The influence of cooked grated African walnut on the nutritional composition, antioxidant and sensorial properties of a cookie snack

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ABSTRACT

Emphasis has significantly been placed on the production of functional foods and the utilization of indigenous food crops in the management of some diet-related non-communicable diseases. This study included African walnut in the production of a cookie snack, and the effect of the inclusion on its nutritional, antioxidant and sensory quality was assessed. The inclusion of cooked grated walnut in the cookie caused a significant increase in crude protein (2.67%), fat (2.57%), fibre 91.17%), TPC (2.97 mgGAE/g db), DPPH (1.44 µmol TE/gdb) except for total starch, in-vitro protein, and starch digestibility. This resulted in nutrient-dense cookies, rich in antioxidants with a low estimated glycemic index, suitable for people with non-communicable pathophysiological conditions. Considering the sensory scores, walnut enriched cookies were accepted by the consumers comparably with the wheat flour cookies. Hence, walnut enriched cookies

may be adequate in promoting health-related functions, while satisfying consumer's urge for snacking.

Keywords: *Tetracarpidium conophorum*; *in-vitro* protein digestibility; dietary fiber; functional food

1. Introduction

The relationship between diet and health has been demonstrated extensively via various clinical and epidemiological studies (Shahidi, 2004). In the intention of increasing life expectancy and quality, functional foods play an outstanding role, this is why recent research is aimed at the development of functional foods, which confer health benefits other than the usual nutritional requirement on consumers. Functional foods vary from fortified, enriched, enhanced, and altered products, across different countries, food categories and health claims (Hasler, 2002). Apart from the health and nutritional benefits, functional foods can also be designed to satisfy the hunger need of consumers.

All over the world due to more busy schedules and lifestyles, snacking has become a huge part of the world culture. Baked foods especially biscuits and soft version cookies are consumed universally among all age groups, and it's fast-growing in the global market (Research and Market, 2020). Cookies are cheap, convenient, and ready to eat, flat, sweet baked goods made from unleavened dough and other ingredients (Adeyeye et al., 2017). Most cookies are usually energy-dense with high carbohydrate content, however, so many diet-related, non-communicable diseases (diabetes, hypertension, coronary heart diseases and neurodegenerative diseases) have resulted in the need for the promotion of healthy snacks (Onyenweaku, Oko, & Fila, 2019). Several cookies have been formulated with composite flour, cereals, legumes, pseudo-cereal, nuts, fruits, resistant starch, vegetables and dietary fiber (Aziah et al., 2012; Chauhan et al., 2015; Saeed et al., 2015; Fasogbon et al., 2017).

Walnuts generally have been reported to be an excellent source of antioxidants, which reduce oxidative stress, neuro-inflammation, and progression of other brain disorders (Chauhan & Chauhan, 2020). The English variety of walnut (*Juglans regia L.*) is high in antioxidant compounds, which could delay cognitive decline in combination with its polyunsaturated fatty acids (PUFA) (Poulose, Bielinski, & Shukitt-Hale, 2013). The African walnut variety (*Tetracarpidium conophorum*), though widely cultivated for its edible seed in several parts of Africa, still remains underutilized due to its poor storage and preservation. The seeds are mostly cooked and consumed as snacks when in season, and has been reported to be rich in protein, vitamins and minerals, with huge antioxidant potential capable of promoting anti-depressant activity (Ayodeji & Aliyu, 2018).

Functional foods is gaining much popularity in bakery products, hence, this study aimed at incorporating cooked grated Africa walnut in cookies, thereby improving the nutritional, antioxidant and beneficial health properties of the cookies.

2. Materials and Methods

2.1 Materials

Fresh African walnuts were obtained from a neighboring village around Ile-Ife, Nigeria. Other cookie ingredients (flour, date syrup, unsalted butter, egg, milk powder, baking soda, baking powder, vanilla, nutmeg and salt) were purchased from Ojota market, Lagos, Nigeria. All chemicals used were of analytical grade.

2.2 Methods

2.2.1 Walnut processing

The raw walnuts were washed under running water to remove extraneous materials. The nuts were cooked for about 2 h in a pressure pot, allowed to cool, de-shelled manually using mortar and pestle, and the nuts were shredded into a uniform shape and size using a hand grater. The grated walnuts were thinly spread on a tray and dried in the digital electric oven (Macadams, 78, South Africa) set at a temperature of 60 ± 2 °C for 6 h. The dried walnut was cooled and stored in a plastic container with a lid and refrigerated at 4 °C before the production of the cookies. Uncooked walnuts were also cleaned, grated, dried and stored in the refrigerator at 4 °C until further analysis.

2.2.2 Walnut cookies preparation

The cookies were prepared according to the modified method of Fasogbon et al. (2017). The oven-dried walnuts were removed from storage and allowed to thaw at room temperature (27 °C) before preparing the cookies. The flour, baking powder, baking soda, salt and nutmeg together in a bowl and the milk powder was added to the flour mixture. In another bowl, the butter was mixed until light and fluffy, followed by the addition of egg, vanilla and date syrup with further mixing until creamy. The flour mixture was added gradually to form a dough, and the grated walnut was added to the mix. The dough was rolled out in a flat surface, cut into the round shapes, egg washed, sprinkled with walnut on the surface and baked in a moderately high oven (Macadams, 78, South Africa) set at 160-180 °C for about 15-30 min. The baked cookies were allowed to cool and packed till further analysis as shown in Plate 1 (a-d).

2.2.3 Proximate analysis

The proximate composition of the walnuts and cookies were determined using AOAC (2005) methods. The total percentage of carbohydrate was calculated by difference.

2.2.4 Total Phenolic Content

Total phenolic content (TPC) of the extracts from the walnuts and cookies was determined according to the method of Singleton et al. (1999), with Folin-Ciocalteu as reagent procedure described by Apea-Bah et al. (2014). The absorbance measured at 750 nm and expressed as milligrams of gallic acid equivalent per g of dry weight (mg GAE/gdb).

2.2.5 ABTS+ radical scavenging activity determination

The procedure described by Awika et al. (2003) was used to determine the ABTS+ radical scavenging activity of the walnuts and cookies. The absorbance of the reaction mixture was read at 734 nm and expressed as micromole Trolox equivalents per gram sample (μmol TE/g) on a dry weight basis.

2.2.6 DPPH radical scavenging activity determination

The DPPH radical scavenging activity of the walnut and cookies was determined using a modified method described of Apea-Bah et al. (2014). A 0.609 mM DPPH stock solution was prepared in 80% (v/v) aqueous methanol from which 0.102 mM working solution was prepared. A 3x dilution (dilution containing 1 part of a 2X dilution and 9 parts of diluent) of each sample (10 μl) was reacted with 190 μl of DPPH working solution and incubated in the dark at a temperature (15 ± 2 °C) for 1 h in a 96-well plate. Absorbance was read at 570 nm using a microplate reader (Multiskan FC, Thermo Fisher Scientific, Shanghai, China). Results were expressed as millimole Trolox equivalent per gram sample (μmol TE/g) on a dry weight basis.

2.2.7 Total Starch Determination

Total starch of the walnut and cookie samples was determined using the method described by McCleary et al. (1994). The thermostable α-amylase and amyloglucosidase from Megazyme (K-TSTA07/11) were used to breakdown starch to glucose. Glucose was quantified calorimetrically, and the absorbance was examined at 510nm. Total starch was expressed as a percentage (%) of complete sample weight.

2.2.8 Soluble and Insoluble Dietary Fiber Determination

The dietary fiber kit from megazyme (K-TDFR) was used to determine the soluble and insoluble dietary fiber according to the method described by Oladiran & Emmambux (2018).

2.2.9 In-vitro protein digestibility (IVPD) and In-vitro starch digestibility (IVSD)

A multi-enzyme method of (Vilakati et al., 2015) as described by (Oladiran & Emmambux, 2018) was used to determine IVPD while modification method described by Oladiran & Emmambux (2018) was used to determine IVSD of the walnut and cookie samples.

The kinetics of starch hydrolysis and estimated glycemic index (EGI) of the cookie samples were determined using equations 1 & 3.

$$C = C_{\infty}\,(1 - e^{-kt}) \qquad (1)$$

where C is the concentration of starch hydrolyzed at time t, C_{∞} is the percentage (%) of starch hydrolyzed after 180 min, k is digestibility rate constant (min^{-1}), and t is time (min). The area under the hydrolysis curve (AUC) was calculated using equation 2:

$$\mathrm{AUC} = C_{\infty}\,(t_f - t_0) - \left(\frac{C_{\infty}}{K}\right)\left(1 - \exp\left(-\mathrm{K}(t_f - t_0)\right)\right) \qquad (2)$$

where t_f is the final time (180 min), t_0 is the initial time (time 0 min). The hydrolysis index (HI) defined as the AUC of a sample divided by the corresponding area of the reference sample (white bread) was used for calculating EGI.

$$\text{EGI} = 39.71 + 0{:}549\text{HI} \qquad (3)$$

2.2.10 Sensory evaluation

Twenty (20) semi-trained panelists who were staff and students of Yaba College of Technology, Lagos, Nigeria, evaluated the two cookie samples. The samples were coded, served in white plastic plates to the panelists at a different time and in a different order. The two cookie samples (walnut cookies and wheat flour cookies) were evaluated for paired preference test, while only the walnut cookies were ranked descriptively on scale 1- unappealing to 5- very appealing for appearance, flavor, mouthfeel, taste, overall quality. The panelists were instructed to cleanse their mouth with water between each sample evaluated.

2.2.11 Statistical analysis

Data collected were analyzed using Stata/SE 13.0 for the paired t-test, and SPSS Statistics 27 for the one-sample binomial test of the walnut cookies. Other data generated were analyzed statistically using XLSTART, one-way analysis of variance (ANOVA) was used to determine the mean, standard deviation and least significant difference (LSD) for the post hoc test. All analyses were carried out in triplicates and differences were considered statistically significant at $p \leq 0.05$.

3. Results and Discussion

3.1 Proximate composition of the walnut and cookie samples

Table 1 presents the proximate composition results of the walnut (cooked and uncooked) and the cookies (walnut and wheat flour) samples. The moisture content of all samples analyzed ranged from 3.30% for uncooked walnut to 8.44% for walnut cookies. The result of the uncooked walnut is similar to that obtained by Nwaoguikpe et al. (2012) for *T. conophorum* (2.88%), differences in the value may be due to location, species and/or time of harvesting. When cooked, the moisture content increased to 3.42%, and this corresponds with the moisture content of boiled fresh walnut reported by Djikeng et al. (2018). However, the wheat flour cookies had a significantly ($p \leq 0.05$) lower moisture content than the walnut cookies. This means that the incorporating cooked grated walnut in wheat flour could be responsible for a significant increase (1.77 %) in the moisture content of the walnut cookies.

Table 1 Proximate composition of the cookies, grated uncooked and cooked walnuts

Samples	Moisture (%)	Crude protein (%)	Crude fat (%)	Ash (%)	Crude fiber (%)	Carbohydrate (%)
GUW	$3.30^{a}\pm0.3$	$22.45^{c}\pm0.3$	$48.50^{d}\pm0.3$	$3.62^{c}\pm0.2$	$17.60^{d}\pm0.5$	$4.53^{a}\pm0.3$
GCW	$3.42^{b}\pm0.3$	$25.18^{d}\pm0.1$	$44.33^{c}\pm0.2$	$3.67^{c}\pm0.2$	$14.85^{c}\pm0.2$	$8.55^{b}\pm0.2$
WC	$8.44^{d}\pm0.5$	$13.97^{b}\pm0.2$	$22.96^{b}\pm0.1$	$1.61^{b}\pm0.3$	$4.68^{b}\pm0.1$	$48.34^{c}\pm0.4$
FC	$6.67^{c}\pm0.2$	$11.30^{a}\pm0.4$	$20.39^{a}\pm0.1$	$0.99^{a}\pm0.2$	$3.51^{a}\pm0.3$	$57.14^{d}\pm0.5$

Values are means ± standard deviations of three independent experiment. Values within the same column followed by different letters are significantly different at $p \leq 0.05$.

Keys: GUW- Grated uncooked walnut; GCW- Grated cooked walnut; WC- Cookies from wheat flour with grated walnut; and FC- Flour cookies (Wheat)

Grated cooked walnut had significantly ($p \leq 0.05$) higher crude protein content (25.18%) than the uncooked one (22.45%), this may be due to release of some bound crude protein during processing, and it aligns with the result of Udedi et al. (2013). The protein content in walnut is comparable with that of legumes making it an alternative source of dietary protein for consumption (Ekwe & Ihemeje, 2013) to combat protein-energy malnutrition among the populace. The incorporation of grated cooked walnut in the cookies caused a significant ($p \leq 0.05$) increase (2.67 %) in the protein content of the walnut cookies when compared with the 100% wheat flour cookies. Essential amino acids such as tryptophan, tyrosine and phenylalanine found in walnuts are the precursors for the neurotransmitters, serotonin, dopamine and norepinephrine which are very vital for optimal brain function and health (Glenn et al., 2019), hence walnut exploration in healthy snacks.

The crude fat content of the walnut reduced with cooking from 48.50% to 44.33%, which is similar to the results of Udedi et al. (2013). This reduction may be due to the complex formation of interaction between the crude fat, protein or carbohydrate that may occur during cooking. The inclusion of grated cooked walnut in the cookies increased the crude fat value from 20.39% to 22.96%, which may also be due to the release of bound crude fat during baking. African walnuts are a rich source of linoleic and α-linolenic acid which are precursors to eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), these omega-3 fatty acids have been associated in normal brain and heart functions.

The ash content of all samples ranged from 0.99-3.67%. Cooking did not significantly affect the ash content of uncooked and cooked walnut (3.62% and 3.67% respectively), this corresponds with the report of Udedi et al. (2013) where % ash of both raw and cooked walnut is 2.0 %. Ash represents the mineral content of a food product, and walnut has been reported to be a rich source of several minerals such as magnesium, zinc, potassium, manganese, calcium and copper (Şen & Karadeniz, 2015). With the ash content of walnut cookies being significantly ($p \leq 0.05$) higher than that of the wheat flour cookies, it could exhibit biological activities associated with walnut.

The crude fiber content of the grated uncooked walnut is high, but reduced with cooking which could due to leaching out of soluble fiber into the cooking water. The walnut cookies contain significantly higher crude fiber (4.68%) content than the wheat flour cookies (3.51%). The consumption of walnut helps to control the microbiome in the gut and thus maintaining the integrity of the gut microbiome flora due to the presence of these indigestible fibers and roughages (Bamberger et al., 2018). Wheat flour cookies had the highest carbohydrate content (57.14%) while cookies with grated cooked walnut had 48.34% carbohydrate content. The carbohydrate content of the walnut cookies makes a good source of energy and overall source of nutrients, making walnut and walnut cookies a healthy choice of snack (Arinola & Adesina, 2014).

3.2 Total phenolic and antioxidant properties of the walnut and cookie samples

Table 2 presents the total phenolic content and antioxidant properties of the walnut (uncooked and cooked) and cookie (walnut and wheat flour) samples. The result showed that the grated cooked walnut had the highest total phenolic and antioxidant values ($ABTS^+$ and DPPH scavenging activities) while the wheat flour cookies had the least. The grated cooked walnut (26.52 mgGAE/g db) possess a significantly ($p \leq 0.05$) higher total phenolic content than the grated uncooked walnut (24.62 mgGAE/g db). This increment may be due to the heat treatment promoting the release of bound phenolic compounds in the food matrix (Lemos et al., 2012). The total phenolic contents, $ABTS^+$ and DPPH scavenging activities of the walnut cookies were 15.42 mgGAE/g db, 4.22μmol TE/g db and 5.52μmol TE/g db respectively and are significantly ($p \leq 0.05$) higher in value than the wheat flour cookies. There exists a direct correlation between the phenolic content and antioxidant activities, higher total phenolic content translates into better and higher antioxidant activity (Lemos et al., 2012; Udedi et al., 2014). The presence of phenolic compounds in walnut has been implicated in several of its biological activities. Walnut reduced damage caused by oxidative stress and improved the level of antioxidants in a mouse model of Alzheimer's disease (Pandareesh, Chauhan, & Chauhan, 2018). These phenolic compounds have also been connected to the metal chelating activity of walnut to protect against neurodegenerative damage (Ayodeji & Aliyu, 2018).

Table 2 Total phenolic contents and antioxidant properties of the cookies, grated uncooked and cooked walnuts

Samples	TPC (mgGAE/g db)	$ABTS^+$ (µmol TE/gdb)	DPPH (µmol TE/gdb)
GUW	$24.62^c \pm 0.4$	$8.21^c \pm 0.5$	$7.82^c \pm 0.3$
GCW	$26.52^d \pm 0.5$	$8.96^c \pm 0.3$	$9.12^d \pm 0.2$
WC	$15.42^b \pm 0.3$	$4.22^b \pm 0.2$	$5.52^b \pm 0.3$
FC	$12.45^a \pm 0.5$	$3.28^a \pm 0.3$	$4.08^a \pm 0.5$

Values are means ± standard deviations of three independent experiment. Values within the same column followed by different letters are significantly different at $p \leq 0.05$.

Keys: GUW- Grated uncooked walnut; GCW- cooked Walnut; WC- Cookies from wheat flour with grated walnut; and FC- Flour cookies (Wheat)

3.3 Total starch, IVPD, insoluble, and soluble dietary fiber of the walnuts and cookies

The results of the total starch content, in-vitro protein digestibility (IVPD), insoluble, soluble, and total dietary fiber of the walnut and cookies samples are presented in Table 3. As expected the wheat flour cookies had the highest total starch (61.48%) followed by the walnut cookies (52.68%). Cooking leads to hydrolysis of starch making it more available hence the higher starch content of the cooked walnut (16.42%) when compared to the uncooked walnut (8.21%).

Table 3 Total starch, in-vitro protein digestibility, insoluble and soluble dietary fiber of the cookies, grated uncooked and cooked walnuts (%)

Samples	Total starch	In-vitro protein digestibility	Insoluble dietary fiber	Soluble dietary fiber
GUW	8.21^{a}±0.2	39.87^{a}±0.2	52.42^{d}±0.6	6.56^{c}±0.3
GCW	16.42^{b}±0.2	51.20^{d}±0.5	48.67^{c}±0.3	7.11^{d}±0.5
WC	52.68^{c}±0.3	42.51^{b}±0.5	17.96^{b}±0.4	3.62^{b}±0.2
FC	61.48^{d}±0.3	48.32^{c}±0.4	16.56^{a}±0.5	2.03^{a}±0.4

Values are means ± standard deviations of three independent experiment. Values within the same column followed by different letters are significantly different at $p \leq 0.05$.

Keys: GUW- Grated uncooked walnut; GCW- Cooked Walnut; WC- Cookies from wheat flour with grated walnut; and FC- Flour cookies (Wheat)

The uncooked and the cooked walnut had IVPD value of 39.87% and 51.20% respectively. The reason for the higher IVPD value in the cooked walnut may be due to the softened seed coats aiding the attack of the peptidase enzymes on the peptide bonds. This is comparable to the report of Manullang et al. (2020) that thermal processing (cooking) improves protein digestibility and consequently its accessibility. IVPD value of the walnut cookies and wheat flour cookies are 42.51% and 48.32% respectively. The reason for a higher IVPD in the wheat flour cookies compared to that of the walnut cookies could be due to polyphenols interaction with the protein. These polyphenols form a cross-linkage with protein blocking some amino-acid residues (Seczyk et al., 2019), thereby limiting the digestibility and accessibility of the protein. IVPD helps to monitor the effect of processing on protein quality and its digestibility. Increased protein digestibility means the release of amino acids some of which are essential for brain function and health.

Insoluble dietary fiber was found to be higher in the uncooked (52.42%) than in cooked walnuts (48.67%), and the soluble dietary fiber was lower in the uncooked (6.56%) than in cooked walnut (7.11%). This could be due to loss of hemicellulose to cooking or solubilization of some structural polysaccharides which are in turn lost to cooking water (Dhingra et al., 2012). Also, the incorporation of walnut into the cookies conferred a significantly higher dietary fiber content (both insoluble and soluble) than the wheat cookie sample. From this result, one can infer that cookies with African walnut may be a better source of total dietary fiber (21.58%) than wheat flour cookies (18.59%), and the composite cassava flour biscuits (3.40) reported by Jisha, Padmaja, & Sajeev, (2010). Dietary fibers are non-digestible, they ferment in the colon to give butyrate, which serves as energy for the brain, and the dietary fiber bulk helps to suppress hunger and reduce food consumption (Burton-Freeman et al., 2017).

3.4 In-vitro starch digestibility (IVSD) of the walnuts and cookie samples

The result of the in-vitro starch digestibility of the samples revealed that hydrolysis increased with increasing time. Almost all the starch present in the grated uncooked and cooked walnuts were hydrolyzed at 180 min. Cookies with grated cooked walnut had the lowest rate of starch hydrolysis, such that at 180 min of hydrolysis, only about 60% of the total starch was hydrolyzed. This may be due to the presence of dietary fiber trapping starch granule thereby limiting its accessibility to a digestive enzyme (Perry & Ying, 2016).

Starch digestibility kinetic parameters (C_∞, K, HI, and EGI) of cookie samples and the reference sample (white bread) are shown in Table 4. Starch digestibility was higher in the cookies than grated walnut (uncooked and cooked). This is because gelatinized starches are prone to digestion by amylase enzymes than ungelatinized ones (Park et al., 2018). Starch digestibility after

180 min was higher in the wheat flour cookies (43.40%) than in walnut cookies (32.99%), due to the higher amount of starch the amylase enzymes were able to digest in the wheat flour cookies.

Table 4 In-vitro starch digestibility kinetic parameters and starch fractions of the grated walnuts, cookies and reference sample

Samples	C_{∞} **(%)**	K **(min** $^{-1}$**)**	**HI (%)**	**EGI**	**RDS (%)**	**SDS (%)**	**RS (%)**
GUW	$10.38^{a}\pm1.3$	$0.01^{a}\pm0.0$	$25.74^{b}\pm0.8$	$26.78^{a}\pm1.2$	$13.88^{a}\pm0.2$	$45.23^{e}\pm0.9$	$40.89^{d}\pm0.4$
GCW	$21.43^{b}\pm1.2$	$0.01^{a}\pm0.0$	$27.09^{a}\pm0.7$	$27.53^{b}\pm1.8$	$15.32^{b}\pm0.3$	$41.74^{d}\pm0.6$	$42.94^{e}\pm0.8$
WC	$32.99^{c}\pm1.5$	$0.02^{a}\pm0.0$	$31.99^{c}\pm0.5$	$38.25^{c}\pm0.7$	$32.83^{c}\pm0.1$	$27.83^{c}\pm0.4$	$39.34^{c}\pm0.7$
FC	$43.40^{d}\pm1.2$	$0.03^{a}\pm0.0$	$48.07^{d}\pm0.6$	$58.30^{d}\pm0.8$	$42.72^{d}\pm0.3$	$20.35^{b}\pm0.5$	$36.93^{b}\pm0.5$
Bread	$99.51^{e}\pm1.5$	$0.04^{a}\pm0.0$	$100.00^{e}\pm1.5$	$94.61^{e}\pm1.2$	$85.19^{e}\pm1.1$	$13.98^{a}\pm0.4$	$0.87^{a}\pm0.0$

Values are means ± standard deviations of three independent experiment. Values within the same column followed by different letters are significantly different at $p \leq 0.05$.

Keys: GUW- Grated uncooked walnut; GCW- Cooked Walnut; WC- Cookies from wheat flour with grated walnut; and FC- Flour cookies (Wheat) C_{∞}- % Starch digested after 180 min, HI- Hydrolysis index, K- Digestibility rate constant, EGI- Estimated glycaemic index, RDS- Rapidly digestible starch, SDS- Slowly digestible starch, and RS- Resistant starch.

The EGI of cookies with grated walnut was lower (38.25) compared to wheat flour cookies (58.30), while EGI of bread was the highest (94.61). The reduction in EGI of the walnut enriched cookies may be attributed to its least amount of starch and high amount of lipids which can interact to form complexes and other forms of interaction that lead to increase in the phenolic compound. The ability of amylose-lipid complexes to inhibit activities of alpha-amylase enzyme is reported by Wang et al. (2020). Also, the ability of phenolic compounds to inhibit the starch digestive enzyme (α-amylase and α-glucosidase) are reported by Chipiti et al. (2015). Phenolic compounds may bind to the active and secondary sites of digestive enzymes, therefore, making them inactive during digestion.

The different starch fractions estimated as rapidly digestible starch (RDS), slowly digestible starch (SDS), and resistant starch (RS) which can be used to understand the in-vivo glucose response of the cookies are shown in Table 4. The SDS and RS of the walnut enriched cookies was higher than the wheat flour cookies, which means that the addition of grated cooked walnut significantly ($p \leq 0.05$) decreased the RDS of cookies. The reference sample (white bread) had the highest RDS and least RS. The low starch hydrolysis rate observed in the walnut enriched cookies correlate with the fact that most of the starch present in the sample is a resistant starch which has nutraceutical benefits.

3.5 Sensory properties of the walnut and flour cookies

In the sensory analysis, the panelists determined how each cookie sample compared with the other on a paired preference test. The numbers of panelists preferring each sample were totaled and tested for significance. The results in Table 5 showed that 16 out of 20 panelists preferred the walnut cookie sample. From the statistical table, the level of probability is required for the result to be considered significant, t-test between both variables gave the value of 0.004 since the value is less than 0.05, it means walnut cookies is significantly (80%) preferred over the wheat flour cookies.

Table 5 Summarized paired preference scores of the walnut and wheat flour cookie samples

Samples	Observation	Mean	Standard deviation	t	Intensity
Walnut cookies	20	0.8	0.410	0.004	80%
Wheat Flour Cookies	20	0.2	0.410		20%

Considering the ranking the walnut cookies for several attributes related to appearance, flavor, mouthfeel, taste and overall quality, the result was subjected to one-sample statistical test and the result was shown in Figure 1. Appearance is a very important parameter in judging the quality of a baked product. The mean score of the appearance of the walnut cookie was 4.75 on a 5- point scale, it is evident that the judges like the appearance of the cookies. The flavor is a criterion that translates the product been liked or disliked, the means of the flavor was 4.35, it is the lowest score observed but still falls in the category of been acceptable like other parameters tested. Some panelists gave an impression of sensing nutty flavor in the cookies. The walnut cookies had a score of 4.85 for mouthfeel, which is also a good score on a 5 point scale. Regarding the taste and the overall quality of the walnut cookies, the panelists found the presence of walnut in the cookies acceptable and therefore gave the parameters the highest (4.95) score. The one-sample binomial test shows no significance between the parameters tested, but due to the lower score of the flavor as compared to other parameters, improvement may be required. The sensory evaluation results showed that functional food such as walnut cookies will be well accepted among consumers.

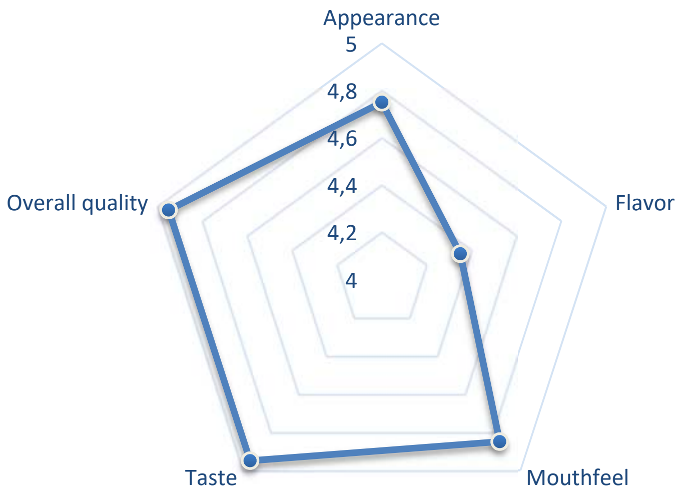

Figure 1 Mean scores of the ranking test for the walnut cookie

4. Conclusions

This study showed that walnut enriched cookies may provide needed nutrients with other potential health-promoting benefits. The high dietary fiber content, low starch hydrolysis rate, polyphenolic content and a considerable amount of protein make walnut enriched cookies a suitable snack, which may help to improve health of consumers. The sensory evaluation results showed that the panelists preferred the walnut cookies to the wheat flour cookies, and the sensory attributes of the walnut cookies were highly scored, indicating its acceptability to the panelists. A healthy cookie such as walnut cookie should be explored as it may also be feasibly cheap for production.

(a) Shredded walnut

(b) cookie dough

(c) Baked cookies

(d) Packed walnut cookies

Plate 1: Picture of the processed walnut, cookie dough and baked cookies

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