



Physicochemical and sensory properties of cookies produced from blends of wheat and defatted African elemi pulp flours

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Abstract

This study determined the physicochemical and sensory properties of cookies produced from blends of wheat and defatted African elemi pulp. The composite flours formulated showed nutritional superiority over the control in terms of ash, protein, calcium, iron, sodium and magnesium. Mean sensory scores of cookies produced from African elemi ranged from 5.55-8.70 colour and taste of the samples ranged from 5.05-8.75, mouthfeel and flavour ranged from 5.15-8.60 and 5.35-8.90 respectively, overall acceptability of the cookies ranged from 5.35-8.74.

Keywords: cookies, defatted African elemi pulp, sensory properties, physicochemical properties

Introduction

Cookies are consumed all over the world as snack food by children and adults. It is a sweet biscuit having a fairly soft, chewy texture and typically containing pieces of chocolate or fruit. It usually contains flour, sugar, egg, and some type of oil, fat, or butter. It may include other ingredients such as raisins, oats, chocolate chips, nuts, etc. They are ready-to-eat, convenient and inexpensive food product, containing digestive and dietary principle of vital importance. Cookies contribute valuable quantities of iron, calcium, protein, calorie, fibre and some of the B-vitamins to our diet and daily food requirement (Ikuomola *et al.*, 2017) [20].

Cookies are important baked product in human diet, which are usually consumed with beverage and also used as weaning foods for infants (Ikuomola *et al.*, 2017) [20]. Cookies had been suggested as a better form of composite food than bread because of its ready to eat nature and relatively long shelf-life. These characteristics make protein-rich cookies attractive in countries where protein energy malnutrition is prevalent and also in areas needing child feeding programs, low income and disaster relief operations. Cookies with high sensory ratings had been produced from blends of wheat and cowpea flours, wheat and soybean flour, wheat and composite flour from wheat and plantain (Ebere *et al.*, 2015) [10]. In trying to improve the quality of cookies, African elemi is blended into flour to supplement wheat.

African elemi (*Canarium schweinfurthii*), also known as bullet pear (English), Ube mgbá (Igbo), Origbo (Yoruba), and Atili (Hausa), is an ever-green Burseraceae tree native to Central and West Africa (Anyaloubu *et al.*, 2020). The plant bears fruit, a drupe that is macerated and the pulp eaten as masticatory in most parts of Nigeria (Anyalogbu *et al.*, 2020) [4]. Maduelosi and Angaye (2015) reported that the fruit is commonly found in large quantity in Pankshin, Plateau State of Nigeria and is also produced in similar quantities in other states of the northern and south-eastern Nigeria. The plant produces its fruits in the rainy season (usually between the months of April and September). The flowers grow in clusters at the end of the twigs and are

small and dark green in colour. The fruits which are of two varieties-long spiral and short round in shape develop from the flowers. The fruits contain single triangular-shaped seed with small projections at the three edges. The seeds are embedded in a purplish green pulp which is oily and edible, with a desirable sweet but not too sugary taste similar to that of avocado pear. It can be eaten raw or softened in warm water to improve palatability. The pulp oil is about 71 % palmitic acid and 18 % oleic acid. The seed-kernel is oily and edible too. They contain several fatty acids including oleic (36 %), linoleic (28 %), palmitic (26 %), stearic (7 %). Whole seeds and pulp of African Elemi have been used as medicinal remedies, as source of vitamin C and as flavour in snacks and non-alcoholic beverages (Maduelosi and Angaye 2015) [24].

The findings of this study would impact on households and eaters who will utilize African elemi flour by employing its flour in the making of cookies and other bakery products, thereby reducing wheat flour importation. This Study will also diversity the use of African elemi for value addition and reduce and at the same time improve on African elemi cultivation and production by farmers. The main objective of this study therefore is to determine the physicochemical and sensory properties of cookies produced from blends of wheat and defatted African elemi pulp.

Materials and Methods

The African elemi (*canarium schweinfurthii*) was purchased from Obolo market, Enugu State while wheat flour (*triticum aestivum*), sugar, baking fat, eggs, milk, salt and baking powder was purchased from mile 3 market in Port Harcourt local government area of Rivers State, Niheria. The chemicals and equipment used was of analytical grade and were obtained from the Biochemistry Laboratory, Department of Food Science and Technology, Rivers State University, Port Harcourt, River State, Nigeria.

1. Preparation of African elemi pulp flour

African elemi pulp flour was processed according to the method described by Monanu *et al* (2014) [25]. The *canarium*

schweinfurthii fruits was macerated (by putting in water bowl, adding sufficient water (55°C) to cover them and the bowl covered) for 30mins. The water was drained off and the fruit pulps scrapped from the stone, sliced thinly with a knife and dried for 48 h in an air circulatory oven at 50°C

(Universal wärmeschrank, UNB 100). The oven-dried samples were grounded in a mill (Kenwood BL357), and was sieved with 0.4mm sieve into flour, ready for use as shown in Fig. 1.0.

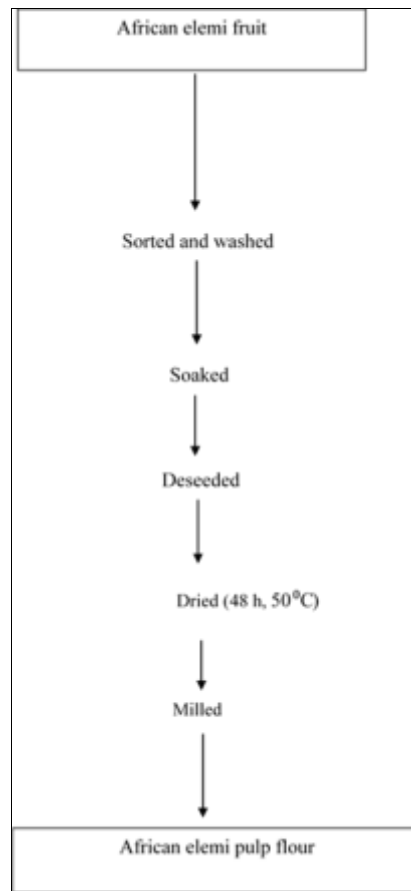


Fig 1: Processing of African eleme pulp flour

2. Sample formulation of composite flour

The flour samples were prepared using wheat flour and African eleme pulp flour in ratios of 100:0, 90:10, 80:20, 70:30, 60:40 to produce composite flour. The composite

flour produced was packaged individually in airtight plastic bags, labelled and stored until it is needed for analysis. One hundred percent (100%) wheat flour was used as control.

Table 1: Formulation of composite flour blends

Samples	Wheat flour	African eleme pulp flour
A	100	0
B	90	10
C	80	20
D	70	30
E	60	40

3. Production of cookies

The essential ingredients for the production of cookies and their various proportions are shown in Table 2.0. Powdered milk, fat, baking powder, salt and sugar were the same for all the proportions. After weighing, the butter was manually mixed vigorously with sugar for 10 min to form cream,

wheat flour and African eleme pulp flour blends at different levels were then added with other ingredients (milk and baking powder). The mixing was properly carried out and the method described by Ikuomola *et al.* (2017) [20] was followed to produce the cookies.

Table 2: Recipe for the production of cookies from blends of wheat and African eleme pulp flour

Sample	Wheat flour (%)	African eleme pulp flour (%)	Butter (g)	Sugar (g)	Egg (g)	Water (ml)	Salt (g)	Flavour (drops)
A	100	0	80	60	1	30	2	4
B	90	10	80	60	1	30	2	4
C	80	20	80	60	1	30	2	4
D	70	30	80	60	1	30	2	4
E	60	40	80	60	1	30	2	4

4. Determination of physical characteristics of wheat-African elemi flour cookies

The weight, diameter, thickness, spread ratio and breaking strength of the cookies was determined according to the method of Ikuomola (2017) [20].

5. Proximate analysis of wheat-African elemi flour cookies

Moisture content, fat, protein, crude fibre, and ash composition of the cookies was determined according to the methods described by AOAC (2012). Carbohydrate content was determined by difference.

6. Pasting properties of wheat-African elemi flour

Pasting properties of the composite flours were measured using a Rapid Visco Analyser (RVA) (Newport Scientific Instruments, Warriewood, Australia), following the standard method described by the manufacturer. Peak viscosity (RVA) peak time (min), peak temperature (°C) trough (RVU), pasting temperature (°C) and final viscosity (RVU), breakdown and setback viscosities (RVU) was read on the instrument. The RVA pasting curve was automatically plotted. The viscosities, temperature and time was expressed centipoise (cP) and measured respectively using the method described by Salami *et al* (2019) [34].

7. Sensory analysis of the cookies

Sensory evaluation of the cookies was carried out according to the method described by Ikuomola (2017) [20]. A panel of twenty members consisting of students of Home Science and Management Department, Rivers State University Port Harcourt. Cookies produced from each flour blend was presented in coded form on white plastic plates to the panellists. The panellists were provided with portable water to rinse their mouth between evaluations. However, a questionnaire describing the quality attributes (colour, taste, flavour, crispiness and overall acceptability) of the cookies was given to each panellist. The panellist assigned scores for each parameter as against the maximum score of 9. Each sensory attribute was rated on a 9-point hedonic scale (1 = dislike extremely and 9 = like extremely).

8. Statistical analysis

The method of Wahua (1999) [39] was used to analyze the data using analysis of variance (ANOVA). All means was separated using Duncan Multiple Ranger Test (DMRT) at 5% probability level ($p > 0.05$) using SPSS version 20.0 software 2011.

Results and Discussions

Table 3: Proximate composition (%) of cookies produced from wheat and defatted African elemi flour blends

Samples	Moisture	Ash	Fat	Crude Protein	Crude fibre	Carbohydrate
A	9.97 ^b ±0.53	1.67 ^b ±0.11	41.62 ^{bc} ±0.54	10.06 ^a ±0.62	10.97 ^a ±1.37	25.71 ^a ±0.82
B	7.97 ^c ±0.53	1.67 ^b ±0.39	38.75 ^c ±1.77	10.94 ^a ±0.62	13.00 ^a ±1.41	27.67 ^a ±0.05
C	9.89 ^b ±0.56	2.65 ^a ±0.28	41.71 ^{bc} ±1.82	7.44 ^b ±0.62	11.22 ^a ±1.10	27.18 ^a ±2.15
D	11.82 ^a ±0.10	2.52 ^a ±0.04	42.25 ^{ab} ±0.35	7.87 ^b ±0.00	10.00 ^a ±0.00	25.54 ^a ±0.42
E	11.22 ^a ±0.04	2.65 ^a ±0.28	41.25 ^{bc} ±0.35	7.00 ^b ±1.24	11.25 ^a ±1.77	26.64 ^a ±3.61
F	9.68 ^b ±0.46	2.55 ^a ±0.57	45.02 ^a ±1.07	7.87 ^b ±0.00	10.94 ^a ±0.71	23.95 ^a ±0.66

Mean values are of duplicate determinations. Mean values within a column with different superscripts are significantly different at ($p < 0.05$).

Keys:

A= 100% wheat flour cookies

B= 90% WF: 10% DAEF cookies

C= 80% WF: 20% DAEF cookies

D= 70% WF: 30% DAEF cookies

E= 60% WF: 40% DAEF cookies

F= 50% WF: 50% DAEF cookies

WF= Wheat Flour

DAEF= Defatted African Elemi Flour

1. Proximate Composition of cookies produced from wheat and defatted African elemi flour blends

Moisture content of the cookies ranged from 7.97% to 11.82% with the lowest value (7.97%) recorded in sample B (90% WF: 10% DAEF cookies) and sample D (70% WF: 30% DAEF cookies) as highest. There was a significant ($p < 0.05$) difference in the moisture content of the cookies. Moisture content of sample A (control sample) was significantly different from samples B, D, and E. The moisture content of the cookies increased with the increase in the ratio of defatted African elemi flour added (except for samples B and F). This increase was reported by Ayo-Omogie and Odekunle (2015) [6] for wheat-cardaba banana flour blend cookies. They reported moisture increase in the composite products resulting from Cardaba banana flour

substitution might be due to higher moisture content of the dough. Bakery products with moisture less than 13% are stable from moisture-dependent deterioration (Ayo-Omogie and Odekunle, 2015) [6]. The moisture content of all the cookies produced (7.97-11.82%) was below this specified moisture content.

There was an increase in the ash content of the cookies with values ranging from 1.67% in samples A and B to 2.65% in samples C and E. Significant ($p < 0.05$) differences existed between the 100% wheat flour and wheat/defatted African elemi flour cookies. Ash content of any food material is an indication of the non-organic compound containing mineral content of the food. The cookies produced from the substitution of wheat with 20-50% defatted African elemi flour had the highest ash content implying that when used as composite flour, it will improve the mineral content of the product. This finding is in correlation with that of Ayo-Omogie and Odekunle (2015) [6] who also reported an increase in ash content of cookies produced from wheat-cardaba banana flour blends (0.52-1.20%) as the substitution with Cardaba banana increased.

Fat content of the cookies ranged from 38.75% in sample B (90% WF: 10% DAEF cookies) to 45.02% in sample F (50% WF: 50% DAEF cookies). There was an increase in the fat content of the cookies as substitution of wheat flour with defatted African elemi flour increased. This trend was also observed by Chinma *et al.* (2012) [9] who reported an increase in fat content of unripe plantain-defatted sesame seed blend (8.95-10.59%) as the substitution with defatted

sesame seed flour increased. Fat plays a significant role in predicting the shelf-life of food products and as such high fat content could be undesirable in baked food products as it promotes rancidity leading to development of unpleasant and odorous compounds (China *et al.*, 2020)^[7].

Protein content of the cookies decreased as substitution of wheat flour with defatted African elemi flour increased. The protein content of the cookies ranged from 7.00% in sample E (60% WF: 40% DAEF cookies) to 10.94% in sample B (90% WF: 10% DAEF cookies). This decrease was also reported by Edima-Nyah and Ukwu (2016)^[11] who reported that decrease in crude protein of cookies was as a result of increase in banana proportion. Ayo-Omogie and Odekunle (2015)^[6] also reported a decrease of wheat-cardaba flour blend cookies from 20.97-12.97% due to increase in substitution of cardaba banana flour. Protein plays a part in the organoleptic properties of the cookies in addition to being a source of amino acids (Usman *et al.*, 2015)^[37].

Crude fibre content of the cookies increased significantly (except for samples D and F) from 10.00% in sample D to 13.00% in sample B. This is in line with the findings of Loza *et al.* (2017) that the addition of banana flour increased

the crude fiber content of wheat flour cookies. Onyekwelu and Ogbu (2017)^[30] also reported an increase in fibre content of wheat, unripe plantain and morning leaf blend cookies from 0.50-2.00% as the substitution with the unripe plantain flour increased. China *et al.* (2020)^[7] also reported an increase from 1.06-2.81%. Increase in fibre content of the cookies suggests that these products will aid digestion thereby preventing constipation (Elleuch *et al.*, 2011)^[15].

There was a decrease in the carbohydrate content of the cookies (except for samples B, C and E) from 23.95% in sample F to 27.67% in sample B. Cookies made from 100% wheat flour have been reported to contain high amount of carbohydrate due to higher amount carbohydrate in wheat flour (Hawa *et al.*, 2018)^[17]. The reduced carbohydrate content in some of the cookies samples (samples D and F) may not favour better production of energy in meeting daily activities, as Ijeh *et al.* (2010)^[18] has reported that high carbohydrate is important as it provides the energy needed to do work; however, low carbohydrate content in diets is also of advantage to for diabetic patients that need very low carbohydrate contents in their diets.

Table 3.1: Mineral composition (mg/100g) of cookies produced from wheat and defatted African elemi flour blends

Samples	Sodium	Zinc	Iron	Calcium	Magnesium
A	395.97 ^c ±1.04	4.98 ^c ±0.02	4.02 ^d ±0.03	44.80 ^d ±0.02	70.32 ^e ±0.14
B	359.76 ^f ±0.62	4.78 ^d ±0.05	3.47 ^e ±0.04	41.92 ^e ±0.05	66.87 ^f ±0.49
C	389.26 ^d ±1.50	5.10 ^a ±0.00	4.42 ^b ±0.03	41.96 ^e ±0.05	91.67 ^d ±0.06
D	382.78 ^e ±0.95	5.57 ^a ±0.03	4.23 ^b ±0.03	76.90 ^b ±0.01	127.82 ^b ±0.42
E	406.76 ^b ±0.62	4.54 ^e ±0.00	4.38 ^e ±0.01	69.20 ^c ±1.01	105.53 ^c ±0.27
F	461.76 ^a ±0.11	5.10 ^b ±0.00	5.07 ^a ±0.04	99.58 ^a ±0.05	153.17 ^a ±0.06

Mean values are of duplicate determinations. Mean values within a column with different superscripts are significantly different at ($p < 0.05$).

Keys:

- A= 100% wheat flour cookies
- B= 90% WF: 10% DAEF cookies
- C= 80% WF: 20% DAEF cookies
- D= 70% WF: 30% DAEF cookies
- E= 60% WF: 40% DAEF cookies
- F= 50% WF: 50% DAEF cookies

2. Mineral composition of cookies produced from wheat and defatted African elemi flour blends

Iron content of the samples ranged from 3.47 mg/100g to 5.07 mg/100g with the lowest value recorded in sample B while sample F had the highest value. There was a significant ($p < 0.05$) increase in the iron content (except for sample B) as the ratio of defatted African elemi flour increased in the blends. Iron content of the wheat/defatted African elemi flour blend cookies is within the range (2.75-3.72%) obtained by Inyang *et al.* (2018)^[21] for cookies prepared from rice, unripe banana and sprouted soybean flour blend. The high iron content in the wheat/defatted African elemi flour blend cookies is good since regular consumption of food rich in iron has the potential to prevent anemia.

Calcium content ranged from 41.92-99.58 mg/100g with sample B having the lowest value while sample F had the highest value. In this study, calcium content of the cookies increased significantly ($p < 0.05$) as the ratio of defatted African elemi flour increased in the blends. The result obtained for calcium is within the range (46.28-62.30%) obtained by Inyang *et al.* (2018)^[21] for cookies prepared from rice, unripe banana and sprouted soybean flour blend.

Calcium consumption is generally very low in most populations considering the recommended values. Calcium is an essential micronutrient in infants and young children for building bones and teeth, functioning of muscles and nerves, blood clotting and for immune defense (Rashida *et al.*, 2014).

Sodium content of the samples ranged from 359.76 mg/100g in sample B to 461.76 mg/100g in sample F. Increase in the proportion of defatted African elemi flour resulted in a significant ($p < 0.05$) increase in the sodium content of the cookies. These results were higher when compared to the values (7.69-10.64 mg/100g) reported by Inyang *et al.* (2018)^[21] for cookies prepared from rice, unripe banana and sprouted soybean flour blends. Sodium is an essential nutrient necessary for the maintenance of plasma volume, acid-base balance and normal cell functions (Verbalis *et al.*, 2016).

Zinc content of the cookies ranged from 4.54-5.57 mg/100g with the lowest value found in sample E while sample D had the highest. Similarly, there was a significant ($p < 0.05$) increase in the zinc content of the cookies (except for samples B and E) as the proportion of defatted African elemi flour increased. Zinc content obtained from this study is slightly higher than the values (1.99-2.95 mg/100g) obtained by Inyang *et al.* (2018)^[21] for cookies prepared from rice, unripe banana and sprouted soybean flour blends. Zinc is an important co-factor for more than 70 enzymes and it plays a central role in cell division, protein synthesis and growth. The deficiency of zinc in complementary foods will result to growth failure, anemia, enlargement of liver and spleen and impairment of skeletal development (Okoye and Egbujie, 2018).

Magnesium content of the samples ranged from 66.87 mg/100g in sample B to 153.17 mg/100g in sample F. There was also a significant ($p < 0.05$) increase in the magnesium content of the cookies as the proportion of defatted African elemi flour increased in the blends. These values were also higher when compared to the values (27.15-34.11 mg/100g) obtained by Inyang *et al.* (2018) [21] for cookies prepared from rice, unripe banana and sprouted soybean flour blends.

Table 3.2: Functional properties of wheat and defatted African elemi flour blends

Samples	Oil absorption capacity (ml/g)	Water absorption capacity (ml/g)	Packed bulk density (g/ml)	Solubility (%)
A	2.19 ^a ±0.28	2.00 ^a ±0.00	0.75 ^a ±0.01	39.09 ^a ±6.07
B	2.00 ^a ±0.00	1.56 ^c ±0.00	0.69 ^b ±0.01	29.51 ^a ±0.15
C	2.19 ^a ±0.28	1.56 ^c ±0.00	0.71 ^{ab} ±0.02	31.87 ^a ±6.60
D	2.00 ^a ±0.00	1.56 ^c ±0.00	0.71 ^{ab} ±0.04	29.80 ^a ±1.70
E	2.20 ^a ±0.28	1.60 ^b ±0.00	0.70 ^{ab} ±0.03	33.70 ^a ±5.52
F	2.19 ^a ±0.28	2.00 ^a ±0.00	0.69 ^b ±0.03	29.20 ^a ±3.11

Mean values are of duplicate determinations. Mean values within a column with different superscripts are significantly different at ($p < 0.05$).

Keys:

A= 100% wheat flour
 B= 90% WF: 10% DAEF
 C= 80% WF: 20% DAEF
 D= 70% WF: 30% DAEF
 E= 60% WF: 40% DAEF
 F= 50% WF: 50% DAEF

3. Functional Properties of Wheat and Defatted African Elemi Flour Blends

Oil absorption capacity (OAC) of the samples ranged from 2.00 ml/g to 2.20 ml/g with samples B and D recording the lowest values (2.00 ml/g) while samples E had the highest value (2.20 m/g). There was no significant ($p < 0.05$) difference in the oil absorption capacity of the flour blends. This indicates that the substitution with defatted African elemi flour had no significant ($p < 0.05$) effect on the oil absorption capacity of the flour blends. Oil absorption capacity is a very important functionality in food formulations such as ground meat, meat replacers and extenders, doughnut, pancakes and soups as it is the ability of flour to retain flavours (Amandikwa *et al.*, 2015). The OAC values obtained from this study were slightly higher than the range of values of 1.59-1.88g/g reported by Orisa

and Udofia (2020) for wheat, acha, cowpea and *Moringa oleifera* leaf powder blends. The result is also higher than the range of values (0.63-1.04g/g) reported for maize/African yam bean flour blends (Anosike *et al.*, 2020). Water absorption capacity of the samples ranged from 1.56 ml/g in samples B, C and D to 2.00 ml/g in samples A and F. There was a significant ($p < 0.05$) decrease in the water absorption capacity of the samples (except for sample F) as the proportion of defatted African elemi flour increased in the blends. This may be attributed to the decrease in protein content. According to Ikpeme-Emmanuel *et al.* (2010), water absorption capacity is determined by the ability of protein in flours to physically bind with water. This explains why water absorption capacity decreased with increased defatted African elemi flour substitution incorporation. The values obtained from this study were higher than those reported by Anosike *et al.* (2020) for maize/African yam bean flour blends (0.67-1.13g/g).

Packed bulk density of the samples ranged from 0.69 g/ml in samples B and F to 0.75 g/ml in sample A. Packed bulk density of the control sample was significantly ($p < 0.05$) different from sample B but not from other samples (C, D, E and F). There was also a decrease in the packed bulk density as the supplementation of wheat flour with defatted African elemi flour increased in the blends. The decrease in bulk density observed from this study could be due to variation in starch content as African elemi flour has low starch content than wheat flour. This trend was also reported by Iwe *et al.* (2016) for rice, African yam bean and brown cowpea seeds composite flour. Bulk density of flours is an indication of their relative volume of packaging material required. According to Udensi and Eke (2000), flours with higher bulk densities are desirable for greater ease of dispersibility and reduction of paste thickness while low bulk densities of flour is advantageous because it contributes to lower dietary bulk, ease of packaging and transportation (Aluge *et al.*, 2016). The result of this study showed that the composite flours have lower bulk density than 100% wheat flour and should be used where such properties are required.

Solubility of the flour blends ranged from 29.20% in sample F to 39.09% in sample A. There was a decrease in the solubility of the flour blends, however this decrease was not significant ($p > 0.05$). Solubility is defined as the ability of flour to dissolve or disperse in an aqueous solution mostly in water (Falade and Okafor, 2015). The solubility from this study was higher than the values of 8.69-16.06% for cooking banana/plantain flour blend as reported by China *et al.* (2019) [8].

Table 3.3: Pasting properties of wheat and defatted African elemi flour blends

Samples	Peak Viscosity (RVU)	Trough Viscosity (RVU)	Breakdown Viscosity (RVU)	Final Viscosity (RVU)	Setback Viscosity (RVU)	Peak time (min)	Pasting temp (°C)
A	202.71 ^a ±5.13	103.96 ^a ±3.13	98.75 ^a ±2.01	225.25 ^a ±4.48	121.29 ^a ±1.36	5.97 ^a ±0.05	94.73 ^a ±0.18
B	157.50 ^b ±1.53	82.34 ^b ±1.18	75.17 ^b ±0.35	167.96 ^b ±1.36	85.63 ^b ±0.18	5.87 ^b ±0.09	94.83 ^a ±0.04
C	144.96 ^b ±3.36	80.09 ^b ±1.29	64.88 ^c ±2.06	142.25 ^b ±1.53	62.17 ^c ±0.23	5.73 ^b ±0.00	94.88 ^a ±0.04
D	127.46 ^c ±11.02	59.67 ^{cd} ±3.77	67.80 ^{bc} ±7.25	100.71 ^d ±7.13	41.05 ^c ±3.36	5.24 ^d ±0.05	93.28 ^a ±0.60
E	125.83 ^c ±3.89	55.13 ^d ±0.64	70.71 ^{bc} ±3.24	84.75 ^c ±2.59	29.63 ^d ±1.94	5.04 ^e ±0.05	70.60 ^c ±0.64
F	124.38 ^c ±1.00	60.71 ^c ±0.53	63.67 ^c ±0.47	109.00 ^d ±1.65	48.29 ^d ±1.12	5.47 ^c ±0.09	94.63 ^b ±0.18

Mean values are of duplicate determinations. Mean values within a column with different superscripts are significantly different at ($p < 0.05$).

Keys:

A= 100% wheat flour
 B= 90% WF: 10% DAEF
 C= 80% WF: 20% DAEF
 D= 70% WF: 30% DAEF
 E= 60% WF: 40% DAEF
 F= 50% WF: 50% DAEF

4. Pasting Properties of Wheat and Defatted African Elemi Flour Blends

Peak viscosity of the flour blends ranged from 124.38 RVU to 202.71 RVU with the lowest value (124.38 RVU) recorded in sample F while sample A had the highest value (202.71 RVU). There was a significant ($p < 0.05$) decrease in the peak viscosity as the supplementation of wheat flour with defatted African elemi flour increased in the blends. Peak viscosity is an indicator of the strength of pastes which are formed from gelatinization during processing in food applications. It also reflects the extent of granule swelling (Eke-Ejiofor and Owuno, 2012). Sanni *et al.* (2004) also reported that peak viscosity is the ability of starches to swell freely before their physical breakdown and it indicates the strength of the pastes formed during gelatinization. According to an earlier report by Orisa and Udofia (2020), it was revealed that higher starch content of flour resulted to higher peak viscosity.

Trough viscosity of the samples ranged from 60.71 RVU to 103.96 RVU with sample F recording the lowest (60.71 RVU) while sample A had the highest value (103.96 RVU). There was also a significant ($p < 0.05$) decrease in the trough viscosity as the ratio of defatted African elemi flour increased in the blends. Trough is the minimum viscosity which measures the ability of paste to withstand breakdown during cooling. High trough viscosity for 100% wheat flour indicates that the flour can withstand high heat treatments during processing; hence the addition of defatted African elemi flour to products can decrease their hold period (trough).

Breakdown viscosity ranged from 63.67 RVU to 98.75 RVU with sample F recording the lowest (63.67 RVU) while sample A had the highest (98.75 RVU). Similarly, there was a significant increase in the breakdown viscosity of the flour blends as the proportion of defatted African elemi flour increased in the blends. The breakdown is

essentially a measure of the degree of paste stability or starch granules disintegration during heating (Oluwalana *et al.*, 2012).

Final viscosity ranged from 84.75 RVU in sample E to 225.2 RVU in sample A. There was also a significant ($p < 0.05$) decrease in the final viscosity of the samples as the proportion of defatted African elemi flour increased in the flour blends. The reduced final viscosity of the flour blends could be attributed to the supplementation with defatted African elemi flour. Egbujie and Okoye (2019) equally reported reduced final viscosity of sorghum based complementary foods as African yam bean were incorporated. Liang and King (2003) stated that final viscosity of flours is important in determining their ability to form gel during processing.

Setback viscosity of the samples ranged from 29.63 RVU to 121.29 RVU with the lowest value (29.63 RVU) recorded in sample E while the highest value (121.29 RVU) was obtained in sample A. There was a significant ($p < 0.05$) increase in the setback viscosity of the flour blends as the proportion of defatted African elemi flour increased in the blends. A high setback viscosity is associated with a cohesive paste while a low value is an indication that the paste is not cohesive (Oduro *et al.*, 2000). The reduction in setback viscosity in other samples is an indication of a low rate of starch degradation and syneresis of the gel. The lower setback viscosity of these samples also indicates its lowest rate of degradation and this will be useful in the prolonged shelf life of the flour.

Peak time of the flour blends ranged from 5.04 min to 5.97 min with the lowest value (5.04 min) recorded in sample E while sample A had the highest (5.97 min). The peak time is usually regarded as an indication of the total time taken for each sample to attain its respective peak viscosity. Therefore, flour blends with a lower peak time will cook faster than that with a higher peak time.

Pasting temperature of the samples ranged from 70.60°C to 94.88°C with sample E recording the lowest value (70.60°C) while sample C had the highest value (94.88°C). The pasting temperature provides an indication of the minimum temperature required to cook a given food sample which can also have implications on energy usage (Ragae and Abdel-Aai, 2006). A high pasting temperature usually indicates that the flour has a high-water absorption capacity.

Table 3.4: Physical properties of cookies produced from wheat and defatted African elemi flour blends

Samples	Height	Diameter	Weight (g)	Spread ratio
A	0.78 ^a ±0.11	3.03 ^a ±0.03	4.48 ^a ±0.93	3.93 ^{ab} ±0.49
B	0.75 ^a ±0.00	3.10 ^a ±0.07	4.87 ^a ±0.71	4.17 ^{ab} ±0.16
C	0.83 ^a ±0.04	3.03 ^a ±0.04	4.70 ^a ±0.56	3.67 ^b ±0.12
D	0.70 ^a ±0.00	3.08 ^a ±0.04	5.19 ^a ±0.71	4.39 ^a ±0.05
E	0.78 ^a ±0.11	3.10 ^a ±0.07	5.41 ^a ±1.01	4.03 ^{ab} ±0.46
F	0.68 ^a ±0.04	3.03 ^a ±0.04	5.18 ^a ±0.04	4.48 ^a ±0.18

Mean values are of duplicate determinations. Mean values within a column with different superscripts are significantly different at ($p < 0.05$).

Keys:

A= 100% wheat flour cookies
 B= 90% WF: 10% DAEF cookies
 C= 80% WF: 20% DAEF cookies
 D= 70% WF: 30% DAEF cookies
 E= 60% WF: 40% DAEF cookies
 F= 50% WF: 50% DAEF cookies

5. Physical Properties of Cookies Produced from wheat and defatted African Elemi Flour Blends

Height of the cookies ranged from 0.68 cm to 0.83 cm with sample F recording the lowest value (0.68 cm) while sample C had the highest value 90.83 cm). There was decrease in the height of the cookies (except for sample C) as the proportion of defatted African elemi flour increased. Diameter of the cookies ranged from 3.03 cm in samples C and F to 3.10 cm in samples B and E. Increase in the ratio of

defatted African elemi flour led to an increase in the diameter of the cookies.

Weight of the cookies ranged from 4.48 g to 5.41 g. The lowest value (4.48 g) was recorded in sample A while sample E had the highest value (5.41 g). There was also an increase in the weight of the cookies as the proportion of defatted African elemi flour increased. However, there was no significant ($p>0.05$) difference in the height, diameter and weight of the cookies. This implies that the supplementation of wheat flour with defatted African elemi flour had no significant ($p>0.05$) effect of these parameters. Spread ratio ranged from 3.67-4.48 with the lowest value (3.67) recorded in sample A while sample F had the highest value (4.48). There was an improvement in the spread ratio

of the cookies as the supplementation of wheat flour with defatted African elemi flour increased. Spread ratio of cookies has long been used as an important characteristic for determining the quality of flour for cookies production. Cookies with higher values of spread ratio are considered to be more desirable than those with lower values (Inyang *et al.*, 2018) [21]. In this study, cookies prepared from higher substitution ratio of defatted African elemi flour (50% substitution) had the highest spread ratio (4.48). Cookies prepared from this blend might have exhibited the lowest viscosity which resulted in the highest spread ratio. Inyang *et al.* (2018) [21] further added in their studies that doughs with lower viscosity cause cookies to spread at faster rate and vice versa.

Table 3.5: Mean sensory scores of cookies produced from wheat and defatted African elemi flour blends

Samples	Colour	Taste	Mouth feel	Flavour	Overall Acceptability
A	8.70 ^a ±0.47	8.75 ^a ±0.55	8.60 ^a ±0.82	8.90 ^a ±0.45	8.74 ^a ±0.32
B	6.70 ^b ±1.81	7.70 ^b ±1.08	7.55 ^{ab} ±1.64	7.55 ^b ±1.64	7.38 ^b ±1.26
C	6.15 ^{bc} ±1.57	6.75 ^c ±1.52	6.95 ^b ±1.61	6.95 ^b ±1.43	6.70 ^b ±1.20
D	6.25 ^{bc} ±1.48	5.80 ^c ±1.40	5.70 ^c ±1.63	5.80 ^c ±1.82	5.89 ^c ±1.23
E	5.55 ^c ±1.82	5.20 ^c ±1.64	5.15 ^c ±2.21	5.50 ^c ±1.67	5.35 ^c ±1.53
F	5.95 ^{bc} ±1.85	5.05 ^c ±1.99	5.40 ^c ±1.16	5.35 ^c ±1.76	5.44 ^c ±1.67

Mean values are of duplicate determinations. Mean values within a column with different superscripts are significantly different at ($p < 0.05$).

Keys:

A= 100% wheat flour cookies

B= 90% WF: 10% DAEF cookies

C= 80% WF: 20% DAEF cookies

D= 70% WF: 30% DAEF cookies

E= 60% WF: 40% DAEF cookies

F= 50% WF: 50% DAEF cookies

6. Sensory Properties of Cookies Produced from Wheat and defatted African Elemi Flour Blends

Colour is a very important parameter in judging properly baked cookies that not only reflect the suitable raw material used for the preparation but also provides information about the formulation and quality of the product (Ojinnaka and Agubolum, 2013). There was a significant ($p<0.05$) decrease in the colour, taste, mouthfeel, flavour and overall acceptability of the cookies as the supplementation of wheat flour with defatted African elemi flour increased. Similar finding was also reported by Chinma *et al.* (2012) [9] for cookies prepared from unripe plantain and defatted sesame flour blends. Ojinnaka and Agubolum (2012) also reported that colour, taste, flavour and overall acceptability of cashew nut-wheat based cookies decreased as the supplementation of wheat flour with cashew nut flour increased. The control sample (100% wheat flour cookies) was highly preferable by the panelists for all sensory attributes. The control sample was not significantly ($p>0.05$) different from sample B (90% WF: 10% DAEF cookies) for mouth feel. Samples containing 10 and 20% defatted African elemi flour were also accepted by the panelists as they scored above the average (>6.0) for all sensory parameters. The sensory evaluations result therefore indicates that defatted African elemi flour could be incorporated up to 80:20% ratios in the preparation of cookies without affecting the sensory properties of the cookies.

Conclusion and Recommendation

This study indicates that cookies produced from wheat and defatted African elemi flour blends contained sufficient percentage of protein, fat, and crude fibre. Increased in the supplementation of wheat flour with defatted African elemi flour resulted in an improvement in the ash and crude fibre content of the resultant cookies. The control sample was highly preferred by the panelists, however, samples substituted with 10 and 20% defatted African elemi flour scored above the average (<6.0) for all sensory attributes indicating that defatted African elemi flour could be incorporated up to 80:20% ratios in the preparation of cookies without affecting the sensory properties of the cookies. The use of defatted African elemi flour at levels not exceeding 20% is recommended for the production of acceptable and nutritious cookies.

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