COMPARATIVE ANALYSIS OF PHYSICOCHEMICAL PROPERTIES OF KUNNU MADE FROM GROUNDNUT AND MILLET

BY

ABDULAZEEZ, MUZEMIL KUNLE

MATRIC NO: 2004/18332EA

DEPARTMENT OF AGRICULTURAL AND BIORESOURCES ENGINEERING

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE

FEBRUARY, 2010.

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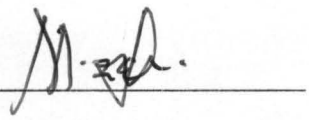
BEING A FINAL YEAR PROJECT REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIRMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG.) DEGREE IN AGRICULTURAL & BIORESOURCES ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGER STATE

FEBRUARY, 2010.

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 Information derived from personal communications, published and unpublished works of others were duly referenced in the text.



Abdulazeez, Muzemil Kunle

18/02/2010

Date

CERTIFICATION

This project entitled "Comparative Analysis of Physicochemical Properties of Kunnu Made From Groundnut and Millet" by Abdulazeez, Muzemil Kunle, 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.

Mrs. B. Orhevba — 17/02/2010
Supervisor — Date

Engr. Dr.A. A. Balami — 17/02/10
H.O.D, Agricultural and Bioresources Engineering — Date

Engr. Prof. G.O. Chukwuma — 10-02-10
External Examiner — Date

DEDICATION

This project is specially dedicated to Almighty Allah who by His mercy gave me success and strength to complete my programme.

ACKNOWLEDGEMENTS

I am most grateful to Almighty Allah for giving me the grace and strength that enabled me to complete this project and my B. Eng. Programme.

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ABSTRACT

In this work proximate analysis was carried out on four different samples named; raw millet, raw groundnut, processed millet *(Kunnu Zaki)* and processed groundnut *(Kunnu gyada)* with the aim of comparing their nutritional qualities. Under approved standard laboratory conditions and using standard method and instruments, experiments were conducted and results obtained. The results obtained showed that *kunnu gyada* has 69.39% Dry matter, 1.50% ash, 4.31% crude protein, 4.25% fats and 89.94% carbohydrates when compared with *kunnu zaki* which has 86.05% Dry matter, 1.75% ash, 1.54% crude protein, 1.05% fats and 95.21% carbohydrates. The results revealed that *kunnu gyada* have higher nutritive values than *kunnu* prepared from millet,therefore the consumption of *kunnu gyada* should be encouraged to make up for the poor nutritional qualities of *kunnu* prepared from millet.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of Study

Agricultural products especially those of plant origin are now frequently used for a wide range of activities. These agricultural products have over the years been under exploited in the region in which they are produced, especially in developing countries. Examples of these agricultural products with high emerging level of use are the groundnut and millet crops which are used in making a locally made beverage known as *Kunnu*.

Kunnu is a traditional non-alcoholic beverage prepared mainly from cereal grains such as (millet, sorghum, corn e.t.c). It is consumed mostly in the Northern part of the country where the larger proportions of these cereals are cultivated. It has low viscosity, with sweet sour taste and milky cream appearance. *Kunnu* plays an important role in the society; the beverage is served as refreshing drink in homes, social gathering and hotels (Obafunmi, 1990).

The beverage made from cereal crops are found to be poor in protein content, which may affect the growth rate of infants who drinks the beverages, therefore, to make up for the poor nutritional qualities of *Kunnu* made from cereals, groundnut was found to be a good substitute for cereal grains. Groundnut or peanut (*Arachis hypogaea*) is derived from 2 Greek words *Arachis* meaning legumes and *hypogaea* meaning below the ground, referring to formation of pods in the soil. Groundnut is a leguminous plant which originated from Brazil from where it was introduced into West Africa by Portuguese traders. The plant is an annual crop; the seeds germinate about 5 days after planting, flowering occurring in one month and the crop ready for harvest in 4-5 months (Onwuemeh, 1979).

Groundnut is sufficiently endowed with protein, Calcium, Iron, Vitamin B_1 and E; the oil is reported to contain about 30% linoleic acid, which is an essential fatty acid for human beings. Chopra (2001) reported that groundnut contains (44-55%) oil, (22-32%) protein and (8-11%) soluble sugar.

Pearl millet (*Pennisetum glaucum*) is the most important dry land food crop of West Africa (Rowland, 1993). In Africa, the crop is primarily grown in the countries like Nigeria and Niger republic, though it has been of local importance in many other countries including South Africa. Pearl millet grows best in warm climate reaching a height of 2-5m. The stem is conspicuously joined and bears narrow leaves up to 1m in length. (ICAR, 2006).

Three types of millet are distinguishable based on maturity date and methods of planting.These are:

(i) ***Gero***: this is photoperiod neutral and has early maturity (70-100 days). It is cultivated in Northern Guinea and Sudan Savannah and in the Sahel. Gero is grown on about 80% of total land area under millet and predominates in the Sahel.

(ii) ***Maiwa***: this is photoperiod sensitive and has late maturity (120-280 days). It is mostly grown in the Southern and Northern Guinea Savanna area. It flowers at the end of the rains and yield much lower than *Gero.*

(iii) ***Dauro*:** known as the transplanted millet, it is photoperiod sensitive and is late maturing. It is cultivated on a restricted scale, mainly in the southern part of Kaduna State and parts of Nassarawa, Kebbi and Plateau states.

Ajayi and Uvah (1988) reported that *Gero* which is usually the earliest cereal to mature in Nigeria is the most common millet variety in the country.

2.1 Statement of problem

In Nigeria especially the northern and southern part of the country the frequency with which *kunnu* prepared from millet is being consumed by young and old persons is high in addition the beverage made from cereal is found to be poor in protein content which may affect the growth rate of infant who drinks the beverage. Therefore, to make up for poor nutritional qualities of *kunnu* prepared from cereals *kunnu gyada* was found to be the good substitute which most Nigeria do not know the important to human health and dietary when compared with commonly consumed *kunnu zaki*

1.3 Objectives of the study

i. To determine the proximate composition of groundnut and millet based kunnu.

ii. To determine the nutritional qualities of these two beverages and compare them.

1.4 Justification of the study

i. There is little or no information on the proximate composition of groundnut based *Kunnu* and its important to health. Therefore this study serves as a compendium or relevant information on *kunnu* prepared from groundnut

ii. In Nigeria, especially Northern part of the country, the rate of consuming *kunnu* is high; hence, it is desirable to conduct a research into the nutritional qualities of these two beverages and compare.

1.5 Scope of Study

The variety of millet used for this project is *Gero* .The nutritional qualities to be determined are limited to the following Dry matter, Ash, Fat, Crude, protein, Crude fibre, and Carbohydrate

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Kunnu a Nigerian Local Beverage

The soft drink segment of Nigerian beverage industry is heavily dependent on imported raw materials and the country is presently passing through a developmental stage in which there is a strong emphasis on local sourcing of raw materials. This awareness has transformed into a general interest in commercial processing of indigenous foods in order to conserve these scarce foreign exchange by limiting the importation of raw materials.

Cereals are the major raw materials in the production of beverages in Nigeria which include *Burukutu*, a local gin and *Kunnu- zaki* (a non-alcoholic refreshing beverage). Adeyemi and Umar (1994) reported that cereals are eaten in large quantities and are the main sources of both major and minor nutrients.

Kunnu or *kunnu Zaki* (depending on the cereal used) is a popular cereal based, non-alcoholic beverage. It is a locally fermented sweetened non-alcoholic beverage that is widely consumed in most parts of Northern Nigeria especially during the dry season (Adeyemi and Umar, 1994). *Kunnu* is a refreshing drink taken as a substitute for soft drinks. It is a staple beverage drink that is relatively cheap and nutritious when compared to carbonated drinks. The gross composition of *kunnu* has been discussed by Ayo *et al.* (2003). Depending on cereal availability; sorghum, maize millet and rice are commonly used for the traditional production of *kunnu*. Spices such as ginger, black pepper, red pepper and cloves are commonly added as flavour and taste improver. Sugar is also added to act as sweetener (Ahmed *et al*, 2003).

The traditional production of *kunnu* is still of village technology level. The traditional process of manufacture involves, wet milling of cereal grains with spices (ginger, cloves, red and black pepper), wet sieving, partial gelatinization of the slurry,

sugar addition and bottling. In its traditional manufacture, the basic processes are not standardized and the level of ingredients such as spices and sweetener are not quantified. Furthermore, a wide variation exists in the method of preparation depending on the taste and cultural habits, which partly explains the lack of consistency in product quality (Adeyemi and Umar, 1994).

Ahmed *et al.* (2003) have been able to investigate the effect of extrusion on the sensory attributes of extruded cereal – legume blends for instant *kunnu- zaki* beverage analogues. Effect of spices on the microbial and sensory quality on the product had been investigated. These tests revealed that spices produce strong flavours that are advantageous in the improvement of food flavours. The components of spices had been evaluated to have antimicrobial effect on *kunnu – zaki* drink. Spices had been revealed to have more potent components that are capable of destroying microbes (Ayo *et al.* 2003).

2.2 Origin and History of Millet

The origin of millet is diverse with varieties coming from both Africa and Asia. Pearl millet (*Pennisetum glaucum)* for example comes from tropical West Africa and finger millet (*Eleusine coracana)* comes from Uganda or neighboring area. From Africa, the crop was taken to India about 3,000 years ago and to Europe at the beginning of era? Later the crop was widely distributed in many African countries and the Indian Subcontinent. The oldest historical roots of millet are to be found in China 4500BC, where it was considered as a sacred crop. One of the earliest recorded writings shows the directions for the growing and storing of the grain.(ICAR, 2006).

2.3 Millet Varieties

Millet includes species *in severa genera,* mostly in the sub-family *panicoidea* of the grass family *panacea* of the major and minor millet. The most widely cultivated are:

i. Pearl millet (*Pennisetum glaucum*)

ii. Proso millet also known as common millet (*Panicum mlleaceum*)

iii. Finger millet (*Eleusine Coracana*).(www.Wikipedia.org)

2.4 Nutritive Value of Millet

The protein content in millet is very close to that of wheat, both provide about 11% protein by weight. Millets are rich in vitamin B especially niacin, B6 and folic acid; calcium, iron, potassium, magnesium and zinc. Millet is tasty, with mild sweet, nut- like flavor and contains a myriad of beneficial nutrients. Air-dried grains of millet contains approximately 12.4%moisture,11.6% protein,5% fat,1.2% fibre,2.7% ash and 67.1% carbohydrate (Sowonola *et al.* 2005).Millets are sources of minerals such as copper, calcium, and manganese and also high in starch components, hence serve as energy food. Millet is considered one of the least allergenic and most digestible of all grains available (Railey, 2006)

2.5 Uses of Millet

It is a staple food for over 100 million people in parts of tropical Africa and India. It can be used for fermented and non fermented beverages.

- The vapour of the inflorescence extract is inhaled for respiratory disease in children.
- In African traditional medicine ,the grain has been used to treat chest disorders and leprosy (ICAR, 2006).

2.6 Local Processing of Millet

The various methods of processing millet in several countries in Africa and India have been reported by Nkama *et a*l, (1994).

Millet is processed for food in several ways, depending upon need and local habits. The main objectives of processing are to improve appearance, texture; culinary properties and palatability and to alter the bioavailability of nutrients. The essential stages in the processing of millet grains are outlined below:

(i) Cleaning

(ii) Dehulling

(iii) Dry & wet milling

2.6.1 Effects of Processing on the Nutritive Value of Millet

Processing has two main beneficial effects on the nutritive value of millet based foods.

- Improve bioavailability of nutrients
- Partial or complete removal of antinutrients and toxic compounds. Millet undergoes four major processes before it is used as food: dehulling, milling, steeping, and cooking.

2.6.2 Common Millet based Foods

After processing the grain into flour, grits or batter, several food products are made from millet. The classification scheme for millet based traditional foods is given in Table 2.1.

Table 2.1: Some Traditional Nigerian Pearl Millet Based Foods

Name of Food product	**Ingredients/raw material**	**Product description**
Tuwo	Dehulled millet flour	Stiff porridge
Fura	Dehulled millet,spices	Steam cooked dough
Masa	Dehulled millet, yeast, potash salt ,sugar, oil	Fermented baked batter
Ogi	Millet	Fermented thin porridge
Kunnu zaki	Millet,spices,sugars,sweet potato	Non-alcoholic beverages
Kunnu gyada	Groundnut, Millet spices, sugar.	Non-alcoholic beverages
Ndaleyi	Millet	Fermented stiff porridge
Kunnu Tsamiya	Millet,tamarind,fruit pulps, spices, sugar	Non-alcoholic beverages
Pito, burukutu	Millet, yeast	Alcoholic beverages
Danwake	Dehulled millet flour, cowpea flour	Steam cooked dumping
Mardam (Buhun)	Millet, spices, lemon juice & sugar	Non-alcoholic beverages
Tawisaka	Millet, Nono, yeast, malt	Non-alcoholic beverages

Source: Nkama *et al*, (1994)

Table 2.2: Proximate Composition of Some Traditional Pearl Millet Based Nigerian Food

Product	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Carbohydrate %)
Ndaleyi	7.1	2.2	1.5	0.3	88.9
Chir	6.9	11.6	7.5	0.8	73.1
Masa	56.9	3.1	1.9	0.23	37.8
Tuwo	7.0	8.6	4.1	6.8	78.9
Burabusko	6.7	8.4	5.9	1.2	86.7
Kunnu gyada	85.0	2.2	6.8	0.1	11.7
Millet	7.7	10.6	4.5	1.3	75.8

Source: Nkama *et al*, (1994)

2.7 Preparation of Kunnu Zaki

Kunnu drink is prepared from pearl millet by cleaning the seeds and soaking in water for about two hours. The soaked seeds are later wet-milled and the slurry sieved with muslin cloth. The filtrate is allowed to ferment for a day during which the slurry settles and form sediments. The supernatant liquid is then decanted and the residue mixed with water and divided into two. Half of the residue is boiled and the second half is poured into it to produce *kunnu* (Sowonola *et al*; 2005)

Figure 1 shows the stages involved in the preparation of millet based *kunnu*

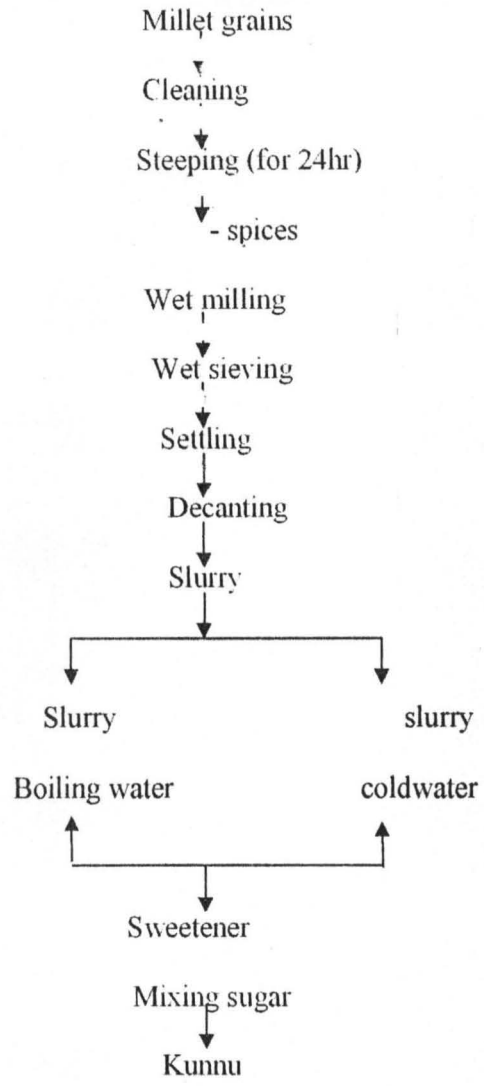


Figure 1: Flowchart for the production of millet based kunnu

2.8 Description of Groundnuts

The peanut, or groundnut (*Arachis hypogaea*), is a specie in the legume family (*Fabaceae),* native to South America, Mexico and Central America. It is an annual herbaceous plant growing 30 to 50cm (1 to 1.5ft) tall. The leaves are opposite, pinnate with four leaflets (two opposite pairs; no terminal leaflet), each leaflet 1 to 7cm (3/8 to 2 ¾ in long and 1 to 3cm (3/8 to 1 inch) broad. The flowers are a typical peaflower in shape, 2 to 4cm (3/4 to 1 ½ in) across, yellow with reddish veining. After

pollination, the fruit develops into a legume 3 to 7cm (1 to 2 in) long, containing 1 to 4 seeds, which forces its way underground to mature.

Peanuts are known by many local names, including earthnuts, groundnuts, goober peas and monkey nuts; the last of these is often used to mean the entire pod.

2.8.1 Origin and Distribution of Groundnut

Groundnut (*Arachis Hypogaea*) originated in the chaco area of South America and has been cultivated in Mexico and the West indies since pre-columbian times. The 16th century Spaniards introduced it to West Africa, Philipines, China, Japan, Malaya, India and Madagascar. Now it is grown in all tropical and sub-tropical countries up to 40^{0}N and South of the equator.

It is a warm season crop and is killed by frost; mostly grown in areas with 100cm or more rainfall. it needs 50cm rain during the growing season and ripens by dry weather. It is a small erect trailing herb 15 to 60cm high. Seeds are produced underground. Seeds are rich in oil (38 – 50%), protein, and Vitamins B and C. Main production areas are India, China, Nigeria, Sudan,Senegal, Niger, Malawi, Gambia, USA, Brazil and Argentina. (Hil and Waller, 1999)

2.8.2 Varieties of Groundnuts

Groundnut is a member of the sub-family *papilionaceae* of the family *leguminosae*. It consists of 2 sub-species, each containing two botanical varieties.

Sub-species hypogae: Variety *hypogae* (Virginia group)

Variety *Hirsuta*

Sub-species fastiginta: Variety fastigiated (Valencia group)

Variety vulgaris (Spanish group)

(ICRISAT, 2006)

Table 2.3: Nutritive Value of Groundnut Seeds

Nutrients	Amount in 100g of seed (raw)	Fried	Daily requirement per adult
Calories	564	582	2400
Protein (gm)	26	26	55
Fat (gm)	47.5	49.7	51
Calcium (gm)	69	72	400-500
Iron (gm)	2.1	2.2	20
Thiamine (B) (mg)	1.1	0.3	1.2
Niacin (mg)	17.2	17.2	16

Source: www.ikisan.com

2.8.3 Health Benefits of Groundnut

- **Teeth Disorders**: chewing fresh groundnuts with a pinch of salt strengthens the gum, cures stomatis, kills harmful bacteria and safeguards the enamel of the teeth. The mouth should, however, be washed with water after eating groundnuts.
- **Beauty Aid**: Groundnut oil can serve as a beauty aid: A teaspoon of refined groundnut oil, mixed with equal quantity of lime juice, may be applied daily on the face once before going to bed. It keeps the face fresh. Its regular use nourishes the skin and prevents acne.

2.8.4 Uses of Groundnut

NPC (1990) stated that groundnut is used for making margarine candy, crackers/cookies and salad oil. Groundnut oil finds extensive use as cooking medium because it has a mild flavour and burn at a relatively high temperature.

- It is used in soap making and in manufacture of cosmetics lubricant. Oleins and their salts.

- The residual oil cake contains 7 – 8% N, 1.5% P_2O_5 and 1.2 K_2O and can be used as manure.
- Groundnut can be consumed as confectionery products.
- Groundnut may be used for preparing nutritive tasty milk.

2.9 Preparation of Kunnu Gyada (Groundnut based kunnu)

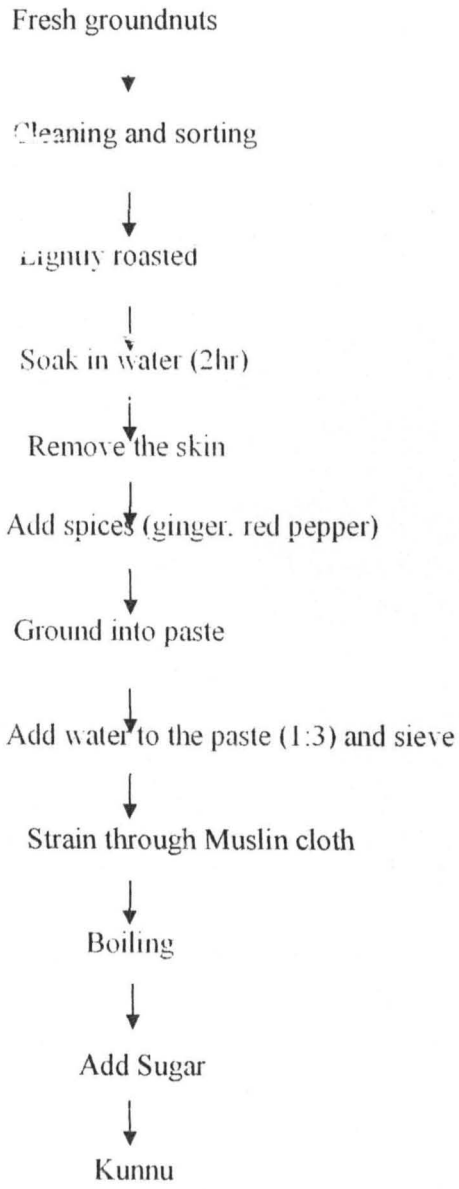


Fig. 2: The Flow Chart for Preparation of Kunnu Gyada

2.10 Proximate Composition of *Kunnu*

Proximate composition refers to the precise content of food material in terms of nutritional value of agricultural products which are of great importance in determining the class of which the agricultural product fall into, as well as finding a suitable substitute in time of shortage and price inflation (usually noticeable in developing countries). The proximate composition discussed here are:

i. Dry matter

ii. Crude protein

iii. Crude fibre

iv. Ash

v. Fat

vi. Carbohydrate

2.10.1 Crude Fibre

Crude fibre is the indigestible parts of plant based- food. Although some parts are said to be soluble, others are not. Crude fibre is the portion of plant materials which is not ash or which dissolve in boiling solution of 1.25% H_2S0_4 OR 1.25% NAOH. Crude fibre is originally thought to be indigestible portion of any main food. it consist of cellulose which can be digested to a considerable extent by both ruminant and non-ruminant, the interest in fibre in food and feed is increased based on the notice of serious illness associated with diet low fibre.

2.10.2 Carbohydrate

These are naturally occurring organic compounds containing carbon, hydrogen and oxygen with hydrogen and oxygen present in the ratio 2:1 as in water. The general molecular formular for carbonhydrate is $C_x\ H_{2y}\ O_y$ (where X and Y are positive integers).

It can be classified into 2 as shown below

i. Simple Sugars

These are sugars that are crystalline in nature, they are water soluble and have a sweet taste. They consist of monosaccharide and disaccharide sugars.

Examples of monosaccharide sugar include glucose, galactose and fructose. The disaccharides are the combination of 2 monosaccharide sugars resulting in the elimination of a molecule of water shown below

$2C_6H_{12}O_6 \underline{\text{condensation}} C_{12}H_{12}O_{11} + H_2O$

Monosaccharide disaccharide water

Examples of disaccharide include sucrose (cane sugar), lactose (milk sugar) and maltose (malt sugar).

ii. **Complex Sugars**

These are a group of complex carbohydrates composed of a very long chains of monosaccharides linked together by condensation; that is elimination of one molecule of water for every bond formed between two monosaccharide molecules. Examples includes starch and cellulose (Ababio, 2001)

2.10.3 Fat/Lipids

Fats are compounds of glycerol with fatty acids. Many fatty acids exist with 16.18 or 20 carbon atoms in the chains. Thus stearic acids contains 18 carbons, $C_{17}H_{35}COOH$, also contain atoms with 1 double bonds, palmitic acids has 16 carbons and linoleic acids has 18 carbon atoms with 2 double bonds. Oleic and linoeic acids are known as unsaturated fatty acids because they can accept additional hydrogen at the sight of double bonds. This is known as hydrogenation.

Usually three different fatty acids are found attached to the glycerol molecules. In butter, the main fat is glyceryl butyro-oleostearate, one molecule of each of the three acids being combined with glycerol molecules. The final nature of

fatty or oily substances is determined when chemical changes take place in fats. In the presence of water and some micro organisms, the links between glycerol and the fatty acids can be split. The fatty acids may give an unpleasant taste as when butter becomes rancid. Another change results from oxidation reactions at the site of double bond in the unsaturated fatty acids. Such reactions may if uncontrolled, produce perioxide groups, which can have far reaching and harmful effect upon living tissues.

All living cells contain traces of fats in their structures this is because fatty acids are among the components of cell wall and other intracellular membrane structures. In mammals and birds, fats deposits and stores are found throughout the body, between muscles, around internal organs and under the skin. Many fishes are have fats stored exclusively in their liver, but in the herring, it is present throughout the flesh. In the vegetable Kingdom, fats are found in the fruiting bodies of various plants such as olives, maize, groundnuts, palm nuts etc. Lipids belong to the same class as fats, except that lipids at room temperature is liquid while fat at room temperature is solid.

2.10.4 Proteins

The word protein is derived from Greek, and means "holding the first place". Proteins literally hold the first place in the architecture and machinery of all living things. Without them no life can exist. No plant can grow or trap sunlight. There is an enormous range of proteins – plant proteins, animal proteins, human proteins all different – but all built up from the same 20 building blocks (the essential amino acids) in long chains. This can be arranged in any order and there may be several hundred amino acids in single protein molecules. The amino acids are relatively simple substances. All amino acids in proteins exist in one of this arrangement only, the mirror images never being found naturally, though chemists can make them artificially.

When amino acids combine to form protein they do this through the NH_2 group of one amino acid reacting with the OH of another amino acids, splitting of water into H and OH in the process. The nine essential amino acids are histidine, isoleucine, leucine tysine, methionine, phenylanine, threonine, tryptophan and valine. Histidine is needed in children only. (Mottram, 1979).

2.10.5 Ash Content

The ash content of a biological material is an analytical term for the inorganic residue that remains after the organic matter has been burnt off. The organic component of food is burnt in air. The residue is ash which consists of the inorganic components in the form of their oxides. The ash is not usually the same as the inorganic matter present in the original food since there may be losses due to volatilization of chemical interaction between the constituents. The ash may however contain material organic origin such as sulphur and phosphorus from proteins and some loss of volatile material in the form of sodium, chloride, potassium, phosphorus and sulphur which will take place during ignition. The ash content is thus not truly a representative of the inorganic material in the food either qualitatively or quantitatively. The value is useful in assessing the quality or grading certain edible materials.

2.10.6 Moisture Content

The amount of moisture or water present in a material or sample is known as moisture content. It is a very useful parameter in the determination of the quality and storability of food samples. Some food samples lose some of their food nutrients due to moisture loss and also some food samples damage during storage due to this. It is the amount of moisture present per given weight of a sample. Its evaluation is useful in preservation, e.g. oil, promoting of shelf life of food products, prevention or

reduction of microbial growth, infestation and oxidative rancidity. Moisture content can be expressed in 2 ways (i) Wet basis and (ii) Dry basis

(i) Wet basis: $M_W = (\frac{W}{W+D} \; x \; 100\%) - - - - - - - - 1$

W = weight of water in product

D = amount of dry matter

M = Moisture content in Wet bass

(ii) Dry basis $M_D = \frac{W}{D} \; x \; 100\% - - - - - - - - 2$

(iii) M_D = moisture content dry basis and can be calculated from wet basis

(iv) $D = \frac{100W - M_{W.W}}{M_W} - - - - - - - - - - - - - 3$

Put equation 3 into equation 2

(ii) $M_D = \frac{W.M_W \; x \; 100}{100W.M_W.W} = \frac{100M_W}{100 - M_W} - - - - - - 4$

(iii) $similarily \; M_W = \frac{100M_W}{M_D 100} - 5$

Moisture content can be determined by directs method or indirect method. Example of direct methods (a) air convention oven (b) Vacuum oven and (c) Distillation method. While indirect methods involve the measurement of such properties of the material which are functions of the moisture content. Calibration of such indirect metres is often achieved by means of any of the direct methods e.g. the oven method. Examples of indirect methods are electrical resistance metres and dielectric (capacitance meter).

2.11 Organoleptic Properties of Food

Flavour, texture and appearance are perhaps the most important characteristics of food because they are attributes the consumer can readily assess. Report shows that colour, flavor and texture are key attributes of food products that determine if they can be used in a whole range of food products (Visser and Thomas,1987).

2.11.1 Appearance (Colour)

Colour is an important quality of many foods. It is a quality attribute that together with flavour and texture plays an important role in food acceptability. Colour can be defined as a psychological response by the eye and brain to the physical stimulus of light radiation at different wavelengths (Ihekoronye and Ngoddy,1985).The effect of the base colour on each end products has to be tested individually (Visser and Thomas,1987).

2.11.2 Flavour

Visser and Thomas (1987) stated that flavor is very important in food appreciation. Flavour is a complex of sensation derived from food, including the sensation of taste and smell (Ihekoronye and Ngoddy, 1985).Apart from nutritional aspect, functionality, and price that determine their applicability, Flavour also play a major role in food acceptability (Vissser and Thomas, 1987)

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials

The millet (*Gero*) and groundnut samples used for the study were obtained from Minna Main Market, Niger State, Nigeria. The millet grains and groundnut seeds were used as obtained. The tests and analysis were carried out at the Animal Production Laboratory Department, Federal University of Technology, Minna. The nutritional analyses were carried out using the Official Methods of Analysis of Association of Analytical Chemist (AOAC, 2005).

3.2 Raw Material Processing

3.2.1 Preparation of Kunnu – Zaki

500g of dehulled millet grains were cleaned, sorted and thoroughly washed and soaked in 1 litre of water at room temperature for 24 hrs and milled with ginger and pepper, 2.5 litres of water was later added and the slurry was sieved using a muslin cloth. The filtrate was divided into two parts ratio (3:2), the larger portion was cooked with the addition of 3 litres of water for 5 minutes, while 2 litres of cold water was added to the second part. The two slurries were thoroughly mixed and sweetened with 50g granulated sugar.

The flow chart below shows the stages involved in the processing millet into *Kunnu*

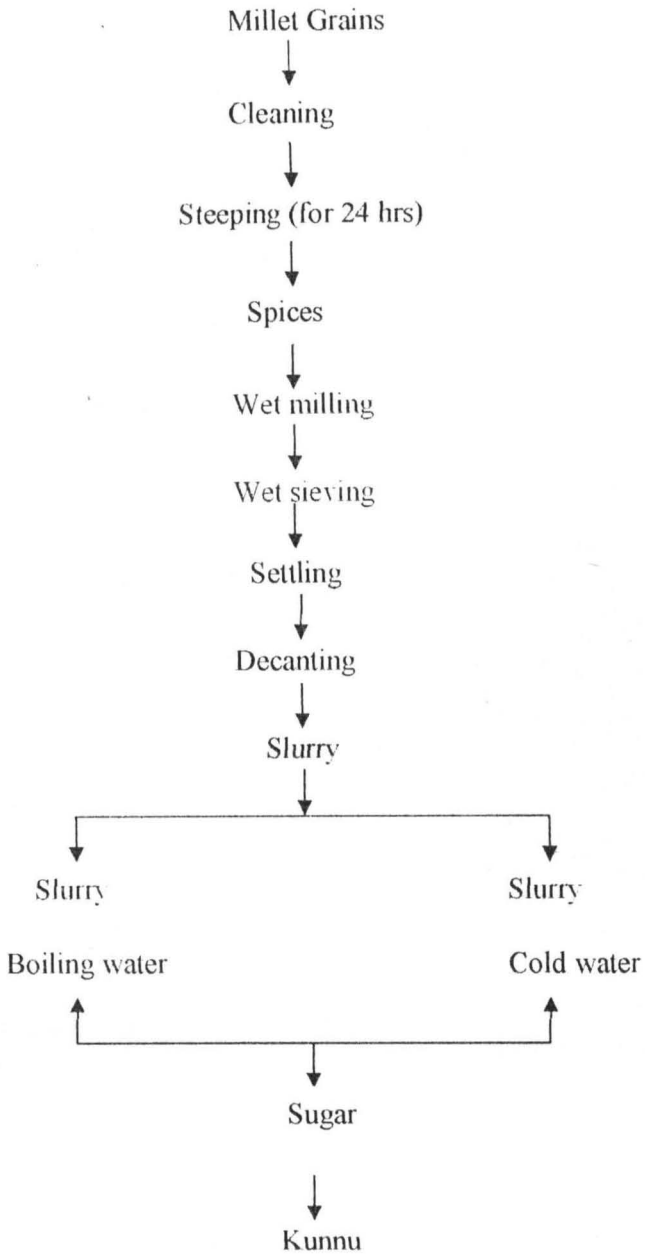


Fig.3.1: Flow Chart for The Production Of Kunnu From Millet

3.2.2 Preparation of Kunnu Gyada

500g of fresh groundnuts were slightly roasted and soaked in 2litres of water for a 2 hours,the skin of the nuts were removed by rubbing it in water. The soaked nuts were made into fine paste by milling with spices (ginger and red pepper).The paste was later mixed with water to the quantity of three times the bulk of the paste,

ratio (1:3) and strained through a muslin cloth with gentle pressure applied to the content to facilitate maximum liquid extraction. The resulting content was heated to 70^0C and about 50g of sugar was added to give taste.

The flow chart below shows the stages involved in the processing of Groundnuts into *Kunnu*

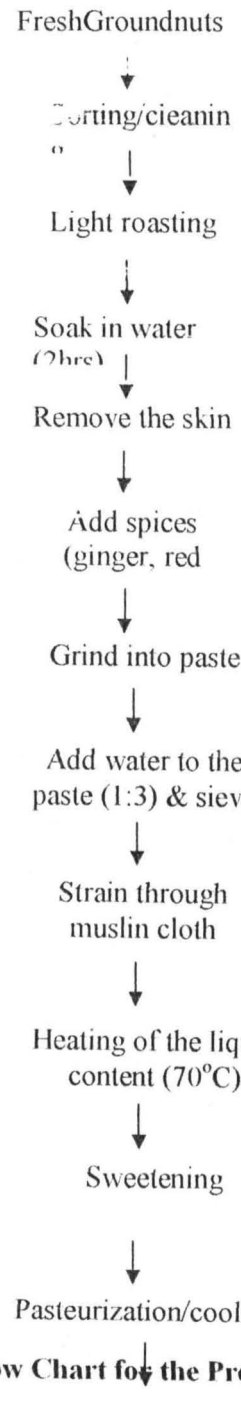


Fig: 3.2 Flow Chart for the Production of kunnu from Groundnut

3.3 Reagents and Instruments

The reagents and instruments used for this study are:-

3.3.1 Reagents

Tetraoxosulphate (vi) acid (H_2SO_4),

Sodium hydroxide (NaOH),

Calcium chloride ($CaCl_2$),

Boric acid, (H_3BO_3)

Methyl orange,

Filter paper,

Ammonium chloride solution (NH_4Cl) and

Petroleum ether.

3.3.2 Instruments/Apparatuses

Petri dish

Desiccators

Weighing balance (Metler, manufactured in Switzerland, Sensitivity 0.000,serial No.1 + 527664)

Oven (Gallenkamp, manufactured in England, serial no. 2062P19N)

Soxhlet extractor

Flat bottom silica dishes

Beaker

Pipette

Thimbles

Conical flasks

Crucible

Muffle furnace

Micro kjedal digestive block

3.3.3 Experimental Procedures

Sample were analyzed chemically according to the official methods of analysis described by Association of Official Analytical Chemists (AOAC, 2005) while crude protein was analyzed chemically according to Laboratory Manual on Basic Methods in Plant Analysis (Ibitoye, 2005).

The following parameters were determined using the above method: Dry matter, Crude fiber, Fat, Nitrogen/Crude protein, Ash content and Carbohydrate content. Full details on the above determinations are included in Appendix A.

CHAPTER FOUR

4.0 RESULT AND DISCUSSION

4.1 Presentation of Results

The proximate composition of Raw and Processed Millet are shown in Table 4.1

Table: 4.1: The proximate composition of Raw and Processed Millet

(Mean values)

%Composition	Sample A	Sample B
Dry matter	8.71	86.05
Ash	2.50	1.75
Crude fibre	1.65	–
Crude protein	9.63	1.54
Ether extract	4.75	1.50
Carbohydrate	81.47	95.21

Sample A = Raw millet

Sample B = Processed millet

Table 4.1.2: Proximate Composition of Raw and Processed groundnut (Mean values)

%Composition	Sample C	Sample D
Dry matter	4.42	69.39
Ash	1.75	1.5
Crude fibre	2.60	–
Crude protein	49.05	4.31
Ether extract	30.25	4.25
Carbohydrate	16.34	89.94

Sample C = Raw groundnut

Sample D = Processed groundnut

4.2 Discussion of Results

The proximate composition of *kunnu* prepared from millet (Table 4.1) were compared to the proximate composition of *kunnu* prepared from groundnut *kunnu gyada* (Table 4.1.2).There were slight differences in dry matter content but high differences in crude proteins. The low cotent in dry matter of *kunnu* prepared from groundnut (69.39%) might be due to its viscous when compared to *kunnu* prepared from millet (86.05%). The result of *kunnu* gyada is lower to the result of Nkama et al (1994) Table 2.2 .The variation in result might be due to addition of millet to the *kunnu* groundnut prepared by these authors.

The ash content of *kunnu* prepared from groundnut is (1.5%) which gives an idea of amount of mineral elements present and the content of organic matter in the sample. The ash content of biological material like groundnut is analytical term for inorganic residue that remains after organic matter has been burnt off. The organic component in food is burn air .The residue is ash which consists of which consist

inorganic components in form of their oxides. The ash is not usually the same as the inorganic matter present in original food since there may be losses due to volatilization or chemical interaction between the constituents. The ash may however contain material of organic origin such as sulphur and phosphorus from proteins and some loss of volatile material inform of sodium chloride, potassium, phosphorus, and sulphur will take place during ignition. The value is useful in assessing the quality or grading certain edible materials.

Groundnut is rich in fibre (2.60%) when compared to that of millet (1.65%) therefore is an excellent source of fibre. A fibre rich diet is very important in reducing the risk of certain types cancer and heart diseases. Thus *kunnu* prepared from groundnut has good potential not only as refreshing drinks but also serves as supplement for standard diet.

The crude protein of *kunnu* prepared from groundnut (4.31%) was three times than that of millet (1.54%).This result was in contrast with the report of Nkama et al (1994),the poor protein content of *kunnu* reported by these authors could be due to the probably the types of ingredients used that is (pearl millet plus groundnut).However the protein content of *kunnu* prepared from millet agreed with report Balewu and Abodunrin (2006)

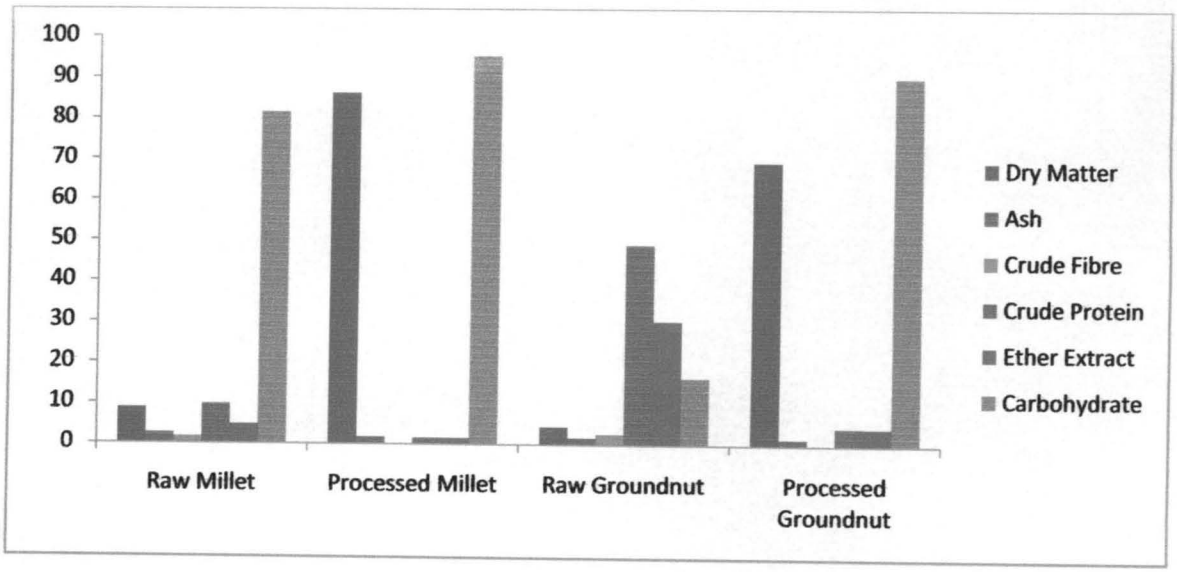
Kunnu prepared from groundnut had the highest fat content (7.50%) which was superior to that of millet (1.50%).The fat percentage of *kunnu* prepared from millet was higher than the result of Sowonola et al (2005).

The carbohydrate content of *kunnu* prepared from groundnut is (89.94%) which is lower compared to that of millet. Carbohydrates are classified as monosachride, disachrides, and polysaccharides. Examples of mononsachrides are ribose doxyribose, glucose, galactose, mannose, aldose, and fructose.

Glucose has an important function as fuel in the body and is of great important in carbohydrate metabolism. Glucose occurs more frequently and to a great extent in nature than any other carbohydrate.

Maltose is an example of disachrides and it is important as an intermediate stage in breakingdown of starch to glucose .Sucrose occurs in certain plants, such as sugarcane and as an important dietary carbohydrates.

Figure 4.1 Graphical Representation of Proximate composition of Raw Millet, Processed Millet, Raw Groundnut, and Processed Groundnut



CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The results of percentage proximate compositions of raw and processed sample of *kunnu* prepared from groundnut and millet has revealed that *kunnu* prepared from groundnut could be used as a beverage for both young and old persons due to high nutrient contents (protein, fat, fibre e. t. c).It is noteworthy that groundnut are good source of niacin and thus contribute to brain health, brain circulation, and blood flow, which is an added advantage to the consumer of the product. A good consumption of *kunnu gyada* is seen in medical sector as a good dietary supplement for people with diabetes, coronary heart disease and cancer patients due to its high protein content, ease of breaking down starch as well as high fibre content.

The results also indicates that the utilization of groundnut in preparation of *kunnu* could enhance the nutritional status of the beverage which will help in solving the problem of protein calorie malnutrition in Nigeria in particular and Africa in general.

5.2 Recommendations

At the end of this study, the following recommendations have been made:

1. Due to its high protein content and other nutritional qualities present in *kunnu gyada*,its consumption should be widely encouraged to exploit the nutritional value of this product.
2. Because of the importance of this beverage as weaning food and the frequency with which it is consumed by infants and young children, further studies should be made to investigate its storage stability and ingredient standardization to improve its quality.

3 Effort should be made on how to process the product in hygienic way and condition in order to retain its high percentage nutritional qualities.

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APPENDICES

APPENDIX A

AOAC (1998) Guidelines for Determining Proximate Parameters

Prior to each analysis, a representative sample of the material should be carefully made: such methods vary with the type of food materials. Determinations are usually made on dry samples except moistures determination; result obtained may be reported in terms of dry or wet weight of the samples. The dried material is ground in mortar into powered form, often necessary to pass through sieve of particular mesh size, and then stored in dry containers. Most food such as meat, fish etc should be minced and then mixed in a mortar. The process should be repeated before analysis. Wet foods can be boost processed in a high-speed blender. Average of several determinations made on random samples from the foods stuff container makes result valid. The following are some of the major determinations on proximate compositions.

1. Moisture: Dry a metallic dish in an oven at 80^0C for 20 minutes, cool in a desicator and weigh (W_1). Take few grams of the sample into the dish and take weight (W_2). The dish with sample is then dried in an oven 80^0C usually 24hours (better until constant weight is reached), and is quickly transferred to a desicator to cool. Weigh quickly with minimum exposure to atmosphere (W_3). The loss in weight of the sample during is the moisture content. (%) = $\frac{W_2-W_1}{W_2-W_1} \times 100$
2. Ash and Organic matter: The ash is an analytical term for the inorganic residue that remains after the organic matter has been burnt away. The ash is

not usually the same as the inorganic matter present in the original food since there may be losses due to the volatilization or chemical interaction between the constituents. The value is useful in assessing the quality or grading certain edible materials.

Hold a clean, flat bottomed silica dish (about 7cm diametre) in a hot Bunsen-burner flame for one minute, transfer it to a dessicator, then cool and weigh (W_1). Take about 5g of the food sample into the dish and weigh (W_2) again, so that the weight of the sample ($W_2 - W_1$) may be found by difference. Heat the silica dish containing the sample gently on a Bunsen burner in a flame cupboard until smoking ceases, then transfer to Muffle furnace heated to about 500^0C. Continue heating until all the carbon has burnt away (usually 24 – 48 hours). Switch the furnace off, take out the silica dish, immediately covered, and place inside a desicator, cool, and weigh (W_3). Calculate ash content and find ash (%).

The portion of the sample, which burnt off is organic matter.

$$\text{Organic matter (\%)} = \frac{w_2 - w_3}{w_2 - w_1} \times 100$$

3. Crude fibre: the portion of the plant material which is not ash or dissolved in boiling solution of 1.25% H_2SO_4 or 1.25% NaOH.

   Procedure

   I. Transfer about 3.5g defatted sample into 500ml conical flask.

   II. Add 200ml of boiling 1.25% H_2SO_4 and bring to boiling within one minute and allow to boil gently for 30 minutes exactly cooling finger to maintain constant volume

   III. Filter through poplin cloth or filter paper by suction using buncher funnel, rinse well with hot distilled water separate material back into flask with spatula

IV. Add 200ml of boiling 1.25% NaOH and few drops of antifoaming agent, bring to boiling within one minute and boil gently for 30 minutes using cooling finger (KOH can be used in the place of NaOH) and vegetable oil as antifoaming agent.

V. Filter through poplin cloth and wash with hot distilled water. Rinse four times with hot distilled water, and once with 10%HCL, four times again with hot water, twice with methylated spirit and three times with petroleum ether (where methylated spirit is not available). Ethanol could be used as a substitute for methylated spirit)

VI. Selvage the residue into crucible after drain, dry in the oven at 105^0C, cool in desicator and weigh W_2.

VII. Place in muffle furnace at about 300^0C for about 30 minutes.

VIII. Remove into desiccators and allow to cool to room temperature, weigh again W_3.

$$\%Crude\ fibre = \frac{W_{2-}W_3}{W_1} x\ 100$$

4. Lipid: The lipid content of biological materials can be estimated by directly extracting the dry material exhaustively using a suitable lipid solvent e.g. petroleum (40^0C – 60^0C), diethyether etc in a convenient continuous extractor, such as Soxhlet, Bolton or bailey – walker type. Direct extraction gives the proportion of free fat.

About 5g of the sample powder is taken into a thimble of known weight (W_1). They together weigh (W_2). The thimble with sample is placed inside a Soxhlet extractor. 300ml of acetonethanol mixture (1:1) is poured into a 500ml round bottom flash. The Soxhlet extractor with the thimble plus sample is filled into the flask, which

is sited in electrically connected heating mentle, the mentle, is switched on and the heat increased carefully and slowly until the solvent boils, (Condensed solvent vapour collects in the thimble and dissolves the lipid in the sample. The solvent with dissolved lipid will continuously run back into the flask). The heating and so the extraction process is continued for about 24 hours when the thimble with contents is removed, dried in an oven at $50^{\upsilon}C$ for 24 hours, cooled in a desicator and weigh (W_3).

Calculation lipid (%) $= \frac{w_2 - w_3}{w_2 - w_1} \times 100$

The solvent is distilled off to about 20ml; the lipid in solvent is quantitatively transferred on to an evaporating dish, cooled, dried in a desicator. The lipid thus recovered may be weighed and lipid (%) calculated.

5. Nitrogen and crude protein (According to Ibitoye, 2005): the reference 'Kjeldahl proteins contain total nitrogenous matter which includes non-proteins as well. Most proteins contain about 16% nitrogen. Total nitrogen, estimated by the Kjeldahl method is multiplied by 6.35 to express the average crude protein, for milk and egg this factor is 6.38 and 6.68 respectively. K_2S raise boiling point of digestion mixtures and copper sulphate accelerate the chemical changes. Nitrates and nitrites are not determined by this procedure. Kjeldahl method is a volumetric method producing $(NH_4)_2SO_4$ by acid digestion of sample. From alkaline digest, ammonia is distilled off, collected as Boric acid complex and estimated.

   There are other methods nitrogen estimates also. Kjeldahl method for nitrogen estimation K_2SO_4, $CuSO_4$

   Reagents:

   a) Mixed catalyt, 160g anhydrous K_2SO_4,10g $CuSO_4 + 5H_2O$, 3g selenium powder are mixed well in a mortar and stored in dry in a container

b) Sulphuric acid, 98g Con.

c) Sodium hydroxide 40%

d) Boric acid

e) Hydrochloric acid, standard, N/70,

Procedure:

Digestion (Stage 1)

1(a) Weigh about 2g wet sample into 50ml Kjeidahl flask, add 20ml conc. H_2SO_4 with one Kjeldahl catalyst tablet.

(b) Weigh about 0.5g dry sample into 50ml microKjeldahl flask, and 5ml conc. H_2SO_4 with half Kjeidahl catalyst tablet. Let the weight be (W_1).

2. Heat on a heater start with a low heat for about 15 minutes, increase to medium heat for 30 minutes again and finally at high heating until digested. Rotate the flask at intervals until the digest is clear (light green or grey white) continue heating for few minutes after that to ascertain complete digestion.
3. Allow to cool, wash sample residue if any filter, make up the digest up to 50, 100ml or as appropriate (V_1)

Distillation (stage 2)

1. Place 5ml of 2% boric acid (H_3BO_3) into 100ml conical flask (as receiving flask). H_3BO_3 as an acid will trap down the ammonial vapour from the digest. (2% is 2g made up to 100ml distilled it requires not water to dissolve).
2. Add 3 drops of mix indicator. (H_3SO_3) and the indicator can be prepared together). Mix indicator 0.1989g bromocresol green plus 0.132g Methyl red in 200 ml alcohol.
3. Place the receiving flask so that the tip of the condenser tube is below the surface of the boric acid.

4. Pipette 5ml for samples rich in nitrogen and 10ml for sample low in nitrogen into Marham distiller or any available distiller that have similar operation.
5. Add 10ml of 40% NaOH, tight the joints and distil about 50 ml into the receiving flask (V_2) (40% is 40g made up of 100ml with distilled water)

Titration and calculation (stage 3).

Titrate the distillate with standard mineral acid (0.01M HCL or 0.025M H_2SO_4). Titrate a blank with the acid as well.

Sample titre T_1

Blank titre T_2

Control titre = $T_1 - T_2 = T$

And Molarity or Acid = M

Reactions

Digestion

$H_2SO_4 + 2NH_3 = (NH_4)2SO_4$

Nitrogen converted to ammonia and reacted with H_2SO_4.

Distillation

$(NH_4)_2SO_4 + 2Na_2SO_4$.

$NH_3 + H_3BO_3 = NH_4 + H_2BO_3$

Titration

$NH_4 + H_2BO_3 + HCl = NH_4Cl + H_3BO_3$

1 mole of HCl = $\frac{M\,x\,T}{1000} = Molarity\ of\ NH_3$

Molarity of $NH_3 = \frac{M\,x\,T}{1000}$

Mass of $NH_3 = \frac{M\,x\,T}{1000}\ x\ 17\ x\ \frac{14g}{17}$

$= M\ x\ T\ x\ 0.014g$

$$\%N = \frac{M \, x \, T \, x \, 0.014}{W} \, x \, \frac{V_1}{V_2} \, x \, 100$$

Specimen calculation

Where control titre (T)

Molarity of Acid (M)

Volume of digest (V_1)

Volume of digest used (V_2)

$$\%N = \frac{M \, x \, T \, x \, 0.014}{W} \, x \, \frac{V_1}{V_2} \, x \, 100$$

Crude protein content (%) = 6.25 x Nitrogen (%)

4. Content of Carbohydrates and nucleic acid: If the total of protein and lipid content is subtracted from organic matter, the remaining accounts for carbohydrate and nucleic acid as organic matter (%) – (protein (%) + lipid

Chemical composition of Raw Millet,Processed Millet,Raw Groundnut,and Processed Groundnut are presented in Table 4.3

Sample	Dry matter	Ash	Crude fibre	Crude protein	Fat	Carbohydrate
R1	7.35	3.50	1.30	8.75	5.0	81.45
R2	10.06	1.5	2.00	10.50	4.50	81.50
Mean	8.71	2.50	1.69	9.63	4.75	81.47
Sample B						
R1	87.84	1.50	-	1.49	1.50	95.51
R2	84.25	2.00	-	1.58	1.50	94.92
Mean	86.05	1.75	-	1.54	1.50	95.21
Sample C						
R1	4.53	2.50	2.70	49.35	30.50	14.95
R2	4.31	1.00	2.50	48.76	30.00	17.74

Mean	4.42	1.75	2.60	49.05	30.25	16.34
Sample D						
R1	69.73	2.00	-	4.29	7.50	86.21
R2	69.06	1.00	-	4.33	1.00	96.67
Mean	69.39	1.50	-	4.31	4.25	89.94

APPENDIX B:

Calculations

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

A = Raw millet

B = Millet milk

C = Raw groundnut

D = Ground milk

Let W_1 be the weight of empty container

W_2 be the weight of container and sample

W_3 be the weight

1. For moisture content using the formulae below:

$$\% \text{ moisture content} = \frac{W_2 - W_3}{W_2 - W_1} * 100\%$$

For sample A

$W_1 = 34.51$

$W_2 = 67.17$

$W_3 = 64.77$

$$\% \text{ moisture content} = \frac{67.17 - 64.77}{67.17 - 34.51} * 100 = 7.35\%$$

$$\% \text{ solid or dry matter} = \frac{W_3 - W_1}{W_2 - W_1} * 100\%$$

$$= \frac{64.74 - 34.51}{67.17 - 34.51} * 100 = 92.6\%$$

Alternative,

% total solid = 100% - % moisture content

$$= (100\text{-}7.35)\ \% = 92.6\%$$

$$\text{Sample B} = \frac{W_3 - W_1}{W_2 - W_1} * 100\%$$

$$= \frac{40.44 - 34.22}{85.36 - 34.22} * 100 = 87.84\%$$

% dry matter B = (100-87.84) = 12.16%

$$\text{Sample C} = \frac{4.53 - 37.46}{76.45 - 37.46} * 100 = 4.53\%$$

% dry matter = (100-4.53) % = 95.47%

$$\text{Sample D} = \frac{85.22 - 53.99}{85.22 - 31.83} * 100 = 69.73\%$$

% dry matter = (100-67.3) % = 32.7%

2. For ash content using the formulae below:

Let W_1 be the weight of crucible

W_2 be the weight of crucible + sample

W_3 be the weight of crucible + ash

$$\% \text{ ash} = \frac{W_3 - W_1}{W_2 - W_1} * 100\%$$

$$\text{Sample A} = \frac{41.78 - 41.71}{43.71 - 41.71} * 100 = 3.50\%$$

$$\text{Sample B} = \frac{37.91 - 37.88}{39.88 - 37.88} * 100 = 1.50\%$$

$$\text{Sample C} = \frac{38.26 - 38.21}{40.21 - 38.21} * 100 = 2.50\%$$

$$\text{Sample D} = \frac{37.90 - 37.88}{39.88 - 37.88} * 100 = 1.00\%$$

3. For crude fibre using the formulae below:

   Let W_1 be the weight of sample

   W_2 be the weight of crucible + sample

   W_3 be the weight of crucible + ash

$$\% \text{ crude fibre} = \frac{W_2 - W_3}{W_1} * 100\%$$

$$\text{Sample A} = \frac{37.04 - 37.02}{1.50} * 100 = 1.30\%$$

$$\text{Sample C} = \frac{39.07 - 39.03}{1.50} * 100 = 2.70\%$$

4. For total lipid using the formulae below:

   Let W_1 be the weight of filter paper

   W_2 be the weight of filter paper + sample

   W_3 be the weight of filter paper + extracted sample

$$\% \text{ fat} = \frac{W_2 - W_3}{W_2 - W_1} * 100\%$$

$$\text{Sample A} = \frac{2.83 - 2.73}{2.83 - 0.83} * 100 = 5.00\%$$

$$\text{Sample B} = \frac{2.84 - 2.81}{2.84 - 0.84} * 100 = 1.50\%$$

$$\text{Sample C} = \frac{2.83 - 2.22}{2.83 - 0.83} * 100 = 30.50\%$$

$$\text{Sample D} = \frac{2.85 - 2.70}{2.85 - 0.85} * 100 = 7.50\%$$

5. For nitrogen and crude protein,

Sample titre, T_1

Blank titre, T_2

Control titre = $T_1 - T_2 = T$

And molarity of acid = M

REACTIONS

Digestion

$H_2SO_4 + 2NH_3 = (NH_4)_2SO_4$

Nitrogen converted to ammonia and reacted with H_2SO_4

Distillation

$(NH_4)_2SO_4 + 2Na_2SO_4$

$NH_3 + H_3BO_3 = NH_4 + H_2BO_3$

Titration

$NH_4 + H_2BO_3 + HCl = NH_4Cl + H_3BO_3$

1 mole of HCl = $\frac{M*T}{1000}$ x molarity of NH_3

Molarity of NH_3 = $\frac{M*T}{1000}*17*\frac{14g}{17}$

= MxTx0.014g

% N = $\frac{M*T*0.014}{W}*\frac{V_1}{V_2}*100\%$

Specimen Calculation

Molarity = 0.1

Titre value =

Weight of powder sample = 0.5g

Weight of liquid sample = 2g

Then, % crude protein content = 6.25xN

$$N = \frac{M * TV * 0.014 * 10}{W_{sample}} * 100$$

F0r sample A,

$$N = \frac{0.1 * 0.5 * 0.014 * 10}{0.5} * 100$$

$$N = 1.4 * 6.25 = 8.75\%$$

For sample B,

$$N = \frac{0.1 * 0.34 * 0.014 * 10}{2} * 100$$

$$N = 0.258 * 6.25 = 1.49\%$$

Sample C,

$$N = \frac{0.1 * 2.82 * 0.014 * 10}{0.5} * 100$$

$$N = 7.896 * 6.25 = 49.35\%$$

Sample D,

$$N = \frac{0.1 * 0.98 * 0.014 * 10}{2} * 100$$

$$N = 0.686 * 6.25 = 4.29\%$$

6. For carbohydrate content using the formulae below:

% carbohydrate = 100% - (% crude protein + % crude fibre + % lipid + % ash)

Sample A = 100 – (8.75 + 1.30 + 5.0 + 3.50)

= 100 – 18.55 =81.45%

Sample B = 100 – (1.49+1.5+1.5)

= 100 – 4.49 = 95.51%

Sample C = 100 – (49.35+2.7+30.5+2.5)

= 100 – 85.05 = 14.95%

Sample D = 100 – (4.29+7.5+2)

= 100 – 13.79 = 86.21%