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Nutritional and Sensory Properties of Cookies Produced from Flour Blends of African Walnut (*Tetracarpidium conophorum*), *Justicia carnea* and Wheat

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Abstract

This study aims to evaluate the nutritional and sensory properties of cookies produced from flour blends of African walnut (*Tetracarpidium conophorum*), *Justicia carnea* and wheat. Walnut flour was used to substitute wheat flour while the *Justicia carnea* flour was used at a constant percentage as an enrichment in the ratio of (A) 100:00:0 (B) 88:10:2 (C) 78:20:2 (D) 68:30:2 of Wheat, walnut and *Justicia carnea*. Proximate composition of the cookies ranged between 0.65 – 1.45% for moisture, 2.15-2.80% for ash, 22.44 – 29.07% for fat, 9.19 – 11.25% for protein, 4.88 – 7.66% for crude fiber and 50.37 - 59.98% for carbohydrate. Moisture content decreased significantly ($P < 0.05$) as walnut substitution increased while fat, protein, crude fiber and ash content increased as walnut substitution increased. The functional properties showed that water and oil absorption capacities ranged between 0.56 – 1.19 ml/g and 0.59 – 1.27ml/g respectively. Bulk density from 0.68 – 0.79ml/g, solubility and swelling power from 14.95 – 17.89% and 6.53 – 7.57g/g respectively. Mineral composition for Sodium, Potassium, Magnesium, Calcium and Phosphorus ranged between 465.16 – 507.29 mg/100g, 176.36 – 436.36mg/100g, 16.60 – 89.86mg/100, 23.69 – 60.80mg/100g and 9.40 – 11.40mg/100g respectively. Sodium, Potassium, magnesium and Phosphorus contents increased significantly ($P<0.05$) while Calcium decreased with increase in walnut flour substitution. The physical properties ranged between 0.50 – 0.60cm, 5.45 – 5.50cm and 9.16 -10.80cm for height, diameter and spread ratio respectively. Only sample D showed significant increase ($P<0.05$) in spread ratio. Sensory scores showed crumb colour, crust thickness, crumb homogeneity, crumb moisture, crumb cohesiveness, fresh cookies odour, crumb consistency and overall acceptability reduced with increase in walnut flour. The study revealed that nutritious and acceptable cookies could be produced from addition of African walnut and *Justicia carnea* flour blend.

Keywords: *Cookies, African walnut, Wheat, Justicia carnea, Proximate composition*

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Introduction

Cookies are known snacks that can be widely eaten by people of all class and age. It is a baked product that is made from flour, water, fat, and sugar. Wheat flour is used as the main ingredient for cookies production due to gluten not present in other cereals. Cookies have some advantages compared with other snacks as they are cheaper, good shelf life, and are available in different sizes, tastes, colors, and packs (Al-

Marazeeq and Angor, 2017). They are readily available for consumption, convenient and inexpensive food products which contain digestive and dietary principles of vital importance (Obasi, 2012). Cookies are high nutritional snacks produced from dough that is transformed into appetizing products by baking in the oven at a particular temperature. Majority of these food products are poor source of protein and micronutrients (Akpuaka 2000).

African walnut (*Tetracarpidinum conophorum*) is underused crop which is rich in phenolic compounds (Prasad, 2003). The kernels of African walnut are sources of oil and the cake removed after extraction of the oil contains protein (Awofadeju, 2020). Uhunmwangho and Omoregie (2017) carried a research on the nutrition and anti-nutrition contents of walnut seed oil at various phases of fruit maturation. This investigation revealed the nourishing profile of the fruit-nut of walnut as a good source of plant protein, carbohydrate and fat, with a decrease in the degree of some anti-nutrients in matured fruits. Due, to, the high protein quality of the seeds including higher levels of essential amino acids, other nutrients and phytochemicals when compared to other nuts, it could be used in the development of functional foods (Oladiji *et al.*, 2010). The kernel is rich in vitamins and mineral (Ojobor et al., 2015). The utilization of the seeds have been further enhance by different researches carried out on the use of processed African walnut flour in bread production (Awofadeju *et al.*, 2018) and biscuit (Olapade and Abu, 2019).

Justicia carnea is a medicinal plant reported to have multiple pharmacological benefits, including blood-boosting potential. Locally, *J. carnea* species are being used in the treatment of respiratory tract infection, inflammation, gastrointestinal disease, rheumatism and arthritis (Faiza, 2013). Due to the function they perform on the central nervous system, they are used as depressors, hallucinogens, sedatives and treatment for epilepsy, somniferous agents and mental disorders (Faiza, 2013). *J. carnea* leaves extract are rich in iron, riboflavin, vitamin A, C, E, B_1, B_2, B_9 and B_{12} (Onyeabo *et al*., 2017). Wheat grains are usually used in processing a wide variety of food products (Shewry and Hey, 2015). Wheat grains is rich in carbohydrate, it contains significant amounts of other essential nutrients like proteins and minor components like vitamins, lipids, minerals and phytochemicals (Shewry and Hey, 2015). Two major groups of phytochemicals gotten from various biosynthetic pathways such as phenolics and terpenoids can be found in wheat grain (Shewry and Hey, 2015). The antioxidant properties of wheat have been linked to its phenolic phytochemicals such as alkylresorcinals, hydroxycinnamic acids (Gayathri and Rashmi, 2016). This is evidence that wheat can really be used as the basis for development of functional foods made to enhance the health of millions of consumers (Kosik *et al*., 2014).

Malnutrition leads to a poor health condition resulting from insufficient or unbalanced consumption of nutrients which pose as a problem in developing countries like Nigeria (Tapsell, 2009). Majority of these products consumed by both children and adults are mostly low in protein and micro-nutrients. Due to insufficient knowledge of the availability of some of these local tree nuts and leaves or its nutritional characteristics, they are usually neglected and as a result have not been utilized to its fullest potential. Therefore this study is being carried out in other to explore these under-utilized plant produce in cookies production. The objective of this study is to evaluate the nutritional and sensory properties of cookies produced from flour blends of African walnut (*T. conophorum*), *J. carnea* and wheat.

Materials and Methods

Sources of raw materials

African walnut, (*T. conophorum*) was purchased from Fruit Garden Market, Port Harcourt, Rivers State. Other ingredient which include wheat flour, sugar and salt (Dangote), baking powder (Longman), Margarine (Pomo), Milk (Dano), Vanilla flavour and eggs were bought at Mile 3 Oroworokwu Market, Port Harcourt. *J. Carnea* was gotten from D/line, Port Harcourt.

Preparation of raw materials

The African walnut (*T. conophorum*) was prepared according to the method by Noha and Almoraise (2019). The raw material was sorted and washed with clean water to remove unwanted materials and then cooked for 1 hour. The walnut was sliced to increase surface area. The sliced walnut was blanched in hot water for 5 minutes and dried in hot air oven (DHG-9140A Shanghai China) at 60ºC for 24 hours after which it was grounded into flour with an attrition mill (Globe P14 Shanghai China) and was sieved to obtain African walnut flour. The flour was packaged in an air tight container until needed for analysis.

J. carnea was prepared according to the method by Otuokere *et al.* (2016) with slight modification. raw material was sorted, washed and dried in an oven (DHG-9140A Shanghai China) at 50ºC for 24 hours and was milled into flour with an attrition mill (Globe P14 Shanghai China) and sieved to obtain *J. carnea* flour. The flour was packaged in an air tight container until needed for analysis.

Formulation of flour blends

Wheat, African walnut and *J. carnea* flours were mixed at different proportion 88:10:2, 78:20:2, 68:30:2 while 100% wheat served as control (Tables 1 and 2).

Table 1: Composition of wheat, African walnut and *J. carnea* flours

Sample code	Flour sample		
	African walnut flour	Wheat flour	*J. carnea*
A (0AWF:100WF:0JCF)	0	100	0
B (10AWF:88WF:2JCF)	10	88	2
C (20AWF:78WF:2JCF)	20	78	2
D (30AWF:68WF:2CF)	30	68	2

Table 2: Formulation of composite flour for cookies production

Ingredients	A	B	C	D
Wheat flour (g)	100	88	78	68
Justicia, carnea (g)	-	2	2	2
Walnut flour (g)	-	10	20	30
Margarine (g)	50	50	50	50
Sugar (g)	25	25	25	25
Whole egg	1	1	1	1
Vanilla(ml)	5	5	5	5
Baking powder (g)	2	2	2	2
Water(ml)	10	10	10	10
Salt (g)	0.4	0.4	0.4	0.4

Preparation of cookies

Cookies were produced according to the method described by Barber and Emelike (2016) with some modifications. Walnut flour substituted Wheat flour at levels 10%, 20% and 30%. The Margarine and Sugar were homogenized using a master chef mixer at medium speed. Composite flour, whole egg, sifted dry ingredients, vanilla essence and water were added to the mixture and homogenized thoroughly until dough is formed. The dough was rolled on a flat surface before using a circular cutter to cut out the cookies which were then baked in a preheated oven at 175^o C for 15 minutes. The cookies were then removed from the oven, allowed to cool before being packaged in an airtight container.

Determination of functional properties of cookies sample

Bulk density, water absorption capacity, oil absorption capacity, solubility and swelling index and least gelation concentration were all determined according to the method of AOAC (2012).

Determination of proximate compositions of cookies sample

Moisture content, crude protein, Crude fiber, fat, ash content and carbohydrate were all determined according to the method of AOAC (2012).

Determination of mineral compositions of cookies sample

Calcium (Ca) and Magnesium (Mg) contents of the samples were determined according to the method of Carpenter and Hendricks (2003). Sodium (Na) and potassium (K) contents were determined by flame photometry method as described by James (1995). Phosphorus (P) was determined by spectrophotometry method.

Determination of physical properties of cookies sample

Height, diameter and spread ratio were determined according to the method of AOAC (2004).

Sensory evaluation of cookies sample

The sensory evaluation was determined according to the method of Iwe (2000).

Data Analysis

Significant differences ($p<0.05$) among treatment means were determine by analysis of variance. Mean separation was carried out using SPSS version 22.0. Separation of means was carried out by Duncan Multiple range test and values were reported as means and standard deviation.

Results

Functional properties of wheat, African walnut and *J. carnea* composite flours

The functional properties of wheat, African walnut and *J. carnea* composite flour are shown in table 3. Water absorption capacity of the flour ranged from 0.56% - 1.19% as 100% wheat (A) recorded the lowest while 30% walnut substitute (D) recording the highest. The control cookie deferred significantly ($P < 0.05$) from the other samples. Oil absorption capacity ranged between 0.59% - 1.27% as sample (A) recorded the lowest and sample (D) recorded the highest. There was significant difference ($P < 0.05$) in Oil absorption capacity between sample A and Sample D. Bulk density ranged from 0.68% - 0.79g/m as sample D and sample A recorded the lowest and highest value respectively. There was significant difference ($P < 0.05$) between sample A and the rest of the samples. Result showed that solubility ranged between 14.9% - 17.8% as 10% walnut substitute (B) recorded the lowest and 20% walnut substitute (C) recorded the highest. There was no significant difference ($P>0.05$) within the substituted samples. Swelling power of the samples ranged from 6.53 – 7.57% as sample D and sample A recorded the lowest and the highest value respectively. Results showed a significant difference between sample A and sample D. The least gelation concentration of the samples was 2.00% with all samples having the same value.

Table 3: Functional properties of Wheat, African walnut and *J. carnea* flour blends

Sample code	water absorption (%)	Oil Absorption (%)	Bulk Density (g/ml)	Swelling power %	Solubility %	Least gelation %
A(0AWF:100WF:0JCF)	0.56 ± 0.00^{b}	0.59 ± 0.00^{a}	0.79 ± 0.00^{a}	7.57 ± 0.20^{a}	7.42 ± 0.82^{ab}	2.00 ± 0.00^{a}
B(10AWF:88WF:2JCF)	0.88 ± 0.15^{ab}	0.78 ± 0.01^{b}	0.78 ± 0.01^{b}	7.42 ± 0.82^{ab}	14.95 ± 0.42^{a}	2.00 ± 0.00^{a}
C(20AWF:78WF:2JCF)	1.18 ± 0.00^{a}	0.89 ± 0.14^{ab}	0.71 ± 0.00^{bc}	7.02 ± 0.00^{ab}	16.76 ± 2.17^{a}	2.00 ± 0.00^{a}
D(30AWF:68WF:2CF)	1.19 ± 0.00^{a}	1.27 ± 0.12^{a}	0.68 ± 0.01^{c}	6.53 ± 0.40^{b}	16.44 ± 1.03^{a}	2.00 ± 0.00^{a}

Values are mean $\pm$ Standard deviation of triplicate determinations. Means with the same superscript in the same column are not significantly ($P>0.05$) different

Proximate composition of cookies produced from wheat, African walnut and *J. carnea* flour blends

The proximate compositions of cookies from wheat, African walnut and *J. carnea* flour blends are shown in table 4. The result showed that moisture content of the samples ranged between 0.65% - 1.45% as sample D recorded the lowest while sample A recorded the highest. There was significant difference (P<0.05) in moisture content of samples A and D. Addition of walnut significantly increased the protein, ash, fat and fibre content of the cookies. The ash content ranged from 1.60% - 2.80% as sample D recorded the lowest while sample C recorded the highest. There was significant difference in the ash content between samples D and A. The fats contents of the cookies ranged from 22.44% - 29.07% as samples D and A recorded the highest and lowest values respectively. The protein content of the sample ranged between 9.19% - 11.25% as sample A recorded the lowest while sample D recorded the highest. The crude fibre content of the sample ranged from 4.88% - 7.37% as sample A recorded the lowest while sample B recorded the highest. The carbohydrate content of the cookies ranged from 50.37% - 59.98%. There was no significant difference (P>0.05) in the carbohydrate content within the samples..

Table 4: Proximate composition of cookies made from wheat, African walnut and *J. carnea* flours

Sample code (%)	Moisture	Ash	Fat	Protein	Fiber	Carbohydrate
A(0AWF:100WF:0JCF)	1.45±0.07^{a}	2.15±0.07^{b}	22.44±0.73^{b}	9.19±0.00^{b}	4.88±0.43^{b}	59.98±0.88^{a}
B(10AWF:88WF:2JCF)	1.16±0.03^{b}	2.49±0.14^{a}	23.29±0.45^{b}	9.56±0.00^{b}	7.66±0.73^{a}	55.86±0.34^{a}
C(20AWF:78WF:2JCF)	1.32±0.02^{ab}	2.80±0.00^{a}	27.55±0.77^{a}	10.59±0.30^{ab}	7.37±0.24^{a}	50.37±1.34^{a}
D(30AWF:68WF:2CF)	0.65±0.00^{c}	2.60±0.00^{a}	29.07±0.67^{a}	11.25±0.62^{a}	5.18±0.55^{b}	51.00±0.86^{a}

Values are mean ±Standard deviation of triplicate determinations. Means with the same superscript in the same column are not significantly (P>0.05) different

Mineral compositions of cookies produced from wheat, African walnut and *J. carnea* flour blends

The mineral compositions of cookies from wheat, African walnut and *J. carnea* flour blends are shown in table 5. Sodium content of the cookies ranged between 465.16 – 507.29mg/100g as sample B recorded the lowest value while C recorded the highest. There was significance difference in the sodium content of the samples. Potassium and magnesium contents ranged from 176.36 – 436.36mg/100g and 16.60 – 89.86mg/100g for samples A and D respectively. Result showed that potassium and magnesium increased significantly (P < 0.05) with increase in walnut substitution. Calcium content of the cookies ranged from 23.69 – 60.80mg/100g as samples B and A recorded lowest and highest respectively. Phosphorus content of the cookies ranged from 9.40 – 11.0mg/100g as sample A recorded the lowest while 10% walnut substitute recorded the highest.

Table 5: Mineral composition of cookies made from wheat, African walnut and *J. carnea* flour blends (mg/100g)

Sample code	Na	K	Mg	Ca	P
A(0AWF:100WF:0JCF)	466.60± 0.14^{c}	176.36± 0.00^{d}	16.60± 0.00^{d}	60.80± 0.14^{a}	9.40± 0.00^{b}
B(10AWF:88WF:2JCF)	465.16 ± 0.00^{c}	315.11± 1.41^{c}	47.00± 1.41^{c}	23.69± 0.00^{d}	11.40± 0.00^{b}
C(20AWF:78WF:2JCF)	507.29 ±1.41^{a}	402.04± 0.00^{b}	76.10± 0.14^{b}	45.37± 0.14^{c}	10.40± 0.01^{c}
D(30AWF:68WF:2CF)	496.16 ± 0.14^{a}	436.36± 0.42^{c}	89.86± 0.04^{a}	49.56± 0.04^{b}	11.00± 0.00^{b}

Values are mean ±Standard deviation of triplicate determinations. Means with the same superscript in the same column are not significantly (P>0.05) different

Physical properties of cookies produced from wheat, African walnut and *J. carnea* composite flour

The physical properties of cookies from wheat, African walnut and *J. carnea* flour blends are shown in table 6. The height of the cookies ranged from 0.50 -0.60 cm as sample D recorded the lowest while Samples A, B and C recorded the highest. Only Sample D showed significant difference (P < 0.05) compared to the other samples. The diameter of the cookies ranged between 5.4 to 5.5 cm as Samples D and A recorded the lowest and the highest values respectively. There was no significant difference in diameter of the cookies. The spread ratio of the cookies ranged between 9.16 – 10.80 m/m as Sample D recorded the highest. Result showed that the spread ratio of sample D was significantly different (P<0.05) from the rest of the samples.

Table 6: Physical properties of cookies produced from wheat, African walnut and *J. carnea* flour blends

Sample code	Height (cm)	Diameter (cm)	Spread ratio (m/m)
A(0AWF:100WF:0JCF)	0.60 ± 0.00^{a}	5.50 ± 0.00^{a}	9.16 ± 0.00^{b}
B(10AWF:88WF:2JCF)	0.60 ± 0.00^{a}	5.50 ± 0.00^{a}	9.16 ± 0.00^{b}
C(20AWF:78WF:2JCF)	0.60 ± 0.00^{a}	5.45 ± 0.00^{a}	9.16 ± 0.00^{b}
D(30AWF:68WF:2CF)	0.50 ± 0.00^{b}	5.40 ± 0.00^{a}	10.80 ± 0.00^{a}

Values are mean ±Standard deviation of triplicate determinations. Means with the same superscript in the same column are not significantly (P>0.05) different

Sensory properties of cookies produced from wheat, African walnut, and *J. carnea* flour blends

The sensory properties of cookies from wheat, African walnut and *J. carnea* flour blends are shown in figure 1. The score for crumb colour ranged from 3.45 to 4.65% as sample A recorded the lowest while sample D recorded the highest. The result showed there was significant difference (P<0.05) between sample A and the rest of the samples. The crust thickness ranged from 2.75 – 3.45% as sample B recorded the lowest while sample D recorded the highest. Result showed a significant difference in crumb thickness within the samples. Crumb Homogeneity ranged from 2.85 – 3.15% as samples C and D recorded the lowest while sample A recorded the highest. Crumb moisture ranged between 1.65-2.2% as sample A recorded the lowest while sample C recorded the highest. Crumb cohesiveness ranged from 2.85 – 3.00% as sample D scored the lowest while sample A scored the highest. There was no significant difference (P>0.05) in the samples. Fresh cookies odour ranged between 2.70 – 3.4% with sample D scoring the lowest while sample A scored the highest. Crumb consistency ranged from 2.95 – 3.20 as sample C scored the highest. Overall acceptability of the cookies ranged from 3.1 – 3.40% as samples C and A scored the lowest and highest respectively.

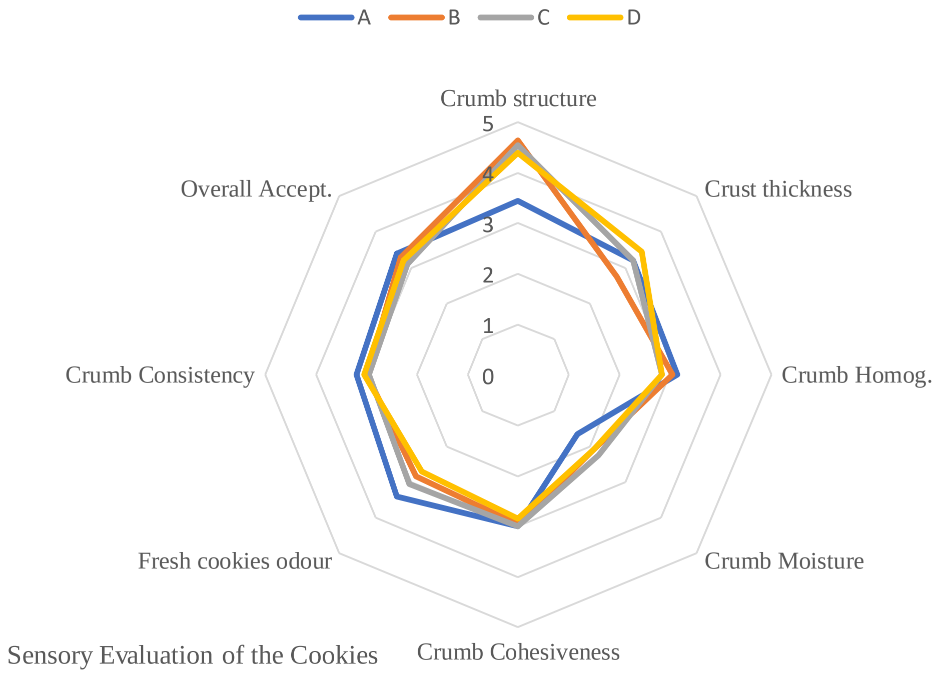

Figure 1: Sensory properties of cookies produced from wheat, African walnut, and *J. carnea* flour blends

Discussion

From table 3, water absorption capacity of the composite flour blend of African walnut, wheat and *J. carnea* flour ranged between 0.56 - 1.19%. A similar result was reported by Eke-Ejiofor and Kporna (2019) on cowpea and Acha composite from (1.20-1.36%). The increase observed in water absorption capacity may be as a result of increase in the protein solubility due to the addition of walnuts which protein is known for its high solubility and assumption capacity (Noha and Almoraise, 2019). The high water absorption capacity of wheat and walnut is an indication that the flour may find application in food preparation where water absorption is needed. Granito *et al* (2004) reported that water absorption capacity is regarded as a function property of proteins which may beneficial in viscous food like soup sauces, dough and in baked food products where good protein-water interaction is required.

Oil absorption Capacity of Wheat, Walnut and *J. carnea* composite flour significantly increased (P < 0.05) showing higher value of oil absorption capacity amongst samples as Walnut substitution increased. The oil absorption capacity was lower when compared with cowpea-acha composite flour as reported by Eke-Ejiofor and Kporna (2019). According to the result obtained, increase in the substitution of walnut flour resulted in an increase in the oil absorption capacity which may be as a result of the availability of surface hydrophobic proteins and non-polar side chain which play major role in binding of oil (Benitez *et al* 2013). High oil absorption capacity is useful in food applications mostly in flavor retention enhancement and reduction of moisture and fat loss which helps to prolong the shelf life of meat products (Noha and Almoraise, 2019). There is a decrease with increased substitute of the walnut flour.

Low bulk density of the blends is beneficial in the formulation of baby food which requires high nutrient density to low bulk (Olapade and Aworth, 2012). The result show that walnut flour has low bulk density and this may be as a result of availability of oil in the sample. Bulk density shows the volume of packaging material that is needed to transport the food product. Bulk density reduces porosity of materials due to surface properties (Olapade and Aworth, 2012).

There was a significant decrease (P < 0.05) in swelling power as walnut substitute increased. Higher protein content in flour may affect the starch granule as it could cause it to be embedded within a stiff protein matrix, which will reduce the intake of water by starch thereby restrict the swelling power (Aprianita *et al.*, 2009). There was no significant (P>0.05) effect on the solubility of the flours. There was a decrease in solubility of the flours as the walnut substitute increase. This may be as a result of low water binding ability of walnut flour available in the oil.

From table 4, the variation in moisture content is below the accepted moisture contents of dry food (not more 9% for flour blends) (Noha and Almoraise, 2019). The addition of walnut to wheat flour affected the binding of moisture as a result, the composite cookies had a reduced moisture content. The low moisture content is important in preventing microbial growth and extending the shell-life of cookies. This could be achieved if the product is protected from absorbing moisture through proper packaging.

The Ash content of the cookies was significantly higher (P < 0.05) with increase in walnut substitution which could be due to the high ash content of walnut flour. The high ash content of cookies indicates high mineral content. Ash content value from this study is lower than that of tigernut-maize flour blend cookies which ranged from 2.03 – 3.38% reported by Obinna-echem and Robinson (2019). The current finding is in agreement with the result of Aleem *et al* (2012) who reported an increase in ash content (0.69 – 2.01%) for wheat – defatted soya bean cookies.

The fat content increased with increase in walnut flour substitution. Sample A (100% wheat flour) had significantly lower (P < 0.05) fat content than Sample D (with 30% walnut flour). This pose, as a problem of rancidity during storage, although fat enhances the absorption of fat soluble vitamin, improves mouthful and retains flavor (Athisaya, 2007).

The protein values of the cookies are similar to those of commercially available biscuits in Nigeria like Top biscuit by Parle (Musa and Lawal, 2013). The protein values of the cookies are within the values of tigernut-maize flour cookies reported by Obinna-echem and Robinson (2019). The cookies from 100% wheat flour had the lowest protein with significant increase in the protein level as walnut substitution increased. This may be due to the high protein content of walnut flour as compared to wheat flour.

Fiber ranged between 4.88 (100% wheat flour) to 7.66 (10% walnut flour) with increase recorded at each level of substitution indicating high dietary fiber in walnut flour. Crude fiber is beneficial in the enhanced utilization of nitrogen and absorption of some other micronutrients and provides bulk which is important for peristaltic action in the intestinal tract (Obinna-echem and Robinson, 2019). The result showed that an increase in walnut substitution resulted in an increase in crude fiber and this may as a result of high crude fiber content of walnut as compared to wheat.

The carbohydrate content of walnut – wheat cookies is similar to some of the commercially available cookies in Nigeria (Musa and Lawal, 2013). The carbohydrate content was significantly (P < 0.05) lower than the carbohydrate content of tigernut-maize based cookies reported by Obinna-echem and Robinson (2019). It was observed that there was a decrease in carbohydrate content of the samples as the walnut substitution increased. This may due to the decrease in the percentage of carbohydrate rich wheat flour.

The levels of the minerals; sodium, potassium, magnesium and phosphorous increased with increase in substitution of walnut flour except calcium. The increase in the mineral content of the flour blend cookies confirms the importance of supplementation. The control (100% wheat flour) had significantly (P < 0.05) the least value with increased value of sodium as the walnut substitution increased. Low sodium level in the blood can result to Hyponatremia (Ijeomah *et al.*, 2012). The level of potassium in samples varied significantly (P < 0.05) with highest value in Sample D. Potassium assist in regulating muscle contractions, fluid balance and nerve signals. It also prevents osteoporosis and reduces blood pressure (Kanu *et al.*, 2013). Cookies from the composite flours blends had higher magnesium when compared with the control sample. This is an indication that African walnut and *J. carnea* are rich in magnesium. Magnesium is associated with over 300 metabolic reactions and it is beneficial in bone formation, new cells production, blood clothing, activation of B vitamins, relaxing navies and muscle and energy production (Guerrera *et al.*, 2009). A decrease in calcium was recorded as the walnut substitution increased. Calcium is beneficial in the growth and development of infant and young children. Phosphorous plays a vital role in every living cell. It is very important in bone formation and other cellular reactions in the body (Ndie 2010). There was an increase in potassium as walnut substitution increase.

The height of the cookies varied significantly (P < 0.05) for sample D while sample A, B and C were not significantly different (P>0.05). There was no significant difference (P>0.05) in the diameter of the cookies. This shows uniform elasticity of the dough and even thermal expansion during baking. The spread ratio is known for the ratio of the diameter to the height. Having higher spread ratios are consider most desirable. Singh *et al.* (2003) reported that the spread ratio of cookies increased as non wheat protein ratio increased. The spread ratio of the cookies increased significantly (P <0.05) with an increase in walnut flour. Higher spread ratio is preferred as reductions are attributed to the hydrophilic nature of flours (Okpala *et al*, 2013).

From figure 1, the control (100% wheat cookies) had the highest score for the overall acceptability but there was no significant difference (P>0.05) among other samples for the attributes of crumb colour. The result showed the decrease in acceptability of cookies as walnut substitution increased. Barber and Obinna-Echem (2016) reported similar values when Walnut was substituted. There was no significant difference in crumb colour for the substituted samples. This is due to the constant ratio of *J. carnea* flour. Generally, panelist preferred cookies formulated with 88% flour, 10% African walnut flour and 2% *J. carnea* flour.

Conclusion

The study revealed that nutritious and acceptable cookies could be produced from addition of African walnut and *J. carnea* flour blend. The substitution of African walnut and *J. carnea* produced nutritionally superior cookies, though the control (100% wheat flour) was the most acceptable organoleptically. The use of wheat/African, walnut/*J. carnea* composite flour in the production of cookies significantly (P < 0.05) improved the protein fat ash, crude fiver, sodium phosphorus, potassium and magnesium as compared to the control. The physical parameter (diameter, height and spread ratio) were comparable with some produced commercially.

This result can help combat the high occurrence of malnutrition in children in Nigeria and other developing countries. It is necessary that we explore the use of non-wheat flour to enhance the nutritional value of staple snacks like cookies.

Competing interests

The authors report no conflicts of interest.

References

Akpuaka, M.U. & Nwankwo, E. (2000). Extraction, analysis and utilization of a drying oil from *Tetracarpidium conophorum*. *Journal of Bioscience and Technology.* 73(2):195 – 196.

analysis.3rd. Springer LLC, New York, N.Y:: 198-206.

Al-Marazeeq, K.M. & Angor, M.M. (2017). Chemical characteristic and sensory evaluation of biscuit enriched with wheat germ and the effect of storage time on the sensory properties for this product, Food Nutr. Sci. 8(2)189–195, https://doi.org/10.4236/fns.2017.82012

Aleem-Zaker M.D.I. Genitha, T.R.I. & Syed, I.H. (2012). Effect of defatted Soy flour incorporation on Physical, Sensorial and Nutritional properties of Biscuits. *Journal Food Process Technology.* 34(1)54-57.

AOAC (2004). Association of Official Analytical Chemists, Washington D.C.Official

AOAC (2012). Official Method of Analysis. 19th Edition. Association of Official Analytical Chemists, Washington DC., USA.

Aprianita, A, Purwandari, U. Watson, B. & Vazijevic, T. (2009). Physicochemical Properties of Flour and Starches from Selected commercial Tubers available in Australia. *International Food Research Journal.*16:507 – 520.

Athisaya, Buransompob, Juming, Runsheng, Mao & Barry G.S. (2007). Rancidity of Walnuts and Almonds affected by short time heat treatments for Insect Control. *Journal of food processing and preservation.* 27(6)445-464.

Awofadeju, O. F. J. (2020), Evaluation of Protein Quality in Blends Prepared from Commercial Wheat (Triticum aestivum) and Yellow Maize Flours (Zea may s) and Afri c an Wa lnut (Tetracarpidium conophorum) Protein Isolate. Euro. Modern Studies J., 4(1) 113-129.

Awofadeju, O.F.J. Awe, A.B. Adewunmi, O.J. Ogidan, E.A. Ojo, A.F. Oyewumi, R.O. & Godson, B. (2018). Physicochemical, nutritional and consumers acceptability of bread made from wheat flour enriched with African walnut flour. *J. Forestry Res. Manage.*, 15(3): 184-194.

Barber, I.C. & Obinna-Echem, P.C. (2016) Nutrient Composition, Physical and Sensory Properties of wheat-African walnut cookies. Sky Journal of Food Science 5(4) 24-30. http://www.skyjournals.org/SJFS

Barber, L.I. Emelike, N.J.T. & Sunday B.N. (2016). Utilization of Breadfruit in Low fat cookie formulation "*Journal of Food and Nutrition Research*, 4(10): 658-663.

Benitez, V. Cantera, S. Yol, A. Esperanza, M. Rosa, M.E. Maria, F.D & Maria, M. (2013). Impact of germination on Starch dietary fiber and physiochemical properties in non-conventional legumes. *Food Research International.* 50 (1): 64-69.

Carpenter,C.E. & Hendrick, D.G. (2003). Mineral analysis.In:S.S. Nielsen(Ed). Food

Eke-Ejiofor, J. & Kporna, J.D. (2019). Nutrient and Sensory Evaluation of Cowpea-Acha Flour Blend in pudding production. *Food Science Nutritional Technology.* 4 (1):000174.

Faiza, R. Waqas, K.K. Adeel, M. & Muhammad G. (2013). Detection of bioactive fractions of *Justicia carnea* leaves. *Canadian Journal of Applied Science*. 1:388-398.

Gayathri, D. & Rashmi, B. S. (2016). Critical analysis of wheat as food. *Maternal and*

Granito, M. Guerrera, M. Torres, A. & Guimand, J. (2004). Efecto del Procesanieto Sobre Las Propiedades functionals de digma simensis. *Imteviciencia*, 29 (9); 521-526

Guerrera, M.P. Stella, L.V. & Jun, J.M. (2009). Therapeutic uses of magnesium. Am. Fam. Physician. *National Library of Medicine* 80(2):157 – 162.

Ijeomah, A.U. Uguwoma, F.U. & Ibrahim, Y. (2012). Nutrient composition of three commonly consumed indigenous vegetables of North-Central Nigeria *Journal of Agriculture, Food and Environmental;* 8(1); 17-21.

Iwe, M.O. (2000). Handbook of Sensory methods and analysis. Projoint Communications Services, ltd, Enugu. Pp 70-72.

James, C.S. (1995).Analytical chemistry of food.Chapman and Hall,London.Pp.64-65

Kanu, P. Aggarwal, S.N. & Monica, K. (2013). Molecular Mechanism of Renal stone formation and the critical role played by modulators. *Journal of Biomedical Research International.* 10:11-55.

Kosík, T. Lacko-Bartošová, M. & Kobida, L. (2014). Free phenol content and antioxidant activity of winter wheat in sustainable farming systems. *Journal of Microbiology, Biotechnology and Food Sciences,* 3: 247-249.

Musa, A. & Lawal, T. (2013). Proximate composition of Ten types of Biscuits and their susceptibility to Tribolium castaneum Herbs (Tenebrionidae Bostrichidae) in Nigeria, *Food Science*. 14:33-40.

Ndie, E.C. Nnamani, C.V. & Oselebe, H.O. (2010). Some physicochemical characteristics of Defatted plants derived from African walnut (*Tetracarpidium conophorum*). An underutilized legume. *Pakistan Journal of Nutrition*. 9(9): 909 – 911.

Noha, M.A. & Almoraise, (2019). The Effect of Walnut Flour on the Physical and Sensory Characteristics of Wheat Bread. *International Journal of Food Science*, 2019, Article ID 5676205, 7

Obasi, N.E. Uchechukwu, N. & Eke-Obia, E. (2012). Production and Evaluation of Biscuits from African yam bean (*sphenostyllis stenocarpa*) and Wheat (*Triticumae stivum*) flour. *Food Science Journal.* 7:5-12.

Obinna-echem, P.C. & Robinson, E.S. (2019). Proximate composition , physical and sensory properties of biscuits produced from blends of maize (Zea mays) and tigernut (Cyperus esculentus) flour. Sky Journal of Food Science, 7(2), 30–36.

Okpala, L. Okoli, E. & Udensi, E. (2013). Physico-chemical and Sensory Properties of Cookies made from Blends of Germinated Pigeon Pea, ferment sorghum, and cocoyam flours. *Journal of Food Science and Nutrition.* 1(1): 8-14.

Olapade, A.A. & Abu, O.M. (2019). Evaluation of blends of wheat (Triticum aestivum) flour and African walnut (Tetracarpidium conophorum) flour in biscuit production. Cro. *J. Food Sci*. *Tech.* 11(2):245-250. https://doi.org/10.17508/CJFST.2019.11.2.14

Olapade, A.A. & Aworth, O.C. (2012). Evaluation of extruded snacks from blends of Acha (Digitariaexillis) and cowpea (Vignaun guiculata) flours. *International Journal of Agricultural Engineering*, 14(3): 210-217.

Oladiji, A.T. Abodunrin, T.P. & Yakubu, M.T. (2010). Toxicological evaluation of Tetracarpidium conophorum nut oil-based diet in rats. Food Chem. Toxicology, 48:898-902. https://doi.org/10.1016/j.fct.2009.12.030

Onyeabo, C. Achi, K. Ekeleme-Egedigwe, E.A. Chima, U. & Okoro, C.K. (2017). Haematological and biochemical studies of *Justicia carnea* leaves extract in phenylhydrazine induced anemia in albino rats. *Journal of Food Sciences and Nutrition*.16(2), 217-230.

Otuokere, I.E. Amaku A.J. Igwe. K. & Chinedum, G.C. (2016). Medicinal Studies on the Phytochemical Constituents of *Justicia* *carnea* by GC-MS. *American Journal of Science and Health*. 2:71-77. *Pediatric Nutrition*, 2(2): 1-3.

Prasad, R.B.N. (2003). Walnuts and Pecans. Encyclopedia of Food Sciences and Nutrition. 2:6071-6079.

Shewry, P.R. & Hey, S.J. (2015). The contribution of wheat to human diet and health. Food and Energy security. 4(3): 178-202. https://doi.org/10.1002/fe3.64

Singh, R. Singh, G. & Chauchan, G.S. (2003). Nutritional Evaluation of Soy fortified Biscuits. *Journal of Food Science and Technology*. 37:162-164.

Tapsell, C.L. David R.J. & Myron D.G. (2009). Food synergy: An operational concept for understanding nutrition. *The American Journal of Clinical Nutrition*. 89 (5) 15433 – 15485.

Uhunmwangho, E.S. & Omoregie, E.S. (2017). Evaluation of nutritive, anti-nutritive and mineral content of Tetracarpidium conophorum (African Walnut) seed oil at different stages of fruit maturation', Haya: Saudi Journal. Life.

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