EFFECTS OF COOKING TIME ON THE NUTRITIONAL CONTENT OF AFRICAN WALNUT (*Tertracarpidium conophorum*)

BY

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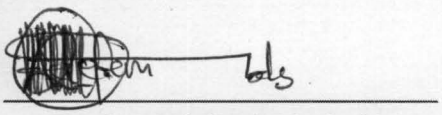
DECLARATION

I hereby declare that this project work 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 Information derived from personal communications, published and unpublished work were duly referenced in the text.



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01/03/2012

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2006/24098EA

CERTIFICATION

This is to certify that the project entitled "Effects of Cooking Time on the Nutritional Content of African Walnut (*Tetracarpidium conophorum*)" by Bonire, Adefemi Olasimide 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.

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DEDICATION

This research work is dedicated to the almighty God, Jehovah.

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ABSTRACT

The effect of cooking time on the nutritional quality of *Tetracarpidium conophorum* nut was investigated with a view to obtaining the appropriate time at which the nut should be cooked to have its optimum benefit for man. Standard laboratory conditions, methods and instruments were used to obtain the results of the experiments. The nuts were cooked for 60, 80 and 105 minutes respectively, at temperature of 100°C and there were differences in the nutritional composition of nut cooked between these time intervals. Raw *Tetracarpidium conophorum* nut was characterized by moisture content of about 42.25%; fat 16.13%; crude protein 21.45%; crude fibre 2.20%; ash 2.02%; and carbohydrate 15.96%. *Tetracarpidium conophorum* nut cooked for 60 minutes was characterized by moisture content 43.85%; fat 16.55%; crude protein 19.27%; crude fibre 2.99%; ash 2.52% and carbohydrate 14.83%. Furthermore, the samples of the nut cooked for 80 minutes contained moisture content of 44.00%; fat 17.13%; crude protein 19.15%; crude fibre 3.35% ash 2.45%; and carbohydrate 13.93%. The samples of *Tetracarpidium conophorum* nut cooked for 105 minutes were characterized by 44.75% moisture content; 5.60% crude fibre; 3.00% ash and lower fat content 16.57%, protein 17.85%, carbohydrate 12.23%. It was evident that there were varying degrees of changes that occurred in each of the nutritional composition of the nut with respect to the different cooking time. From the tests carried out and the result obtained, it was discovered that *Tetracarpidium Conophorum* nut cooked for 80 minutes at a constant temperature of 100°C gave better results in terms of nutrient retention. The values of the nutritional content obtained for this time period of heat treatment were: moisture content 44.00%, fat 17.13%, crude protein 19.15%, crude fibre 3.35%, ash 2.45% and carbohydrate 13.93%.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

The word walnut derives from Old English *wealhhnutu*, literally "foreign nut", *wealh* meaning "foreign" (Wikipedia, 2008). It comprises such families as *Juglandaceae* (English walnut), *Euphorbiaceae* and *Olacaceae*. Each family has its own peculiar characteristics but they have some things in common such as the nuts. *Juglandaceae* is mostly found in Southeast Europe, Japan and more widely in the New World. *Coula edulis* (family - *Olacaceae*) is found in Congo, Gabon and Liberia. *Tetracarpedium conophorum* (family - *Euphorbiaceae)* which is called Africa walnut is found in Nigeria, Western Cameroon and India, it is thought to originate from Nigeria, it is known in the littoral and the Western Cameroon as *Kaso* or *Ngak*. In Nigeria it is found in the South Western part of the country.

Tetracarpedium conophorum is called *Ekporo* by the *Effiks* and *Ibibios* of Cross River and Akwa-Ibom States (Oke, 1995; Petrova, 1980). Dalziel (1937) reported that the plant is known as *Ukpa* (Igbo) and *Awusa* or *Asala* (Yoruba). In Hausa it is known as *Gyadan Kurumi*. Its habitat is usually large trees. It has a long history as food grown by peasant farmers across West African rainforest. The climber bears capsules which are greenish in colour when young and greenish-yellow when fully ripe. They contain four shelled seeds (Willis, 1966). The testa of the seed is hard and the cotyledons white in colour. The fruits are edible (Enujiugha, 2003). In Nigeria they are cultivated principally for the nuts which are cooked and consumed as snacks (Oke, 1995). A bitter taste is usually observed upon drinking water immediately after eating the nuts; this could be attributed to the presence of chemical substances called alkaloids (Edem *et al.*, 2009).

The shell, bark and leaves of the *Tetracarpedium conophorum* plant are antifungal, anti-parasitic and anti-dysenteric and the bark is used by people as a mild laxative. The medicinal uses of the bark, leaves and roots are an ancient prehistoric practice surrounded by many superstitious beliefs (Enujiugha, 2003). It is also reported to be useful in folklore in the treatment of dysentery. This therefore justifies its ethnomedical use, which refers to the cultural specific medical system not in the Western world. The nut lipase could prove useful in industrial biocatalytic hydrolysis; it could also be useful in processes that require lower cooling costs and minimal corrosion problems (Enujiugha, 2003). The nut contains between 48-50% dry weight of oil, which is liquid and golden yellow in colour with taste and odour resembling those of Lin seed oil. The residue after oil contains over 50% protein. Gas chromatographic analysis of the seed oil shows a high level of the Sn-3 fatty acid and Linolenic acid (Adebona and Ogunsua, 1983).

The cotyledon is covered with a hard testa which is not easily penetrated by seed borers during storage. Deterioration of the milky white cotyledons during storage comes by way of off-flavour development as a result of high unsaturation of the seed oil. However, refrigerated storage extends the shelf life of the nuts considerably (Adesioye, 1991). The plant is usually associated with cocoa plantations: as such some of the mites and insects pest that attack the cocoa leaves are occasionally seen on its leaves. The common red spider mite (*Tetranychus Neocaledonicus*) attacks the leaves and flowers causing foliar and flowering distortions. However serious crop damage seldom occurs. The humid tropical climate is not conducive to its growth (Matthysse, 1978).

1.2 Statement of the Problem

Little or no work has been done on the effect of cooking time on the nutritional contents of *Tetracarpedium conophorum* nut. Also the immense benefits and importance of the nut and its derivatives have not yet been fully utilized in Nigeria. Since the nut cannot be consumed in its raw form, they are subjected to hydrothermal treatment and sometimes even excessive heat, thus there is need to investigate the effect of these heat treatments on the nutritional contents of the nut.

1.3 Objectives of Study

The objectives of this project are

1. To determine the nutritional content of *Tetracarpedium conophorum* nuts at various cooking periods.
2. To determine the best cooking time for *Tetracarpedium conophorum* nuts in which its nutritional content is well preserved.
3.

1.5 Justification of Study

Tetracarpidium conophorum is a nut with high nutrient contents; Ayodele (2003) reported the presence of oxalates, phylates and tannin in the raw nuts. Though nuts are generally eaten in Nigeria, very little or no work has been done on the effect of thermal treatment on nutritional content of the nut. The generated data at the end of this work will help in informing on the significance and immense benefits of this nut.

1.4 Scope of Study

The nuts would be subjected to hydrothermal treatment for a period of 60 minutes, 80 minutes and 105 minutes at a temperature of 100°C. The nutritional properties that would be

determined would be limited to the following: moisture content, fat, crude protein, crude fibre, ash and carbohydrate.

CHAPTER TWO

2.0 Literature Review

2.1 Study Background

The name walnut encompasses all types of walnuts bearing plants. Walnut is found in the family of the *Juglandaceae, Olacaceae* and *Euphorbiaceae.* Each family has its own peculiar characteristics but they have some things in common such as the edible nuts they produced.

2.1.1 The *Juglandaceae*

The *Juglans* is a plant genus, containing species known as Walnuts, which is placed in the *Juglandaceae* family. They are deciduous trees, 10–40 meters tall, with pinnate leaves 200–900 millimetres long, with 5–25 leaflets; the shoots have chambered pith, a character shared with the wingnuts (*Pterocarya*). Romans spread cultivation throughout Southern Europe. The 21 species in the genus range across the North temperate Old World from southeast Europe East to Japan, and more widely in the New World from Southeast Canada West to California and South to Argentina. The most famous ones are English (or Persian) walnut (*Juglans regia*), White walnut (*Juglans cinerea*) and Black walnut *(Juglans nigra*). The *Juglans* are mostly planted for the wood used for furniture paneling and gunstocks. They also produce edible nut which are also consumed locally. The nuts are borne singly or in clusters of 2-3 on shoot tips. A green, fleshy shuck surrounds the nut, which splits irregularly at maturity. The shell is rough, wrinkled or furrowed, and thin. Nuts are ovoid to round, ½ -2" in diameter, containing two kernels separated by a thin, papery central plate extending from the inner layer of the shell. The kernel is rich in protein, carbohydrates, fat, vitamins and minerals. Much of the shelled kernels are processed into baked goods, candies, cereals, and other snack foods (Wikipedia, 2010).

2.1.1.1 Nutritional Content of Some *Juglans* Species

Table 2.1 shows the proximate composition of two species of walnuts, *Juglans regia* and *Juglans nigra.*

Table 2.1: Proximate Composition of Some *Juglans* Species

	Juglans regia	*Juglans nigra*
Moisture (%)	3.34	4.56
Ash (%)	1.56	2.76
Fat (%)	63.5	59.00
Crude fibre (%)	0.41	1.03
Protein (%)	19.15	24.06
Carbohydrates (%)	12.00	9.91

Source: Ferhad *et al.,* (2010)

Walnut fat is produced from the inedible nuts rejected during shelling. The oils from the different species of walnut bear a close resemblance to each other in terms of both physical and chemical characteristics. They are light yellow in colour with a greenish tinge and have a delicate nutty odour. The *Juglans* kernels generally contain about 60% oil, but vary from 52% to 70% depending on the variety. The major constituents of the oil are triglycerides. Free fatty acids, di-glycerides, mono-glycerides, sterols, sterol esters, phosphatides and vitamins are present in minor quantities. The triglyceride moiety of the oil is a mixture of tri-unsaturated and non-symmetrical di-unsaturated glycerides that form up to 83-95% of the total fraction. The fatty acids of the *Juglans* oil are predominantly (> 93%) unsaturated and consist mainly of linoleic and oleic acids. The linoleic acid content in English (*Juglans regia*) walnut is higher than that in black walnut (*Juglans nigra*).Walnut oil has also been found to contain at least 29 volatile components, such as terpenes, alcohols and carbonyls. Walnut (the

Juglans) kernels contain about 14.5-24% of protein, and this rises to 61-66% in dry, defatted cake. Walnut cake contains more arginine and less lysine than does casein and soya bean meal. The walnut kernel protein contains all the common amino acids, and glutamic acid which is the main amino acid, followed by arginine. Walnut kernels also contain a sulphur amino acid, taurine (2-aminoethanesulphonic acid). In humans, taurine deficiency may lead to a decreased electro-retinogram and to pigmentary degeneration of the retina. Walnut kernels have the potential to replace meat as a source of dietary taurine. The total carbohydrate content in English and black walnut kernels varies from 15.6-19.9 and 13-16 g/100g, respectively. The fibre content in both the varieties is about 2 g/100 g of kernel. Walnut kernels are also a good source of vitamins. English walnuts contain more vitamin A than black walnut, while the latter is a richer source of thiamin than English walnuts. The contents of riboflavin and nicotinic acid are almost same for all varieties of walnut. The richest sources of vitamin C are the immature fruits or their green hulls. Unripe or green walnuts as reported by Amaral, (2003) is said to have a very high vitamin C content (40~50 times as high as oranges or lemons), the kernels are also found to be rich in vitamin K1. (www.mdidea.com)

The *Juglans regia* nuts are rich source of energy and contain many health benefiting nutrients, minerals, antioxidants and vitamins that are essential for optimum health (www.nutrition-and-you.com). The nutritional contents of this nut are presented in Table 2.2

Table 2.2: Nutritional Value per 100 g of Walnuts (*Juglans regia*),

Principle	Nutrient Value	Percentage of RDA
Carbohydrates	13.71 g	11%
Protein	15.23 g	27%
Total Fat	65.21 g	217%
Dietary Fiber	6.7 g	18%
Vitamins		
Folates	98 µg	24%
Niacin	1.125 mg	7%
Pantothenic acid	0.570 mg	11%
Pyridoxine	0.537 mg	41%
Riboflavin	0.150 mg	11.5%
Thiamin	0.341 mg	28%
Vitamin A	20 IU	0.5%
Vitamin C	1.3 mg	2%
Vitamin E-γ	20.83 mg	139%
Vitamin K	2.7 µg	2%
Minerals		
Calcium	98 mg	10%
Copper	1.5 mg	167%
Iron	2.9 mg	36%
Magnesium	158 mg	39.5%
Manganese	3.4 mg	148%
Phosphorus	346 mg	49%
Selenium	4.9 mg	9%
Zinc	3.09 mg	28%

Source: USDA (2009)

2.1.1.2 Health Benefits of the *Juglans*

The *Juglans* are a rich source of unsaturated fatty acids vitamin E, fibre, magnesium, potassium (Dreher *et al.*, 1996). Compared with most other nuts, which contain mostly monounsaturated fatty acids (MUFA), walnuts are highly enriched in omega-6 and omega-3 polyunsaturated fatty acids, which are essential dietary fatty acids (Amaral *et al.*, 2003). This situation makes walnuts unique for a healthy diet. Frequent consumption of walnuts may provide some protection against coronary heart disease (Hu *et al.*, 1998; Prineas *et al.*, 1993) and cations, such as magnesium and potassium, may improve blood pressure (Elin, 1993). Replacement of dietary saturated fats with either monounsaturated fatty acids or poly-unsaturated fatty acids decreases plasma total and LDL cholesterol concentrations (Dattilo and Kris-Etherton, 1992).

Elin (1993) reported that the form of vitamin E found in walnuts is somewhat unusual, and particularly beneficial. Instead of having most of its vitamin E present in the alpha-tocopherol form, walnuts provide an unusually high level of vitamin E in the form of gamma-tocopherol. Particularly in studies on the cardiovascular health of men, this gamma-tocopherol form of vitamin E has been found to provide significant protection from heart problems. decreased LDL cholesterol; decreased total cholesterol; increased gamma-tocopherol; increased omega-3 fatty acids in red blood cells (alpha-linolenic acid). Walnuts are a very good source of manganese and a good source of copper, two minerals that are essential cofactors in a number of enzymes important in antioxidant defences they also contain an antioxidant compound called ellagic acid, which blocks the metabolic pathways that can lead to cancer. Ellagic acid not only helps protect healthy cells from free radical damage, but also helps detoxify potential cancer-causing substances and helps prevent cancer cells from replicating (www.walnutsweb.com).

Melatonin has been shown to help improve sleep for night shift workers and people suffering from jet lag. The amount of melatonin present in walnut have been quantified to be between 2.5 and 4.5 ng/gram, it was also demonstrated that eating walnuts triples blood levels of melatonin and also increases antioxidant activity in the bloodstream in animals. Walnut also helps to improve several physical illnesses, promote weight loss (even though the caloric content is fairly high) and enhance overall health. These beneficial effects are probably linked to their high content in seldom-eaten Omega-3 polyunsaturated fats, which are slowly but steadily disappearing from our diets but are absolutely essential for the good functioning of our bodies. (www.walnutsweb.com)

From ancient times through the nineteenth century herbalists prescribed the walnut, the bark, the roots, and the leaves as an astringent, a laxative, a purgative to induce vomiting, a styptic to stop bleeding, a vermifuge to expel worms or parasites, and a hepatic to tone the liver. The walnut served to induce sweating, cure diarrhea, soothe sore gums and skin diseases, cure herpes, and relieve inflamed tonsils. The nut itself was used to prevent weight gain, calm hysteria, eliminate morning sickness, and to strengthen one's constitution. The hulls were boiled and used to treat head and body lice, herpes, intestinal parasites and worms, skin diseases, and liver ailments. The leaf was decocted to cure boils, eczema, hives, ulcers, and sores, the oil was also employed as a medicinal aid. It was first diluted before it was used to treat colic, dandruff, dry hair, gangrene, and open wounds, while the green rind of the walnut was used to treat ringworm (www.walnutsweb.com)

2.1.2 *Coula Edulis*

Coula edulis is a tree in the genus *Coula* (family *Olacaceae*), native to tropical Western Africa from Sierra Leone to Angola. It is called Africa walnut and is plentiful in the Democratic Republic of Congo, Gabon, and Liberia. It prefers tropical region and is tolerant of light shade. It can be found in the top canopy of forest as well as the lower story and has no special soil requirements. It is an ever green tree growing to a height of 25-38 m, and has a dense crown that can cast shade. The leaves are arranged alternately, simple 10 to 30 cm and 4 cm broad with an entire margin and acuminate apex. The nut is an ellipsoidal drupe 3-4 cm long, with flesh surrounding the kernel, 5-6 mm thick, smooth in texture and can be red or green. The kernel shell is extremely hard and makes germination difficult. The nuts are usually found under the mother trees. Every part of the tree is used in both raw and finished states. Its timbers and nuts are used extensively. The bark is used locally to produce rinses or enemas for loin pains or kidney problems. The wood is used to make pilings for bridges and railways ties in addition to charcoal and standard construction. It is also used for furniture, cabinetwork construction decorative veneers and panelling. The wood is bronze-coloured, yellow-brown with irregular dark lines. It is extremely very hard, heavy, close-grained, and resist water, making it valuable hardwood. The nut is 50% fat of which 87% is oleic acid. The flavour is mild and is said to be between the flavour of hazel nuts and chest nuts. The nuts are used in varieties of ways; it can be boiled, roasted and fermented before being eaten. The nuts are used in recipes and mixed with meats it is also a source of cooking oil and ground flour (Davidson, 2009). *Coula edulis* is used in traditional medicine as a remedy for parasitic skin diseases, jigger, mouthwash, tonsillitis, sickle cell, and malaria (Mpiana *et al.*, 2007; Walker and Silans, 1961). Saxena *et al.*, (2003) reported that the leaves revealed the presence of phenolic compounds and having anti-plasmodial activity, their presence may, therefore,

explain the antiplasmodial activity observed, the leaves are boiled with those of *Cymbopogon citratus* and *Mangifera indica* in water to form a concoction against malaria.

2.1.3 *Tetracarpidium conophorum* (African Walnut)

Tetracarpedium conophorum formerly known as *Plukenetia conophora* is a woody perennial climber that belongs to the family *Euphorbiaceae*. Its common name is also African walnut, like the *Coula edulis*, it is found in the forest regions of Africa and India (Oke, 1995; Petrova, 1980). In Africa, *Tetracarpidium conophorum* is known in the littoral and the Western Cameroon, where it serves as an edible nut eaten between meals (Tchiegang *et al.;* 2007). In Nigeria, it is found in the West-Southern part of the country namely; Abak, Uyo, Etinan, Akamkpa, Akpabuyo, Lagos, Ibadan, Osun and Ondo states. They are all cultivated principally for the nuts which are cooked and also consumed as snacks (Oke, 1995).

Since there is no accurate yield record of its annual production, walnut has not been fully developed for industrial utilisation; consumption is therefore as snacks. The plant is identified with cocoa plantations where it is planted as a minor component of the mixed cropping system. It is usually cultivated by subsistence farmers in the hot and humid zones of tropical Africa in compounds, gardens and backyards, just for the family and local market consumption (Enujiugha, 2003).

Oyenuga (1997) reported on the amino acid and fatty acid components of the nut and on the use of its leaf juice for the treatment of prolonged and constant hiccups. Okpero (2001) reported on the methods of processing the nuts while Okafor (1988) reported on the use of the seeds and processing waste in livestock feed formulation (Enujiugha, 2003).

2.2 Botany

2.2.1 Taxonomy and Nomenclature

Tetracarpidium Conophorum is in the family *Euphorbiaceae* and is called the African walnut. These are spurge family with plants having swollen, fleshy, sparsely branched stems and candelabroid in appearance. The nut is called *ukpa, awusa* or *asala* in parts of South Western Nigeria (Enujiugha, 2003).

2.2.2 Description

This woody climber is 6-18m long, with a large stem. The stem can be up to 16cm in girth and dark grey when old but green and glabrous when young. The root is mainly fibrous. The leaves (about 10cm long and 5cm broad) are simple, erenulate and ovate with a serrated margin; they are also alternate, abruptly acuminate and rounded at the base. The leaves are three-nerved at the base with the petiole up to 5cm long. *Tetracarpedium Conophorum* plant is monoccious with separate male and female flowers on the same plant. The male flowers are in narrow raceme-like panicles about as long as the leaves, with one to two female near the base. The flowers are arranged alternately on the axis of the raceme in florescence. The style is stout and quadrangular, with four spreading stigmas. The stamens are many, about 40 in number (Enujiugha, 2003).

The fruit is a four-winged, ribbed capsule, containing sub-globose seeds with a thin, brown shell and yellowish kernel. Each seed loculus ends in a wing thereby creating ridges in between the wings. The seed is about 2.5cm in diameter. The fruit is light green to brown when riped (see plate 2.1), while the seeds are round and dark brown at maturity covered with a hard testa (see plate 2.2). Sometimes not all the seeds develop in which case the fruit has fewer wings (Isawumi, 1993).

Plate 2.1: Harvested *Tetracarpidium Conophorum* fruits

Plate 2.2: ***Tetracarpedium Conophorum*** **Seeds/Nuts**

2.2.3 Ecology

The vine is found in the moist forest zones of tropical Africa between $4^{O}15`$ and $8^{O}N$ of the equator (Okafor, 1983). This exotic wild fruit is grown in the traditional farming system of the lowland humid regions. It can tolerate any type of soil, provided it is well drained with moderate moisture-retention capabilities.

2.2.4 Fruit Growth and Development

In Nigeria, the *Tetracarpedium conophorum* plant flowers between November and early January and fruits between February and September (Oluwole and Okusanya, 1993). The nut is harvested between the months of May and August. Gathering and processing of the fruits is at the household level, this creates social interaction between the young and the old within the communities. In most cases, the fruit are allowed to drop after maturity and gathered by both the children and women, but sometimes by the farmers themselves. The gathered fruit are allowed to rot, after which the seeds are removed and washed. The weight of 100 unshelled nuts is about 950g. The ratio of the weight of shell edible portion of the nut is 28:72. The immature fruit are usually green in colour, but turn dark brown as they mature (Enujiugha, 2003).

2.3 Horticulture

2.3.1 Propagation

Propagation is by seeds that remain viable for more than 2-3 years after harvesting. It is planted under an indigenous tree that can provide strong support for the heavy weight of the climber when fully established on the crown of the tree. The plant takes over the crown of the tree which is used as support when fully established and thereby competes for sunlight and also affects fruiting of the host tree. Therefore, trees that do not produce high economic fruits

are mostly used to serve as support for the climber. The seeds germinate within 7-13 days in good soil. It does not need pruning to maintain a straight un-branched trunk (Enujiugha, 2003).

2.3.2 Main Diseases and Pests

The seed cotyledon is covered with a hard testa which is not easily penetrated by seed borers during storage. Deterioration of the milky white cotyledons during storage comes by way of off-flavour development as a result of the high unsaturation of the seed oil. However, refrigerated storage extends the shelf life of the nuts considerably (Adesioye, 1991). *Tetracarpedium Conophorum* is usually associated with cocoa plantations; as such, some of the mites and insect pests that attack cocoa leaves are occasionally seen on the *Tetracarpedium Conophorum* leaves. The common red spider mite (*Tetranychus neocaledonicus*) attacks the leaves and flowers causing foliar and flowering distortions. However, serious crop damage seldom occurs. The humid tropical climate is not conducive to damaging populations (Matthysse, 1978).

2.4 Uses of *Tetracarpedium Conophorum*

The shell, bark and leaves of the *Tetracarpedium Conophorum* plant are antifungal, anti-parasitic and anti-dysenteric and the bark is used by local people as laxative. The plant is cultivated principally for the nuts which are cooked and consumed as snacks, along with boiled maize (Enujiugha, 2003). The leaves and young shoots are occasionally eaten with cooked rice in some parts of West Africa. The kernels are oil-bearing, yielding 45% of light golden coloured oil on a dry weight basis with a taste resembling linseed oil. Walnut oil is not used for high temperature cooking because heating it normally removes the flavor and produces slight bitterness and as a result, it is used primarily as an ingredient in cold dishes such as salad dressings, where its flavor more easily comes through. (Asoegwu, 1995)

The oil is unsuitable for soap manufacture, and being quick drying it is certainly usable in the paint industry provided there is a certain supply and the kernels are free from excessive free fatty acids. Fresh oil has an iodine value of 190 which is excellent for a drying oil, but the seeds do not store well and deterioration caused by enzymatic action needs to be prevented at the time of collection by heat-treatment. The cake left after expression of the oil contains 45% protein. It has local uses for food and is obviously a good source of protein. It can safely be fed to stock. The plant, presumably the kernel, is a good source of Vitamins. The nut shell could be used as fuel on the farm for low cost drier (Asoegwu, 1995)

2.5 Medicinal Uses of African Walnut

Tetracarpidium Conophorum has a high potential as an anti-microbial medicinal plant. It is reported to be useful in folklore in the treatment of dysentery. This therefore justifies its ethno medical use, having displayed activities with the human pathogenic micro-organisms. Scientists have discovered how *Tetracarpidium Conophorum* plant respond to stresses, cancer and heart condition by producing significant amounts of a chemical form of aspirin, antioxidants and essential fatty acids. They have also found that extracts of walnut plant are effective anti-microbial agents, and could be used to boost spermatozoa count, fertility, menstrual flow, treat uterine fibroids, and bring relieve in hiccups (www.yorubareligion.org). Walnut seeds are used in the treatment of fibroid. The leaf juice is drunk to mitigate prolonged and /or constant hiccups. Seeds are chewed to improve spermatozoa count in men. The leaf juice is used to improve fertility in women and also to regulate menstrual flow (NNMDA, 2009). In Southern Nigerian ethno medicine, African walnut is used as a male fertility agent and the leaves are used for the treatment of dysentery and to improve fertility in males. The oil from the nut has found use in the formulation of wood varnish, stand oil, vulcanized oil for rubber and leather substitute. Most of the studies on the plant have been on the nutritive value of the seeds, which is a snack and delicacy (www.yorubareligion.org).

According to Burkill (2011) the plant leaves are considered a headache cure in Southern Nigeria, and have magical use to wash children to cause their mothers to conceive, the Igbo name meaning babies call babies. In Gabon, consumption of the seeds by husbands or wives already pregnant is believed to mitigate the risk of miscarriage. Nigerian material has been screened for alkaloids, a trace of which is recorded in the bark. It was found that walnut leaf extract is beneficial in treating pimples on the face, especially when they are known to have anti-inflammatory activities (www.yorubareligion.org).

2.6 Nutritional and Chemical Composition of T*etracarpidium Conophorum*

Food is stored in the endosperm, which is white and edible after cooking. The high nutrient potential of *Tetracarpidium Conophorum* nut is highlighted in Table 2.3

Table 2.3: Proximate Fruit Composition of *Tetracarpedium Conophorum* Nut in 100g Edible Portion.

Proximate	Percentage (%)
Water	52.10
Protein	20.09
Lipid (fat)	48.90
Carbohydrate	12.58
Fibre	6.34
Ash	3.09

Source: Enujiugha, (2003).

Tetracarpidium Conophorum is rich in ascorbic acid and carbohydrate while it has a moderate amount of protein with low ash content. These shows that *Tetracarpidium Conophorum* nuts could be used to boost the ascorbic acid, carbohydrate and protein content of most food products sold in our markets (Edem *et al.,* 2009). Vishanska and Petrova (1980) also reported that the *conophor* nut is an oilseed with high oil content and adequate protein to satisfy the calorie and protein needs of the consuming population, the very high oil content suggests that *conophor* nut could be used in commercial vegetable oil productions. The protein content is much higher than those obtained for some Russian varieties (Vishanska and Petrova, 1980).

2.6.1 Phytochemical Properties of *Tetracarpidium conophorum* Root

Table 2.4 shows the amount of phytonutrient present in the root sample of Tetracarpedium Conophorum. The root is rich in tannins, saponins, oxalate, alkaloids and phenols. The presence of saponin shows that Tetracarpidium Conophorum has cytotoxic effect such as permealization of the intestine. It also gives the plant the bitter taste. Saponin has relationship with sex hormones like oxytocin. Oxytocin is a sex hormone involved in controlling the onset of labour in women and the subsequent release of milk (Okwu and Okwu, 2004).

Table 2.4: Quantitative Estimates of Phytochemicals of *Tetracarpidium Conophorum* Root

Constituents	Quantity (w/w) mg/g
Tannins	0.545
Saponins	10.705
Alkaloids	0.410
Phenols	0.215
Oxalates	0.895

Source: Ayoola *et al*; (2011)

Alkaloids are the most efficient plant substances used therapeutically. Pure isolated alkaloids and the synthetic derivatives are used as basic medicinal agent because of their analgesic, antispasmodic and bacterial properties. This is why the root is believed to stop asthma and is prescribed to be taken between bouts of asthma, but not for acute asthma, it is used for elderly people as a constipation cure. The presence of tannins in root of Tetracarpidium conophorum can support its strong use for healing of haemorrhoids, frost bite and varicose ulcers in herbal medicine (Igboko, 1983; Maduiyi, 1983). The presence of phenolic compounds in the roots shows that the plant may have antimicrobial potential. This is because phenols and phenolic compounds have been extensively used in disinfections and remain the standards with which other bacteriocides are compared (Okwu, 2001).

2.6.2 Mineral Content of the Root and nut of *Tetracarpidium conophorum*

The mineral composition of *Tetracarpidium Conophorum* as shown in Table 2.5 shows that the root is a rich source of mineral elements

Table 2.5: Mineral Composition of the Root of *Tetracarpidium Conophorum* on a Dry Weight Basis Expressed In Mg/g

Mineral	Composition (Mg/g)
Potassium, K	0.02
Sodium, Na	0.002
Calcium, Ca	0.004
Magnesium, Mg	0.105
Iron, Fe	0.00415
Zinc, Zn	0.0000445
Manganese, Mn	0.000021
Copper, Cu	0.000087
Chromium, Cr	0.000029

Source: Ayoola *et al.;* (2011)

The usefulness of such minerals like calcium (Ca), magnesium (Mg), sodium (Na), potassium (K) in the body is important. The lower sodium content (0.00019mg/g) of *Tetracarpidium Conophorum* plant is an added advantage because of the direct relationship of sodium intake with hypertension in humans (Dahl, 1972). This may be the reason why the plant is used to prevent and control high blood pressure (James, 2009).The presence of chromium even at low concentration is an indication that the plant may be useful for the management of diabetes. It is a cofactor with insulin in carbohydrate metabolism. Therefore if chromium is deficient, insulin will not be effective. The presence of copper may be responsible for the absorption of iron. It is therefore often seen with iron naturally. Copper is important for

cellular defence and protection of the mucous membrane, anti-anaemic and essential for the formation of haemoglobin from iron (Claude and Paule, 1979). The presence of manganese shows that the plant can be used to protect bone disease (James, 2000). The activity of this element is noticed in the metabolism of food incorporated into the bone. According to Claude and Paule (1979), manganese is necessary for the functioning of the pituitary gland, the pineal gland and the brain, it promotes hepatorenal function, combat anaemia and is also essential for growth. *Tetracarpidium Conophorum* plant is also source of manganese and copper, two elements that are very useful to mankind. Manganese is used in the management of diabetes (Edem *et al.*; 2009). The presence of zinc is an indication that the root may have some effect on the nerve function and male fertility. It is important for normal sexual development, especially for the development of testes and ovaries, it is also essential for reproduction. Zinc stimulates the activity of Vitamins, formation of red and white corpuscles (Claude and Paule, 1979), healthy functioning of the heart and normal growth (Elizabeth, 1994).

Table 2.6 shows the concentrations of the different macro- and micro - elements presents in the nut. The seed was high in phosphorus and calcium, which are essential for bone and teeth development. The high phosphorus content agrees with the observation of Nwokolo (1987) that phosphorus was high in some tropical grains and oilseeds. Cadmium and nickel were detected in very low concentrations below the minimum permissible levels for the human body. Zinc and copper contents were comparable to values obtained for some cultivated and wild varieties of lupin seeds (Trugo *et al.;* 1993).

Table 2.6: Concentration of Macro and Micro Elements in *Tetracarpidium Conophorum* nut (mg/100g)

Mineral	Concentration (mg/100g)
Calcium, Ca	42.06±2.01
Magnesium, Mg	57.37±2.53
Phosphorus, P	465.95±7.21
Copper, Cu	1.56±0.05
Iron, Fe	1.55±0.08
Zinc, Zn	6.84±0.02
Nickel, Ni	0.38±0.05
Cobalt, Co	0.05±0.01
Cambium, Cb	0.01±0.01

Source: Enujiugha (2003).

2.6.3 Vitamin Composition of the Root of *Tetracarpidium Conophorum* Plant

The mineral composition of *Tetracarpidium Conophorum* plant is shown on Table 2.7

Table 2.7: Vitamin Composition of the Root of *Tetracarpidium Conophorum*

Vitamin	Amount (mg/g)
Ascorbic acid (C)	4.11
Riboflavin (B_2)	0.004
Thiamine (B_2)	0.002
Niacin	0.004
Cyanocobalamin (B_{12})	0.001

Source: Ayoola *et al.*; (2011)

The presence of ascorbic acid in the root of *Tetracarpedium Conophorum* plant as shown on Table 2.7 indicated that the plant can be used in herbal medicine for the treatment of skin conditions, including eczema, pruritus, psoriasis and parasitic skin conditions (D'Amelio, 1999). This Vitamin can also be used for the treatment of common cold and other diseases like prostrate cancer (Okwu *et al.*, 2004; Okwu *et al.*, 2003). Other vitamins though in trace amount are essential for body metabolism. There is also an interesting ability of ascorbic acid as an antioxidant, to prevent or at least minimize the formation of carcinogenic substances from dietary material (Hunt *et al.*; 1980). Deficiency of ascorbic acid is associated with pains in the joint and defect in skeletal calcification, anaemia, manifestation of scurvy haemorrhage from mucous membrane of the mouth and gastrointestinal track. The intake of *Tetracarpidium Conophorum* reduces these risks (Hunt *et al.*; 1980).

2.6.4 Chemical Composition of T*etracarpidium Conophorum* Nut

African walnut nut contains 48-50% dry weight of oil, which is liquid and golden yellow in colour, with taste and odour resembling those of linseed oil. The residue after oil expression contains about 45% protein. Gas chromatographic analysis of the seed oils shows a high level (>66% dry weight) of the Sn-3 fatty acid, linolenic acid (Ogunsua and Adebona, 1983) Animal feeding experiments indicated that the seeds are highly digestible with a true digestibility of 83, a high biological value (94.7) exceeding that of casein standard (92.3) (Oke and Fafunsho, 1975; Nwokolo, 1987).

Significants concentrations of oxalates, phytates and tannings have been reported for uncooked nut. These factors are effectively removed via hydrothermal treatment which the seeds are usually subjected to before consumption (Enujiugha, 2003; Enujiugha and Oni, 2003).

2.7 Effects of Heat Treatments on *Tetracarpedium Conophorum* Nut

The various forms of heat treatment that *Tetracarpedium Conophorum* nut are subjected to includes

- Hydrothermal Treatment: this is the most common method of processing the *Tetracarpedium Conophorum* nut. The nuts are subjected to heat with the use of water at a controlled temperature over length of time. In the traditional way of processing, the temperature of the water or system is not controlled.
- Toasted treatment: The toasted sample is prepared by continuously stirring mature unshelled nuts in hot sand at a controlled temperature over length of time.

The effects of hydrothermal treatment and toasting on the tannins and phytates of *Tetracarpedium Conophorum* nut is presented in Table 2.8

Table 2.8: Anti-Nutritional Factors in Raw and Processed *Tetracarpedium Conophorum* Nut

	Tannins (mg TA/100g)	Phytic acid (mg/100g)
Raw nuts	0.9±0.1	3.20±0.05
Cooked nuts	0.3±0.1	1.20±0.10
Toasted nuts	1.1±0.1	3.50±0.09

Source: Enujiugha, (2003)

According to Forbes and Erdman, (1983), cooking reduced the levels of the anti-nutritional factors while toasting raised their concentrations in the seed. Tannins usually form insoluble complexes with protein thereby interfering with their bioavailability. Phytates on the other hand form an heterocyclic ring with certain mineral elements, especially Calcium (Ca), Magnesium (Mg), Iron (Fe) and Zinc (Zn), rendering them metabolically unavailable. Results show that *Tetracarpedium Conophorum* nut, when subjected to hydrothermal treatment leads to improved bioavailability of nutrients. Some of this anti-nutritional factor is known to leach into processing water during hydrothermal treatment.

Processing brought about a reduction in the gel forming properties of *Tetracarpedium Conophorum* nut. The gel forming ability is known to be influenced by the nature of the protein, starch and gums in the sample as well as their interaction during heat treatment

(Enujiugha, 2003). Hydrothermal treatment and toasting brought about significant reductions in foaming and emulsion capacities of the nut.

CHATER THREE

3.0 Materials and Method

3.1 Materials

The samples of African walnut (*Tetracarpedium Conophorum*) used for this study were purchased from Okene market in Okene Local Government Area of Kogi State, Nigeria. The samples were washed with water three times to remove impurities from the nut to prevent infestation. The samples were refrigerated at a temperature of 21^{O}C during the course of the analysis to preserve its freshness. The analysis was carried out in the laboratory of National Cereals Research Institute (NCRI) Badeggi, Niger State.

3.2 Reagents and Apparatus

The reagents and apparatus used for this study are;

3.2.1 Reagents

Tetraoxosulphate (VI) acid, (H_2SO_4)

Sodium sulphate (Na_2SO_4)

Sodium hydroxide (NaOH)

Copper sulphate (CuSO4)

Methyl orange indicator/bromocresol green (BCG)

Boric acid (H_3BO_3)

Petroleum ether

3.2.2 Apparatus

Petri dish (Pyrex England)

Desiccator

Weighing balance (manufactured in Switzerland-Metler, sensitivity =0.000, serial No. 1+52764)

Oven plus (Gallenkamp), model No. 2346AA

Filter paper

Soxhlet extractor by pyrex

Flat bottom silica dishes

Beaker

Pipette

Thimbles

Conical flask

Crucible

Muffle furnace. Model No. DH 180

Gerhardt Kjeldathenn Digestion Block, Model No. 451699, England.

3.3 Methods

3.3.1 Sample Preparation

Walnuts weighing 830g was used for this study. 108g of walnut was cooked for 60 minutes, 108g of nut was cooked for 80 minutes and 108g of walnut was also cooked for 105 minutes at a temperature of 100°C. Each of the samples were then grated and placed in a closed container.

3.3.2 Experimental Procedures

The experimental procedures used in the determination of the nutritional content of *Tetracarpedium Conophorum* nut were as described by AOAC (2004).

3.3.2.1 Determination of Moisture Content

The method used was the oven method. The aluminium dishes were washed thoroughly and dried in the oven. The dried dishes were placed in a desiccator to cool and each dish was weighed (W_1). Each of the samples was transferred into the weighed dish and the weight of dish plus weight of the un-dried samples was taken (W_2). The sample was dried in the moisture oven at 70-80°C for 2 hours and at 100-135°C for the next 4 hours until the weight was constant. The sample was brought out of the oven and placed in the desiccator to cool and the weight of the dried sample plus dish was taken as (W_3) then the moisture content was calculated using the formula:

$$\% \text{ Moisture} = \frac{\text{weight of wet sample} - \text{weight of dried sample}}{\text{Weight of original sample}} \times 100$$

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

3.3.2.2 Ash Content Determination

Ash in food constitute the residue remaining after all the moisture has been removed as well as the organic materials (fats, proteins carbohydrates, vitamins, organic acids etc.) is burnt away by igniting at a temperature of around 500°C. This result in the oxidation of organic constituents to volatile materials considered as carbon dioxide, nitrogen oxides and sulphur dioxide.

The silica crucible dishes were washed thoroughly and dry in the oven. The dried silica crucible dishes were placed in a desiccator to cool and each dish was weighed (W_1) 3g of each sample were put into the silica crucible dish and the weight of silica dish plus weight of the un-dried samples was taken (W_2). The samples were placed in an oven at 100°C to evaporate to dryness. Each of the samples was then placed on a heater inside a fume cupboard to drive away most of the smoke. The samples were then transferred to a preheated furnace at temperature of 550°C and left until a light grey ash result. When the residues turned black, it was moistened with a small amount of water to dissolve salts and then oven dry. The samples were placed back into the furnace to complete the ashing process. After the ashing process was completed the sample were placed inside a desiccator to cool and each samples was reweighed (W_3):

$$\% \text{ Ash (dry basis)} = \frac{\text{Weight of ash}}{\text{Weight of original sample}} \times 100$$

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

3.3.2.3 Crude Fibre

Crude fibre represents the organic residue left behind after the material has been treated under standardized conditions with light petroleum, boiling dilute sulphuric acid, boiling dilute sodium hydroxide solution, dilute hydrochloric acid, alcohol and ether. Crude fibre is composed by large cellulose together with a little lignin.

2g of *Tetracarpedium Conophorum* nut samples both cooked and uncooked were defatted with petroleum ether because the fat content of each sample were more than 10%. After defatting, each sample was transferred to a beaker and boiled under reflux for 30 minutes with 200 ml of a solution containing 1.25g of H_2SO_4 per 100ml of solution. The solution of each sample was then filtered with filter paper on a fluted funnel and rinsed well with boiling water then the residue of each samples were then transferred back to the beaker and boiled for 30 minutes with 200ml of a solution containing 1.25g of carbonate free NaOH per 100ml. The final residue of each samples were filtered through a thin closed pad of washed and ignited asbestos in a Gooch crucible. Samples were dried in electric oven and weighed (W_1), the samples was then incinerated cooled and weighed (W_2), Loss in weight after the incineration was then multiplied by 100% as the percentage of crude fibre.

$$\% \text{ crude fibre} = W_1 - W_2 \times 100$$

3.3.2.4 Determination of Fat/Lipids

Three (3) 250ml thoroughly washed and cleaned boiling flasks were dried in an oven at 105^0C for 30minutes and then cooled in a desiccator. Three (3) dried filter papers were selected, labelled A, B and C and their corresponding weights noted and recorded as W_1. 2g of each sample was measured unto each of its corresponding filter paper and the new weight (i.e. weight of filter paper + sample) noted and recorded as W_2 appropriately. The filter papers (with their respective samples in them) were then neatly folded and closed in a manner that the samples were perfectly locked in them.

Each of the cleaned dried boiling flasks was filled with about 300ml of petroleum ether (boiling point 40 -60^0C). The soxhlet apparatus was then assembled, each filter was placed in each extraction chamber of the entire soxhlet setup, the taps controlling the continuous flow of water into the condenser were turned open, the power switch was on and the heating temperature was regulated to about 50^0C until the petroleum ether in the boiling flasks started to boil then the heating temperatures were regulated down to 30^0C; the apparatus was allowed to reflux for 6 hours.

At the end of the stipulated time (6 hours), the filter papers were removed carefully and taken to be dried in an oven for an hour at 105^0C after which they were cooled in a desiccator for some minutes. The new weights of the filter papers along with their contents (defatted sample) were then measured again using the electronic weighing balance and the weights measured were recorded accordingly as W_3. Finally, the percentage fat was calculated using the formula:

$$\%\text{Fat} = \frac{\text{Weight of Fat } (W_3 - W_1)}{\text{Original Sample } (W_2 - W_1)} \quad X \quad 100\%$$

3.3.2.5 Determination of Protein

The method used in determining the protein content is the Kjeldahl method which uses the principle that the total estimation of nitrogen in food and the subsequent conversion of the percentage of that nitrogen to protein with the assumption that all the nitrogen in food are present as protein. Then using a conversion factor the actual percentage of nitrogen in the food is determined.

% protein = % N x F

Where F is the conversion factor

$$F = \frac{100}{(\%\ N \text{ in food protein})}.$$

Kjeldahl flasks were washed and cleaned thoroughly and then oven dried for 30 minutes at a temperature of 100°C and placed in a desiccator to cool. 2g of each sample, uncooked and cooked *Tetracarpedium Conophorum* grated nut were placed in different jeldahl flask already labeled accordingly. 5g of anhydrous sodium sulphate were added to each sample. It was followed up with the addition of 1g of copper sulphate and a speck of selenium. 25ml of concentrated sulphuric acid was added into the mixture. The solutions were then placed in a fume cupboard which was first heated gently and then increased with occasional shaking of the solution till it assumed a green colour. The temperature of the digester was over 420°C. The solution was cooled and black particles at the mouth and neck was washed down with distilled water and then it was reheated again until the green colour disappears. It was allowed to cool. 250ml of volumetric flask was washed and then oven dried to remove all impurities and cooled inside the desiccator. The digested solutions were transferred into the volumetric flask. It was then distilled using Markham distillation apparatus. Before use,

steam was passed through the markham distillation apparatus for 15 minutes. Under the condenser, 100ml conical flask containing 5ml of boric indicator was placed in such a way that the condenser tip is under the liquid. 5ml of the digest was pipetted into the body of the apparatus via the small funnel aperture and was washed down with distilled water followed by 5ml of 60% NaOH solution. Steam was passed through for 7 minutes and enough ammonium sulphate was collected for each samples. The receiving flask was removed and the tip of the condenser was washed down into the flask. The solution in the receiving flask was titrated using N/100 (0.01N) sulphuric acid and then the nitrogen content in the result was calculated.

$$\% \text{ nitrogen} == \frac{V_S \times V_B \times N_{acid} \times 0.01401 \times 100}{W}$$

Where V_S = volume (ml) of acid required to titrate the sample

V_B = volume (ml) of acid required to titrate the blank

Nacid = normality of acid (0.1N)

W = weight of samples in grams

3.3.2.6 Determination of Carbohydrate

Carbohydrates content is giving as total carbohydrates by difference that is the percentage of water, protein, fat, and ash subtracted by 100.

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

CHAPTER FOUR

4.0 Results and Discussion

4.1 Results

The results of the experiments are presented in Table 4.1 below

Table 4.1 Proximate Composition of *Tetracarpidium Conophorum* Nuts at Various Hydrothermal Treatment Periods

	Raw	60 Minutes	80 Minutes	105 Minutes
Moisture	42.25±0.356	43.85±0.248	44.00±0.322	44.75±0.538
Fat	16.13±0.114	16.55±0.448	17.13±0.357	16.57±0.497
Crude protein	21.45±0.417	19.27±0.344	19.15±0.200	17.85±0.319
Crude fibre	2.20±0.163	2.99±0.029	3.35±0.490	5.60±0.726
Ash	2.02±0.128	2.52±0.163	2.45±0.294	3.00±0.172
Carbohydrate	15.96±0.354	14.83±0.382	13.93±0.382	12.23±0.341

4.2 Discussion

4.2.1 Moisture

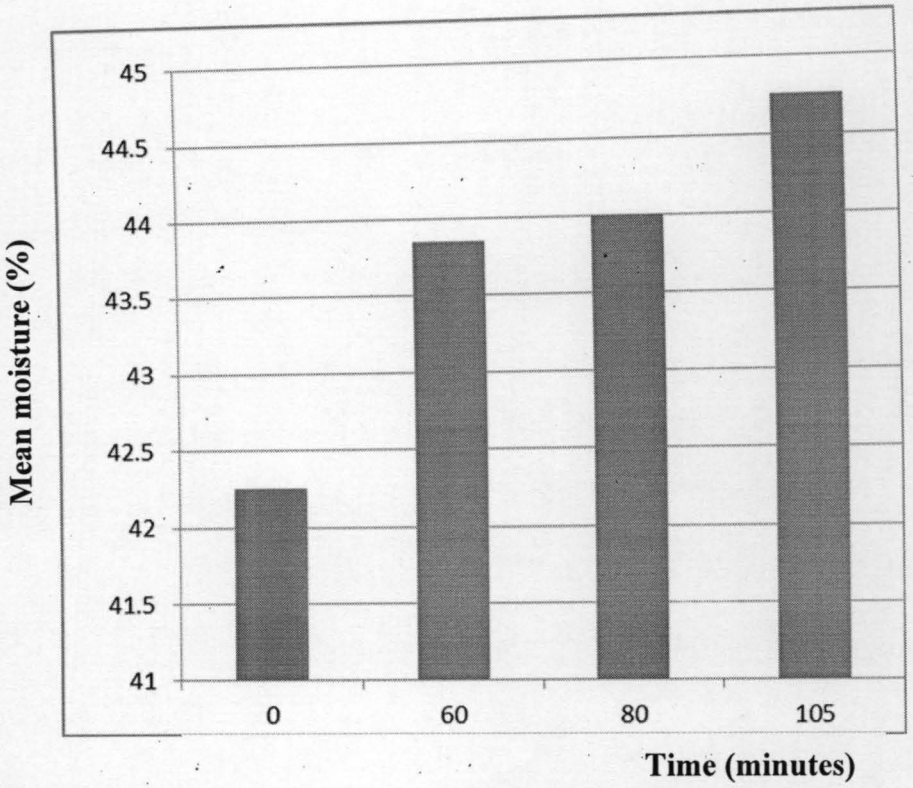

Figure 4.1: Moisture Content of *Tetracarpidium Conophorum* nut

There were insignificant differences in the moisture content of the raw nuts and the samples treated at the same temperature for different cooking periods of 60, 80, and 105 minutes as shown in Figure 4.1. An increase of 2.5% of moisture content was observed as the raw nut was cooked for 105 minutes. The low moisture absorbance properties of the nut when it was subjected to hydrothermal treatment for different period may be due to its hard shell covering, which prevented flow of water to the kernel. There was continuous increase in the moisture content of the walnut as the cooking period time increases. The moisture content reached at 105 minutes was 44.75% while the raw nut had the lowest moisture content of 42.25%. The result for moisture content of the raw nut was comparable to the one gotten by Edem, *et al.*; (2009) whose value was 48.70%. The differences observed in these values may

be attributed to environmental and agronomic factors as has been suggested by Raules and Nair, (1993); Parcerisa (1993). This indicates that as long as the nuts remains in water during treatment it continues to absorb more water. The low moisture content of the raw fruit shows that it could be stored for some time without going bad (Edem, *et al.*; 2009).

4.2.2 Crude Protein

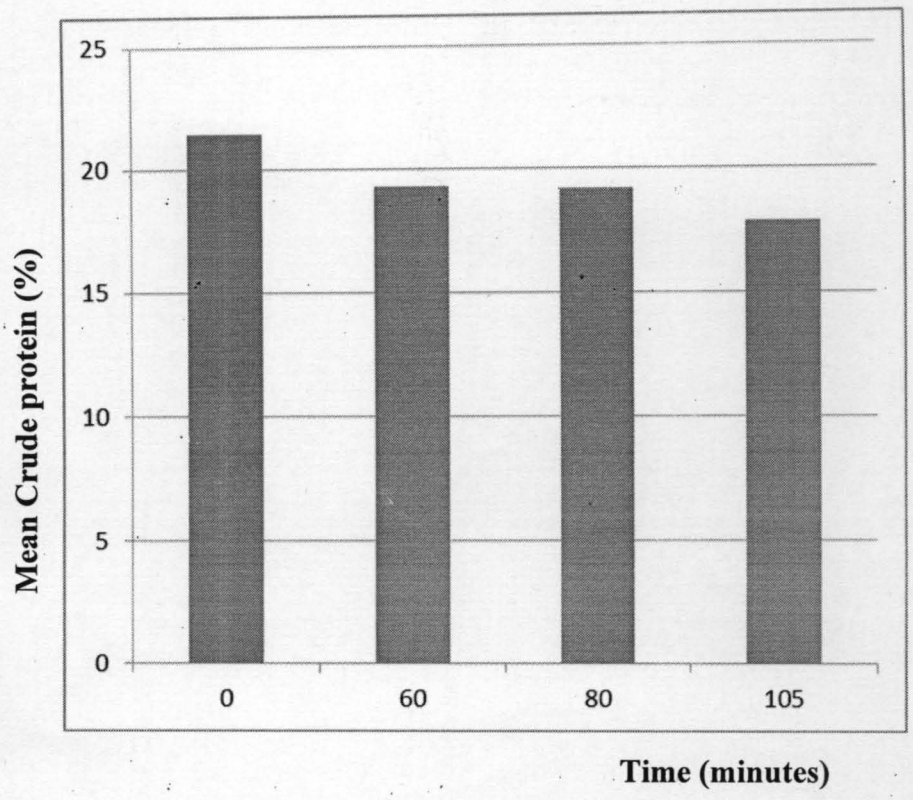

Figure 4.2: Crude Protein Content of *Tetracarpidium Conophorum*

Tetracarpidium conophorum nut cooked for 105 minutes at a temperature of 100°C showed lowest content of crude protein 17.85% than those cooked for shorter period of time. The raw, and those cooked for 60, and 80 minutes had protein content of 21.45%, 19.27%, and 19.15% of protein. Uncooked walnut had the highest protein content. This shows that as the period of cooking increases, there was a corresponding decrease in the protein content of the

nut. The uncooked nut protein was comparable with that of groundnut (20.2%), cotton seed (20.4%) and those of cashew nut (21.4%) but lower than that of tropical almond (25.81%) (FAO, 2000; Ezeokonkwo and Dodson, (2004). The percentage composition of the raw sample is close to the one gotten for the raw nut by Ndie, *et al.;* (2010) whose value was 21.60%. According to Agnieszka *et al.*; (2011) reduction in protein content of nuts may be caused by solubilization of some easy hydrolyzing components and their migration to water and also by enhanced activity of enzymes e.g. lipases.

4.2.3 Crude Fibre

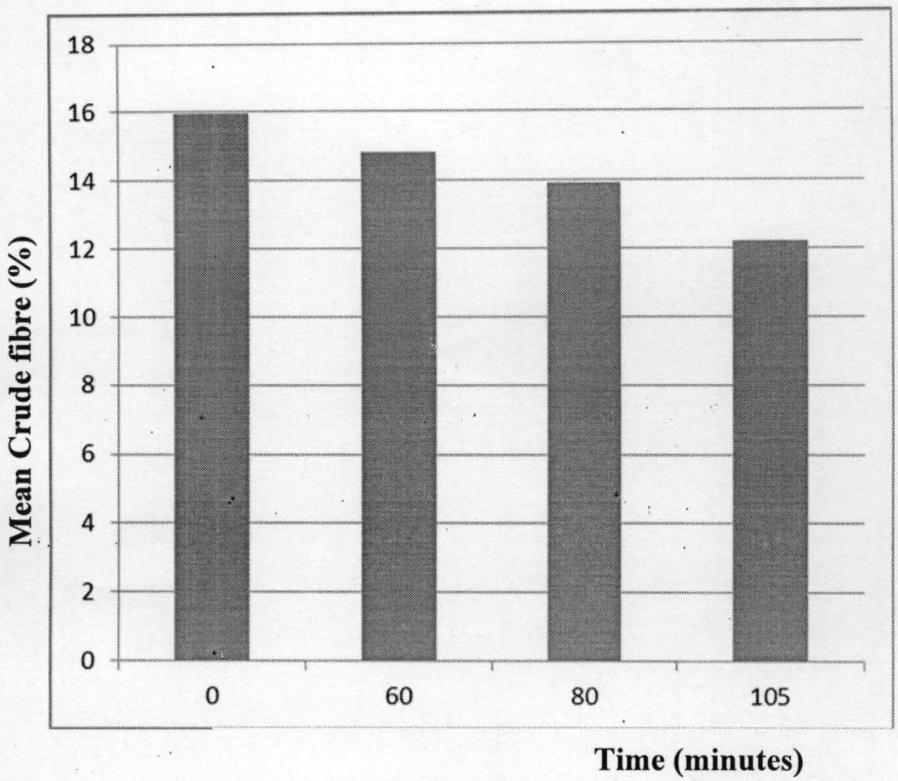

Figure 4.3: Crude Fibre Content of *Tetracarpidium Conophorum* nut

Figure 4.3 shows that there were significant differences in the crude fibre content of the raw nut and between samples treated at the same temperature but different cooking period of 60, 80, 105 minutes. The nut cooked at 100°C for 105 minutes had the highest crude fibre content of 5.60% while the raw nut had the lowest fibre content of 2.20%. An increase of 3.40% was obtained when the raw nut was cooked for 105 minutes. This shows that an increase in period

of hydrothermal treatment of the nut increased the crude fibre content. The result gotten for the raw nut is also close to the one gotten by Ndie *et al.*; (2010) which value was 2.90% and comparable to 3.34% gotten by Edem *et al.*; (2009). Enujiugha (2003) cooked the nut for period of 2 hours and the value gotten for the crude fibre was 6.34% which was comparable to the one gotten for 105 minutes 5.60%. It showed that *Tetracarpidium Conophorum* nut is averagely a good source of crude fibre .The average crude fibre content indicates the ability of *Tetracarpidium Conophorum* nut to maintain internal distension for a normal peristaltic movement of the intestinal tract, a physiological role which crude fibre plays.

4.2.4 Fat

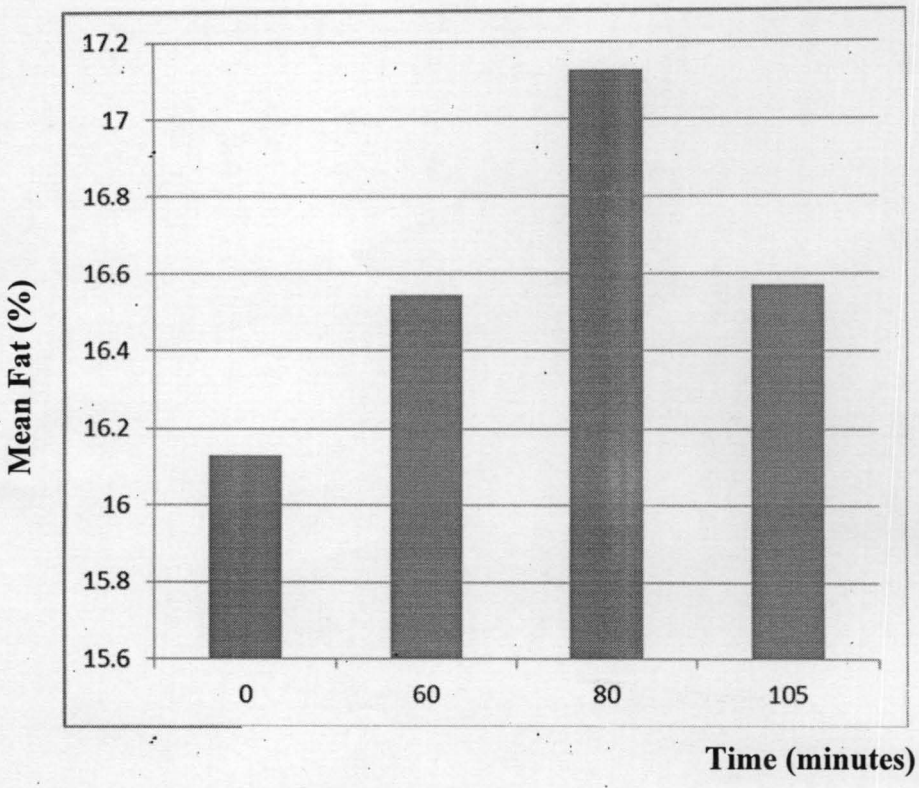

Figure 4.4: Fat Content of *Tetracarpidium Conophorum* nut

The fat content of raw *Tetracarpidium conophorum* nut increased insignificantly with an increase in length of cooking period of 60, and 80 minutes but decreased when the duration

of application of heat treatment increased to 105 minutes under constant temperature as shown in Figure 4.4. The nut cooked for a period of 105 minutes contained 16.57% of fat while the raw nut contained 16.13%. The values are far lower than those gotten by Enujiugha (2003) which was 48.90%, these difference may be attributed to the oven drying which he subjected the kernels to before determining the fat content. 6.21% of fat was gotten by Edem *et al.*; (2009). The differences observed in these values may also be attributed to environmental and agronomic factors as has been suggested by Raules and Nair, (1993); Parcerisa (1993). 1.04% increase of fat content was observed as the nut was cooked for 80 minutes. According to Oladele *et al.*; (2009) the increase could be attributed to leaching of some soluble constituents of the kernel into the cooking water. Constituents such as simple sugars and some anti- nutrients e.g. tannin and phytic acid are leached into water especially at above ambient temperature through the swollen and ruptured cell walls which permeate water and soluble constituents. 0.56% loss of fat was observed when the nut was cooked for additional 25 minutes, from 80 to 105 minutes. The fat content of *Tetracarpidium conophorum* nut cooked for 60 and 80 minutes were 16.55% and 17.13%. An increase in the period of hydrothermal treatment for African walnuts led to an increase in the fat content of the nut at a certain point but then decreased.

4.2.5 Carbohydrates

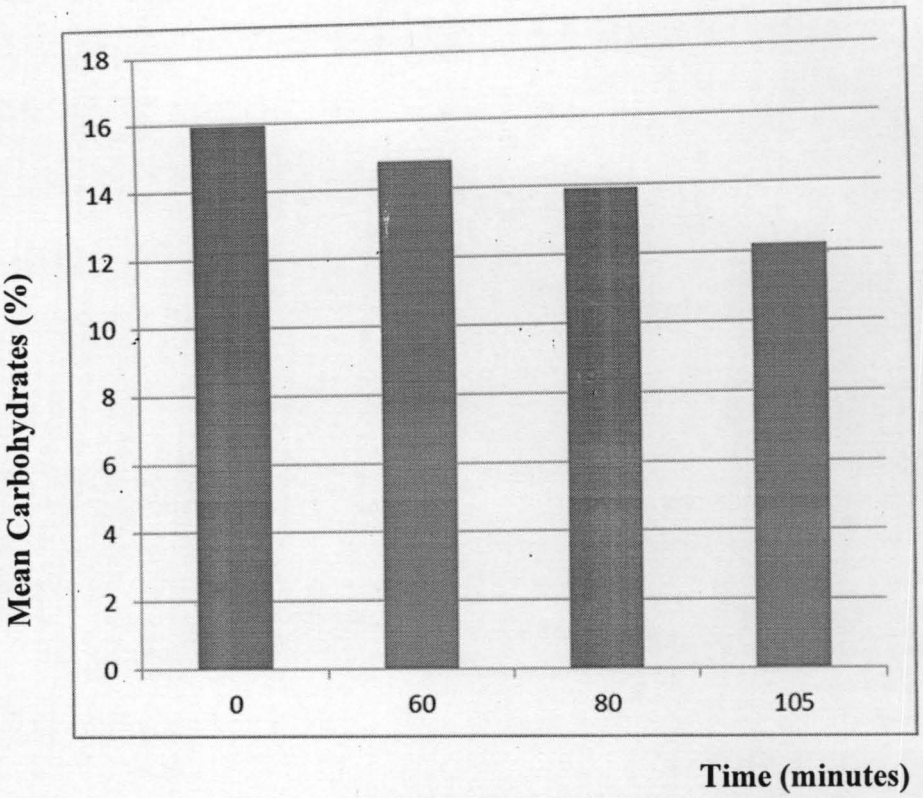

Figure 4.5: Carbohydrate Content of *Tetracarpidium Conophorum* nut

There was significant difference in the carbohydrate content of the nut as heat was continuously applied. The carbohydrate content of the raw nut was found to be 16.00% which was close to the one gotten by Ndie (2010) whose value was 16.90%. At 105 minutes of hydrothermal treatment the carbohydrate content was 12.23% which was also close to the one gotten by Enujiugha (2003) whose value was 12.58% as the nut was cooked for 2 hours. A loss of about 3.73% resulted when the nut was cooked for 105 minutes. As shown in Figure 4.5, increased period of hydrothermal treatment led to decrease in carbohydrate content of the walnut. According to Nkwonta (2010), it is known that during heat treatment, plant food materials suffer considerable loss of low molecular weight of carbohydrates, due to leaching into processing water. The decrease in carbohydrate content in this work agrees with the report of Obizoba and Atti (1994) on pearl millet seeds. It can be said that application of heat for long period of time decreases the carbohydrate content of the nut. Oladele *et al.*; (2009)

also reported that the decreased in the carbohydrate content of the toasted nuts could be due to reaction which occurred between carbonyl group of reducing sugars at high temperature.

4.2.6 Ash

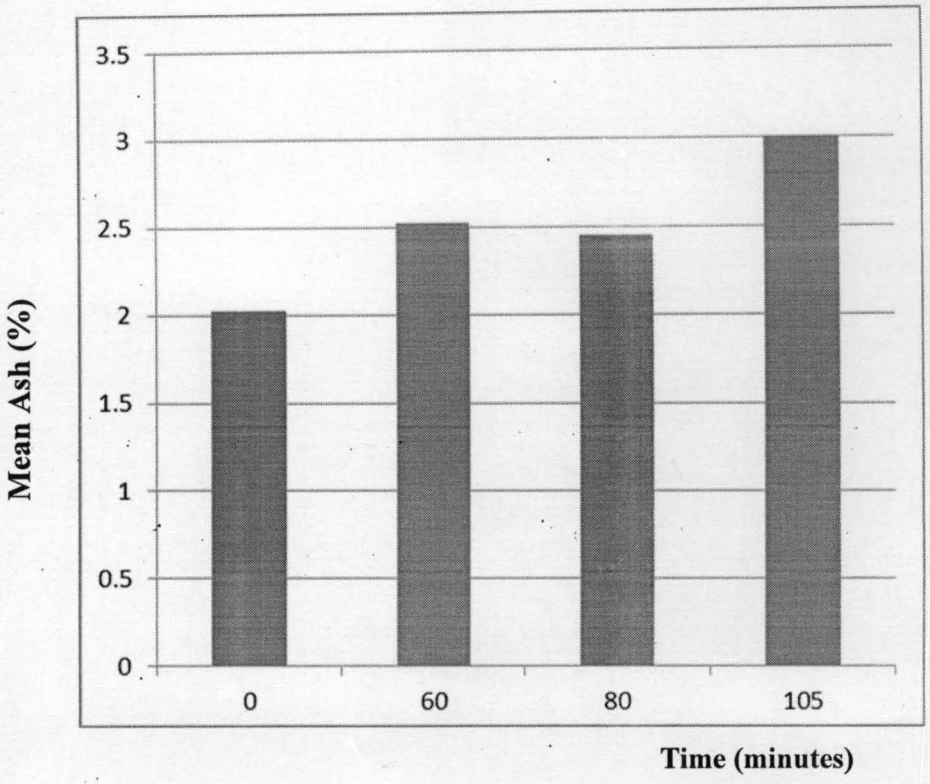

Figure 4.6: Ash Content of *Tetracarpidium Conophorum* nut

The results obtained for ash were 2.02%, 2.52%, 2.45% and 3.00% for raw nut and those cooked for 60, 80 and 105 minutes respectively. As shown in Figure 4.6, it can be observed that there was an increase in ash content of the nut as it was prepared within the time limit. An increase in the period of hydrothermal treatment led to an increase in the ash content of the nut. Agnieszka *et al.*; (2011) reported that the increase in ash content of nuts could be attributed to leaching of some soluble constituents of the kernel into the cooking water. The percentage of ash gotten for raw *Tetracarpidium Conophorum* nut is closed to the one gotten by Edem et al.; (2009) whose value was 2.03% while the nut cooked for a period of 105 minutes had comparable results with what was gotten by Enujiugha, (2003) whose value was

3.09% for a period of hydrothermal treatment of two hours. The presence of ash in *Tetracarpidium Conophorum* nut indicates that minerals are available in it.

4.2.7 Nutritional Composition of *Tetracarpidium Conophorum* Nut

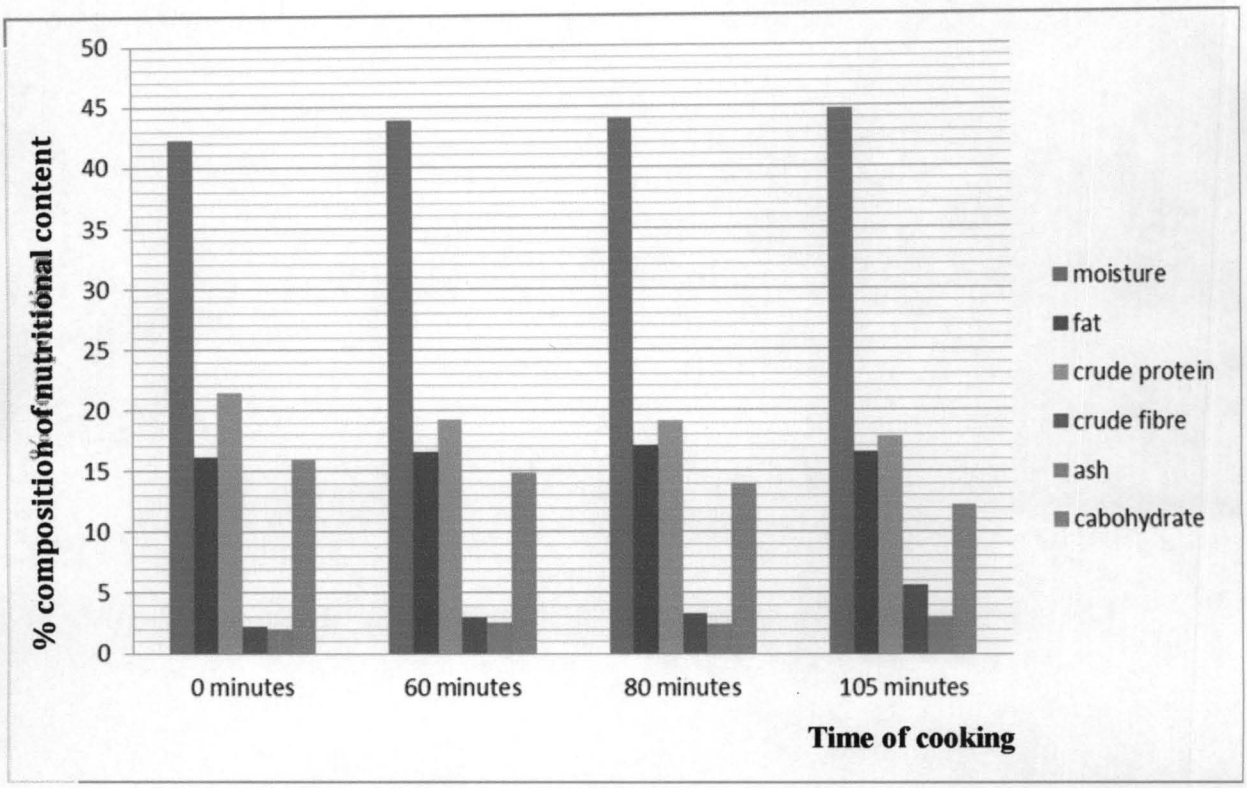

Figure 4.7: Nutritional Composition of Tetracarpidium Conophorum Nut at Various Cooking Time.

From Figure 4.7, it can said that moisture had the highest percentage composition and ash had the lowest percentage composition. Moisture content, fat, crude fibre and ash increased with corresponding increase in period of application of heat treatment but Carbohydrate and protein decreased with duration of application of heat treatment. These shows that as the duration of application of heat treatment increased the percentage composition of crude protein and carbohydrate continued to decrease. Fat increased in composition between time periods of 0 to 80 minutes but decreased between periods of 80 to 105 minutes.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

From the study carried out, it can be concluded that increase in duration of time of application of heat increased the percentage composition of moisture, fat, crude fibre and ash content but decreased the composition of crude protein and carbohydrate content. Also from the results obtained, it was discovered that *Tetracarpidium Conophorum* cooked for 80 minutes at a constant temperature of $100^{O}C$ gave better results in terms of nutrient retention. The values of the nutritional content obtained for this time period of heat treatment were: moisture content (44.00%), fat (17.13%), crude protein (19.15%), crude fibre (3.35%), ash (2.45%) and carbohydrate (13.93%).

5.2 Recommendations

From the study the following recommendations were made

- Studies should be carried out to determine the mineral contents of African walnut (*Tetracarpidium Conophorum*).
- Individuals should be sensitized on the importance of African walnut
- Studies should be carried out on the extraction of oil from Tetracarpidium conophorum and the characterization of the extracted oil.
- Studies should be carried out to determine the physical and mechanical properties of the nut.
- The use of the shell as briquette should also be investigated.

- The use of the shell of the nut as a source of feed for animals shoud be investigated

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APPENDIX

Raw	Sample 1	Sample 2	Sample 3	mean	SD
Moisture content	42.05	41.95	42.75	42.25	0.355903
Fat	16.19	16.23	15.97	16.13	0.114310
Crude protein	21.42	20.95	21.97	21.45	0.416953
Crude fibre	2.20	2.00	2.40	2.20	0.163299
Ash	2.20	1.91	1.95	2.02	0.128323
Carbohydrates	15.46	16.23	16.18	15.96	0.354345
60 minutes					
Moisture content	44.00	43.50	44.05	43.85	0.248328
Fat	16.50	16.02	17.12	16.55	0.448163
Crude protein	18.99	19.06	19.75	19.27	0.343972
Crude fibre	2.95	3.00	3.02	2.99	0.029439
Ash	2.32	2.72	2.52	2.52	0.163299
Carbohydrates	14.32	14.93	15.24	14.83	0.382187
80 minutes					
Moisture content	44.32	44.12	43.56	44.00	0.321662
Fat	17.60	17.05	16.73	17.13	0.357095
Crude protein	19.42	18.94	19.09	19.15	0.200499
Crude fibre	3.35	3.95	2.75	3.35	0.489898
Ash	2.05	2.75	2.55	2.45	0.294392
Carbohydrates	13.45	13.94	14.39	13.93	0.381859
105 minutes					
Moisture content	45.17	43.99	45.09	44.75	0.538393
Fat	16.45	16.03	17.23	16.57	0.497192
Crude protein	18.23	17.45	17.87	17.85	0.318748
Crude fibre	4.90	5.30	6.60	5.60	0.725718
Ash	3.20	2.78	3.02	3.00	0.172047
Carbohydrates	12.03	11.95	12.71	12.23	0.340979

Moisture Content

Weight of Petri-dish only $W_1 = 10.13g$

Weight of Petri-dish + Wet Sample $W_2 = 13.13g$

Weight of Petri-dish + Dried Sample $W_3 = 11.8685g$

$$\% \text{ Moisture} = \frac{W_2 - W_3}{W_2 - W_1} \times 100\% = \frac{13.13 - 11.8685}{13.13 - 10.13} \times 100\%$$

$$= 42.05\%$$

This was replicated for three times at each periods of hydrothermal treatment.

Ash Content

Weight of Crucible only $W_1 = 47.85g$

Weight of Crucible + Wet Sample $W_2 = 50.85g$

Weight of Crucible + Ash $W_3 = 47.916g$

$$\% \text{ Ash} = \frac{W_3 - W_1}{W_2 - W_1} \times 100\% = \frac{47.916 - 47.85}{50.85 - 47.85} \times 100\%$$

$$= 2.2\%$$

This was replicated for three times at each periods of hydrothermal treatment.

Crude Fibre Content

Weight of Sample used = 2.00g

Weight of Dried Sample + Crucible W_1 = 98.78g

Weight of Incinerated Sample + Crucible W_2 = 98.758g

%Crude Fibre = W1 – W2 x 100%

%Crude Fibre = 98.78 – 98.758 x 100%

2.2%.

This was replicated for three times at each periods of hydrothermal treatment.

Lipid Content (Ether Extract)

Weight of Filter Paper only W_1 = 0.82g

Weight of Filter Paper + Sample W_2 = 2.82g

Weight of Filter Paper + Defatted Sample W_3 = 1.1438g

$$\% \text{ Lipids} = \frac{W_3 - W_1}{W_2 - W_1} \times 100\% = \frac{1.1438 - 0.82}{2.82 - 0.82} \times 100\%$$

$$= 16.19\%$$

This was replicated for three times at each periods of hydrothermal treatment.

Crude Protein Content

Weight of Sample W = 2g

Sample titre value = 4.9

Blank titre value = 1

$$\% \text{ nitrogen} == \frac{V_S \times V_B \times N_{acid} \times 0.01401 \times 100}{W}$$

$$\%\text{Nitrogen} = \frac{4.9 \times 10 \times 0.1 \times 0.01401 \times 100}{2} \times 100\%$$

$$= 3.4272\%$$

Therefore, %Crude Protein = %Nitrogen x 6.25 (i.e. conversion factor)

$$= 4.9\% \times 6.25$$

$$= 21.42\%$$

This was replicated for three times at each periods of hydrothermal treatment.

Carbohydrates Content

%Carbohydrate = 100% - (%Fat + % Ash + %Crude Fibre + %Crude Protein+% moisture)

$$= 100\% - (16.19\% + \% \ 2.2 + 2.2 \ \% + 21.42 \ \% + 42.05\%)$$

$$= 100\% - 84.545\%$$

$$= 15.455\%$$

This was replicated for three times at each periods of hydrothermal treatment.