bottom silica dishes

Beaker

Pipette

Thimbles

Conical flasks

Crucible

Muffle furnace (Manufactured in England – Lento, Serial no. 4399)

Micro kjedal digestive block (Manufactured in England, Serial no. 44103)

3.3 Experimental Procedures

Ibitoye A.A. (2005) Laboratory Manual on Basic Methods in plant analysis. **3.3.1 Determination of Moisture Content**

The determination of moisture content was carried out using the following procedure.

Procedure

A clean and well labeled dish was weighed and oven dried (W_1). Enough samples of maize was added into the dish and weighed (W_2). The dish and content were transferred to the thermo setting oven at about 105^0C for 24hours.Then the dish was transferred from oven to the desiccators to cool for 1hour and was weighed (W_3).

$$\%\ Moisture\ Content = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

3.3.2 Determination of Crude Fibre

The crude fibres was determined using Ibitoye A.A. (2005) Laboratory Manual on Basic Methods in plant analysis.(Appendix A).

Procedure:

Transfer about 3.5-5g defected sample into 500ml conical flask (W_1), add 200ml of boiling (1.25%) H_2SO_4 and bring to boil within one minute and allow to boil gently for exactly 30mins using finger to maintain constant volume. Filter with filter paper by using buncher funnel, rinse well with hot distilled water, separate material back into flask with spatula, add

200ml of boiling (1.25%) NaOH and few drops of antifoaming agent, boil for one minute and 30 minutes using finger (KOH can be used in place of NaOH) and vegetable oil as antifoaming agent. Filter through poplin cloth and wash with hot distilled water. Rinse four times with hot distilled water, and once with 10% HCL, twice with methylated spirit and three times with petroleum ether. Savage the residue into crucible after the drain, dry in the oven at 105^0C and cool in desiccators and weigh (W_2). Place in muffle furnace at about 300^0C for about 30minutes, remove from desiccator and allow cooling to room temperature and weigh again (W_3).

$$\% \, crude \, fibre = \frac{W_2 - W_3}{W_1} \times \frac{100}{1}$$

3.3.3 Determination of Lipids Content

Lipids are mixtures of various glycericides of fatty acids, which are soluble in certain organic solvents. Extraction is carried out with soxhlet apparatus with ether or petroleum ether. The procedure is to continuously extract the fat content with $40/60^0$C petroleum ether in a convenient extractor (soxhlet extractor).

Procedure

Weigh thimble previously dried (W_1) it should be fat free. Add enough samples into the thimble and weigh again (W_2). Weigh the 500ml round bottom flask (fat free) W_3, fill the flask with petroleum ether up 2/3 of the 500 ml flask, fit up the Soxhlet extractor with a refiux condenser adjust the heat source so that the solvent boils gently, leave it to siphon over several hours (5 – 6 hours), finally wait until the petroleum ether has just siphoned over the barrel, detach the condenser and remove the thimble or filter paper. Distill petroleum ether from the

flask dry the flask containing the fat residue in an air oven at 100°C for 5 minutes. Cool in adesiccator and weigh (W_4) place the thimble in the beaker in an oven at 50°C and dry to constant weight with sample, cool in desiccators and weight (W_5).

i. Weight of lipid in the flask after extraction

$$\% \, Fat = \frac{W_4 - W_3}{W_2 - W_1} \times 100$$

ii. From the thimble by weight loss in the sample

$$\% \, fat = \frac{W_2 - W_5}{W_2 - W_1} \times 100$$

3.3.4 Determination of Protein

The amount of crude protein contained in the seed, roots, tubers and other stuff can be obtained by multiplying the nitrogen content of the food 6.25, the factor 6.25 owes its origin to the assumption that all food protein contains 16% nitrogen, and that all nitrogen in a feed is present as protein, although these assumptions are not entirely valid. The protein contained in plant tissue or feed may vary in terms of nitrogen content from 13.18%. in many cases, a factor other than 6.25 would be more valid.

3.3.5 Determination of Ash

Ash is not usually the same as the inorganic matter present in the organic material since there may be losses due to the volatilization or chemical interaction between the constituents. The importance of the ash content is that is gives an ideal amount of the mineral elements present and the content of organic matter in the sample.

Procedure

The silica dish or crucible in muffle furnace for about 15 minutes at 350^0C, remove the dish or crucible cool in desiccators for about 1 hour or cool to room temperature, weigh (W_1), add enough sample into the crucible (0.5-2g the quantity will depend on texture and source of sample) and weigh content (W_2). Pre-dry the sample place the crucibles inside muffle furnace and slowly increase the temperature from 200^0C - 450^0C it is to avoid incomplete ashing. Sample the ash until it comes whitish colour. If ashing incomplete (evidence of black particles) within a reasonable period remove crucible, cool, moisten with few drops of distilled water dry on water bath and return to the furnace. Remove the furnace to desiccators and allow to cool to room temperature re-weigh the crucibles content (W_3).

$$\%\ Ash\ content = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

Organic matter is the portion samples which burnt off.

$$\%\ Organic\ matter = \frac{W_2 - W_3}{W_2 - W_1} \times \frac{100}{1}$$

3.3.6 Determination of Carbohydrate

The determination of carbohydrate is the subtraction of the total protein and lipid content from the organic matter.

% carbohydrate = % organic matter – %(crude protein + crude fibre + ash + lipid)

3.3.7 Determination of Vitamin A

Vitamin A samples was determined using Ibitoye A.A. (2005) Laboratory Manual on Basic Methods in plant analysis guidelines shown in (Appendix A).

Procedure

The samples were weighed and mince into fairly fine pieces, and 1g of liquor was weighed and transferred to a mortar. Followed by the addition of 3-5g $NaSO_4$, the tissue was grinned with a pestle until a free-flowing powder was obtained. This samples were transferred into a 250ml conical flask and about 50ml petroleum ether of the (boiling point of 40-60^{0}C) was accurately measured as added to the flask while the flask was then covered with Clingfilm. The flask was shaking for about 3minutes in doing this it allows the vitamin A to be extracted, and allow to dry for 10 minutes. During the 10minute interval trifluoroactic acid regent was prepared in pipette into test tube 5ml chloroform, followed by 2.5ml trifluoroactic acid. Spectrophotometer was set to zero absorbance at 620mm with a cuvette containing 0.1ml chloroform +0.1ml an acetic amhydride +1.0ml. pipette 0.5ml of pet. ether-extract into a cuvette and evaporate by means of a gentle current of air. Redissolve residue immediately in 0.1ml chloroform + 0.1ml acetic anhydride, add 1.0ml trifluoroactic, transfer cuvette to

spectrophotometer and read the absorbance at 620mm extractly 30 seconds after addition of reagent.

$$\%\ Vitamin\ content = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

3.6.8 Determination of Vitamin C

Vitamin C samples were determined using Ibitoye A.A. (2005) Laboratory Manual on Basic Methods in plant analysis guidelines shown in (Appendix A).

Procedure

Pipette out 5ml of the working standard solution into a 100ml conical flask, add 10 ml of 4% oxalic acid and Titrate against the dye (V_1ml). End point is the appearance of pink colour which persists for a few minutes. The amount of the dye consumed is equivalent to the amount of ascorbic acid. Extract the sample (0.5 – 5g depending on the sample) in 4% oxalic acid and make up to known volume (100ml) and centrifuge. Pipette out 5ml of this supernatant all 10ml of 4% oxalic acid and titrate against the dye (V_2ml)

$$\text{Ascorbic Acid mg/100g} = \frac{Sample - Blank}{Standard - Blank} \times n$$

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Results

The proximate compositions of raw and cooked maize are presented in Table 4.1.

Table: 4.1. The Proximate Composition of Raw and Cooked Maize. (White)

	Uncooked	80^{0C}	100^{0C}	120^{0C}
Crude protein %	12.216	11.868	7.26	5.6168
Crude fiber %	14.82	14.11	13.82	13.99
Lipid %	5.22	6.22	4.71	4.02
Ash %	4.20	4.01	3.02	4.22
Moisture content %	12.00	-	-	-
Carbohydrate %	63.544	65.798	71.19	72.153

Vitamin A	Sample Weight g	Absorbance Reading at620nm	μg vitamin A/g
White	1.00	0.016	10.40
Yellow	1.00	0.012	7.80

Table 4.1.2 Proximate Composition of Raw and Cooked Maize (Yellow).

	Uncooked	80^{0C}	100^{0C}	120^{0C}
Crude protein %	10.912	11.564	7.564	4.799
Crude fiber %	15.11	15.29	15.01	14.99
Lipid %	6.51	6.66	4.38	4.41
Ash %	5.10	5.21	3.89	4.01
Moisture content %	11.92	-	-	-
Carbohydrate %	62.368	61.30	69.156	71.791
Vitamin C	Sample Weight g	Absorbance Reading at 620nm		μg vitamin mg/100ml
White	1.00	0.016		10.40
Yellow	1.00	0.012		7.80

4.2 Discussion of Results

The nutritional analysis of maize (White and Yellow) are presented in the Table 4.1. Above. Some major differences were observed in the physicochemical composition of maize of various types. The differences are an expression of the specificity of each of the varieties of maize. In nutritive value, maize is quite similar to other cereal grains. However, the protein content of white maize (12.216 %) obtained in this study is higher when compared to the reported values (8.1 %) by Bressani *et al.* 1985, when the samples are subjected to heat (at 100^0C, t = 10 minutes) and that of yellow maize (10.912) is also greater than the reported value by the same researcher.

In general the nutritional compositions obtained in this study are of higher values compared to the reported values of Bressani *et al.* (1985) the percent ash content (4.01 %),

crude fibre (14.11 %), carbohydrate content (65.798 %) and fat (6.22 %) are higher when compared with the reported values of (1.3 %), (1.1 %), (70.00), and (4.8 %) for percent ash, percent crude fibre, percent carbohydrate and percent fat respectively except for the carbohydrate content which is greater than the obtained values in this study. However, the nutritional content of yellow maize is also observed that the percent ash content (3.89) and percent crude fibre (15.01) obtained in this work is higher than that of *Bressani et al* (1984) while the composition of crude protein (7.54 %), carbohydrate (69.156) and lipid fat (4.380) are observed to be lower than the reported values of Bressani *et al* (1985) as in crude protein (8.4), carbohydrate (73.9) and lipid fat (4.5).

Because of the great importance of maize as a basic staple food for large population groups, particularly in developing countries, and its low nutritional value, mainly with respect to protein, many efforts have been made to improve the biological utilization of the nutrients it contains. Three approaches have been tried: genetic manipulation, processing and fortification. The data obtained in this work shows a great variability in the chemical composition of maize. Although environment and cultural practices may be partly responsible, the variability of various chemical compounds is of genetic origin; some efforts have also been made to manipulate other chemical compounds such as nicotinic acid and carotenoids. Processing is not widely recognized as a means of improving nutritive value; however, examples are presented to show its effects and potential. Finally, there have been many efforts to fortify maize, with outstanding results, but unfortunately fortification has not been implemented to a large extent. This approach, however, may become important in the future as more people consume industrially processed foods, which can be more easily and efficiently fortified (Gómez-Brenes *et al.,* 1972).

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

The study in this research made it known that maize is a supplementary foods necessary to upgrade human nutrients. The physicochemical properties data obtained in this work indicate that maize is one of the major staple foods in all West African Countries. It is often known that processing of food stuffs stabilizes the nutrients in the food, but losses may take place when optimum conditions are exceeded. Although after much research work, it shows that cooking induces beneficial changes in the maize grain.

However, it shows that cooking maize has proximate composition on its physicochemical properties.

5.2 Recommendations

The following recommendations are hereby given:

1. There is need to improve on the mechanical processing of maize e.g. threshing, dehusking and destonner in order to eliminate sand uncooked maize.
2. There is need to recommend both white and yellow maize consumption for both old and young people including the livestock (animal feed) based on the nutritive constituent it possesses.
3. There is need for the provision of laboratory equipments for the department to enhance student improvement on their research work.

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APPENDICES

Appendix A

IBITOYE, A.A (2005) Laboratory Manual on Basic Methods in Plant Analysis.

The procedures to each of the analysis and sample of the material were carefully made, the methods varies with the type of plant materials (food materials). Determinations are made on dry samples excluding moisture content. The results are reported in terms of dry or wet weight of the samples, Dried of the sample is ground in a mortar into a powdered form. Moist foods are processed in a high-speed grounder e.g. blender. Several determination made on random samples from foodstuff container makes result valid. The major determinations on proximate composition and physicochemical properties of maize are:

1 Moisture content: A clean and well labeled dish was weighed and oven dried (W_1). Enough sample was add into the dish and weigh (W_2) then the content was transfer into the dish, to a thermo setting oven at about 105°C for 24 hours. Transfer dish from oven to desiccators, cool for about one hour and weigh (W_3). The loss in weight of sample during drying is the moisture content.

$$\% \, Moisture = \frac{W_2 - W_1}{W_1} \times 100$$

2 Ash content: The biological materials are analytical term for the inorganic residue that remains after the organic matter has been burnt off. Ash is not usually the same as the inorganic matter present in the original material because there are losses due to the volatilization or chemical interaction between the constituents. Ash content is so important, that it gives an idea of the mineral elements present and the content of organic matter in the sample.

A silica dish or crucible was place in muffle furnace for about 15 minutes at 350^0C,then the dish or crucible was remove and cool in a disiccator for about one hour weigh the crucible (W_1). Add enough samples into the crucible (0.5-2g the quantity will depend on texture and source of sample) weigh content (W_2). The crucible is placed inside the muffle furnace, and slowly increased the temperature from 200^0C-450^0C this to avoid incomplete ashing. Ash sample until it become whitish in colour. Remove from the desiccator and allow it to cool to room temperature reweigh the crucible and content (W_3).

$$Ash(\%) = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

Crude fibre: is that portion of the food material which is not ash or dissolve in boiling solution of 1.25% H_2SO_4 or 1.25% N_aOH. Crude fibre was originally thought to be indigestible portion of any main food. It is however known that fibre consists of cellulose which can be digested to a considerable extent by both ruminants and non-ruminants.

3 Lipid (Fat): fats are mixtures of various glycericide of fatty acids, which are soluble in organic solvents. Extraction is carried out with soxhlet apparatus with ether or petroleum ether. The usual procedure is to continuously extract the fat content with 40/60^{0}C petroleum ether in a convenient extractor (soxhlet extractor). The ether extraction method is based on the principle that non-polar components of the sample are easily extracted into organic solvents. Direct extraction gives the proportion of free fat but gives no clue to the particular fatty acids; the soxhlet extractor is mostly suitable for dried samples. Weighed thimble previously dried (W_1) it is fat free, enough sample was added into the thimble and weigh again(W_2), the 500ml round bottom flask (fat free) weigh (W_3). Fill the flask with petroleum either up to 2/3 of the 500ml flask. The soxhlet extractor is fit up with a reflux condenser as shown above. The heat

source so that the solvent boils gently, level it to siphon for about (5-6hours), then wait until the petroleum ether has just siphoned oven the barrel. The condenser was detached and removed from the thimble or filter paper. Distill petroleum ether from the flask. The flask containing the fat residue was dried in an air oven at 100^0C for 20 minutes cool in desiccators.

$$\frac{W_2 - W_3}{W_2 - W_4} \times 100$$

4 Crude protein: The amount of crude protein contained in the seed, roots, tubers and others stuff can be obtained by multiplying the nitrogen content of the food by 6.25. The factor 6.25 owes its origin to the assumption that all food protein contains 16% nitrogen, and that all nitrogen in a feed is present as protein. Although these assumptions are not entirely valid, the protein contained in plant tissue or feed may vary in terms of nitrogen content from 13-18%. In many cases, a factor other than 6.25 would be more valid.

$$\% = \frac{Tv \times m \times 0.014 \times 10}{weight\ of\ sample} \times 100$$

5 Carbohydrate content: Is the subtraction of the total protein and lipid content from the organic matter.

% carbohydrate = % organic matter- % protein + %lipid.

6 Vitamin: Ascorbic acid otherwise known as vitamin C is an antiscorbid. Ascorbic acid reduces the 2.6 – dichiorophen indophenoil dye to a colourless leuco-base, the ascorbic acid gets oxidized to dehydroascorbic acid. Though the dye is a blue coloured compound, the end point is the appearance of pink colour, the coloured acid medium. 5ml of the sample was added into 2ml of glacial acetic acid and 1m of chloroform.

$$\underline{T - B_1} \times \text{n dilntion}$$

Appendix B: Calculations

Calculations on how the tables in chapter four were gotten are as follows:

WHITE MAIZE

Moisture content data:

$W_1 = Weight\ of\ petri\ dish$

$W_2 = Weight\ of\ petri\ dish + sample$

$W_3 = Weight\ of\ petri\ dish + dry\ sample$

$$\frac{W_2 - W_3}{W_2 - W_1} \times 100$$

$$\frac{44.62 - 44.38}{44.62 - 42.62} \times 100 = 12\%$$

Crude protein data:

$T_V = Titre\ Value$

$M = Molarity\ of\ acid$

$W = Weight\ of\ sample\ (0.5)$

$$Crude\ Protein = \frac{T_V \times m \times 0.014 \times 10}{W} \times \frac{100}{1}$$

$$= \frac{0.74 \times 0.1 \times 0.014 \times 10}{0.5} \times \frac{100}{1}$$

$N = 2.072$

$= 2.072 \times 5.90$

$Crude\ Protein = 12.2\%$

Crude fibre data:

$W_1 = Weight\ of\ crucible\ \ dry\ sample$

$W_2 = Weight\ of\ crucible + ash$

$W_3 = Weight\ of\ sample$

$$\frac{W_1 - W_2}{W_3} \times 100$$

$$\frac{15.89 - 15.66}{1.55} \times 100 = 14.82\%$$

Ash data:

$W_1 = Weight\ of\ crucible$

$W_2 = Weight\ of\ crucible + sample$

$W_3 = Weight\ of\ crucible + ash$

$$\frac{W_3 - W_1}{W_2 - W_1} \times 100$$

$$\frac{15.43 - 15.39}{16.74 - 15.39} \times 100$$

$= 4.37\%$

Lipid (fat) data:

$W_1 = Weight\ of\ thimble$

$W_2 = Weight\ of\ thimble + sample$

$W_3 = Weight\ of\ thimble + extraction$

$$\frac{W_2 - W_3}{W_2 - W_1} \times 100$$

$$\frac{2.45 - 2.35}{1.92} \times 100$$

$= 5.21\%$

Carbohydrate = Organic matter – (crude protein + lipid + ash + crude fibre)

%Carbohydrate = $100 - (12.216 + 5.2 + 4.2 + 14.82)$

= 63.544%

YELLOW MAIZE

Moisture content data:

$W_1 = Weight\ of\ petri\ dish$

$W_2 = Weight\ of\ petri\ dish + sample$

$W_3 = Weight\ of\ petri\ dish + dry\ sample$

$$\frac{W_2 - W_3}{W_2 - W_1} \times 100$$

$$\frac{46.40 - 46.08}{46.40 - 43.72} \times 100$$

$$= 11.9\%$$

Crude fibre data:

$W_1 = Weight\ of\ crucible\ dry\ sample$

$W_2 = Weight\ of\ crucible + ash$

$W_3 = Weight\ of\ crucible$

$$\frac{W_1 - W_2}{W_3} \times 100$$

$$\frac{15.89 - 15.65}{1.59} \times 100$$

$$= 15.094\%$$

$$\cong 15.1\%$$

Crude protein data:

$T_V = Titre\ Value$

$M = Molarity\ of\ acid$

$W = Weight\ of\ sample\ (0.5)$

$$Crude\ Protein = \frac{T_V \times m \times 0.014 \times 10}{W} \times \frac{100}{1}$$

$$= \frac{0.66 \times 0.1 \times 0.014 \times 10}{0.5} \times \frac{100}{1}$$

$N = 1.848$

$= 1.848 \times 6.25$

$= 10.91\%$

Lipid (fat) data:

$W_1 = Weight\ of\ thimble$

$W_2 = Weight\ of\ thimble + sample$

$W_3 = Weight\ of\ thimble + extraction$

$$\frac{W_2 - W_3}{W_2 - W_1} \times 100$$

$$\frac{2.50 - 1.964}{1.32} \times 100$$

$= 6.51\%$

Ash data:

$W_1 = Weight\ of\ crucible$

$W_2 = Weight\ of\ crucible + sample$

$W_3 = Weight\ of\ crucible + ash$

$$\frac{W_2 - W_3}{W_2 - W_1} \times 100$$

$$\frac{15.45 - 15.38}{16.76 - 15.38}$$

$$\frac{0.07}{1.38}$$

$$= 5.10\%$$

Carbohydrate = $10.912 + 6.51 + 5.10 + 15.11 - 100$

$$= 62.368\%$$

Vitamin A: = A620 × 650

=10.4 ug

White maize C: = 0.012 × 650

= 7.8 ug