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Chemical Composition and Sensory Properties of Wheat-African Yam Bean Composite Flour Cookies

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Abstract

The proximate composition, mineral content and sensory properties of wheat – African yam bean composite cookies were determined. African yam bean flour (AYBF) was prepared and used at varying replacement levels (10-50%) for wheat flour (WF) in the preparation of wheat-African yam bean cookies. The increase in African yam bean flour substitution resulted in increase in the protein, fat, ash and crude fibre contents of the composite cookies. The protein, fat, ash and crude fibre contents of the cookies ranged from 9.87 ± 0.02-13.06 ± 0.10 %, 3.84 ± 0.03 – 4.63 ± 007 %, 4.84 ± 0.03 – 5.21 ± 0.06 % and 3.84 ± 0.03 – 4.22 ± 0.04 %, respectively. The control (wheat flour cookies) and the cookie samples substituted with 50% African yam bean flour had the least and highest values. The carbohydrate content of the cookies ranged from 67.69 ± 0.11 to 72.86 ± 0.06 % with the control having the highest value compared to the samples substituted with African yam bean flour. The mineral content of the cookies showed that the calcium, potassium, phosphorus, magnesium and iron contents of the samples increased significantly with increasing substitution of African yam bean flour. The sensory properties of the samples also revealed that the cookies made with 100% wheat flour used as control were the most acceptable by the panelists and also differed significantly ($p \leq 0.05$) from the other samples in taste, flavour and texture. However, the cookie samples substituted with 50% African yam bean flour were rated highest (6.86± 0.06) in colour. The nutrient composition and sensory properties of wheat-African yam bean cookies observed showed that African yam bean flour could be used as a partial substitute for wheat flour at the levels of 10 to 50%, thus providing an alternative means of diversifying the use of non-wheat flour.

Keywords: African Yam bean, cookies, proximate composition, mineral content, sensory properties.

INTRODUCTION

The high cost of animal protein has directed interest towards several leguminous seed proteins as potential sources of vegetable protein for human food and livestock feed. Legumes or pulses are good sources of protein in human and animal food and are protein complements to cereals (Onimaivo and Asugo, 2004). They are relatively richer in protein than the cereal grains and many diets formulated from legume-cereal mixtures are known to be nearly completed in essential amino-acid content (Okaka *et al.,* 2006). The complementary role of legume protein and increased cost of animal protein for human food has made legumes important as alternative and cheap sources of dietary protein in human nutrition. Among the plant species, grain legumes are considered as the major source of dietary proteins. They are consumed worldwide, especially in developing and under developed countries where the consumption of animal protein may be limited as a result of economic, social, cultural or religious factors (Enwere, 1998; Eke, 2002). However, the use of legumes as protein source is limited by the presence of anti-nutrients which interfere with digestive processes and prevent efficient utilization of their proteins. Some of the anti-nutrients present in legumes are protease inhibitors, heamagglutinins, saponins, oxalates, phytates and flatulence factors (Udensi *et al.,* 2010; Ojokoh *et al.,* 2013). To improve the nutritional quality and organoleptic acceptability of leguminous seeds, processing techniques such as soaking in water, boiling at high temperatures in water, alkaline or acidic solutions, germination, autoclaving, roasting, dehulling, microwave treatment, steam blanching and fermentation have been employed to reduce or destroy the anti-nutrients present in them. (Ugwu and Okaka, 2008; Nzelu, 2008). African yam bean (*Sphenostylis stenocarpa*) is one of the lesser known and underutilized legumes that is very rich in protein, carbohydrate, vitamins and minerals (Wokoma and Aziagba, 2001). The protein of African yam bean is made up of over 32 percent essential amino acids, with lysine and leucine being predominant. African yam bean seeds can be roasted and eaten with palm kernel as snacks or boiled and eaten with local seasoning, starchy root crops and fruits (Eneche, 2006). African yam bean seeds can be also processed into flour which can be used for the production of bakery and confectionary products such as breads, biscuits, cookies, doughnuts, pie crust and cakes.

Cookies (soft type biscuits) are one of the bakery products that are widely accepted and consumed in many developed and developing countries of the world (Giami *et al.,* 2004). African yam bean flour can be used in composite with other flours from cereals, legumes, nuts or root and tuber crops for the preparation of baked and confectionary products. Composite flour is a mixture of different flours from roots and tubers, legumes, cereals or other raw materials that is created to satisfy specific functional characteristics and nutrient composition. However, the term may mean mixing of different flours from cereals, legumes or root and tuber crops into a composite with wheat for the preparation of baked and fried products like breads, cookies, doughnuts, pie crust, burns and chin-chin. FAO (1990) reported that the substitution of wheat flour with 20 percent non-wheat flour for the manufacture of bakery products would result in an estimated savings in foreign exchange of twenty million US dollars for developing countries of the world. The utilization of non-conventional flours, such as, African yam bean flour in the production of baked products can serve as an alternative means of diversifying the use of non-wheat flour because it has the potential to increase farmer's income by adding value to the products, increase the protein intake of the consumers of the products, reduce wheat importation and support food diversification and security. The objective of this study, therefore, is to determine the proximate composition, mineral content and sensory properties of wheat/ African yam bean composite flour cookies.

MATERIALS AND METHODS

The African yam bean seeds *(Sphenostylis stenocarpa)* used for the study were purchased from Ogbete Market Enugu, Enugu State, Nigeria. Commercial wheat flour and the other ingredients (fat, sugar, baking power, salt, eggs and flavouring) used for cookie production were also purchased from the same market.

Preparation of Germinated African Yam Bean Flour

The germinated African yam bean flour was prepared according to the method of Eke (2002). During preparation, one kilogramme (1kg) of African yam bean seeds which were free from dirt and other foreign particles such as stones, sticks and leaves were thoroughly cleaned and soaked in 3 litres of potable water at room temperature (30 ± 2^{0}C) for 48 h with occasional change of soak water at intervals of 8 h to prevent microbial fermentation. The soaked seeds were drained, rinsed and spread on wet jute bag and allowed to sprout at ambient temperature for 96 h. During this period, the seeds were sprinkled with water at intervals of 6 h to facilitate germination. The growth of the sprouted seeds was terminated by drying the seeds in a hot air oven (Model 10-D1390) at 60^{0}C for 24 h with occasional stirring of the seeds at intervals of 30 min to ensure uniform drying. The dried seeds were cleaned manually and rubbed in between palms to remove the sprouts and the hulls. The dehulled seeds were milled in a locally fabricated attrition mill and sieved through a 400 micron mesh sieve. The flour produced was packaged in an airtight plastic container, labeled and stored in a freezer until needed for further use.

Flour Blend Formulation

Wheat flour (WF) was blended with African yam bean (AYBF) in the ratios of 90:10, 80:20, 70:30, 60:40 and 50:50 in a Kenwood mixer (Model Nx908G, Kenwood, Britain, UK) to produce wheat-African yam bean composite flours. The composite flours produced were packaged individually in an airtight plastic container, labeled and stored at room temperature (30±2^{0}C) until needed for cookie production.

Preparation of Cookies

The cookies were prepared according to the method of Okpala and Okoli (2011). The recipe used for the preparation of cookies contained 100% flour, 40% sugar, 80% fat, 2% baking powder, 2% salt, 5% beaten egg and 5% vanilla flavour. During preparation, the flour, sugar, baking powder and salt were hand mixed in a plastic bowl. This was followed by the addition of fat and further mixing by hand until a bread crumb-like mixture was obtained. The mixture was transferred into the food processor (Homeluck). The beaten egg and vanilla flavour were then added and the mixture was mixed thoroughly at medium speed for 5 minutes to obtain the dough. The dough was manually rolled out on a flat and smooth floured board into sheets of uniform thickness of 4cm and cut with a circular cookie cutter with diameter of 4cm. The cut doughs were transferred into baking trays lined with grease – proof paper and baked at 180^{0}C for 20 min in a domestic oven (Camara, Italy). Thereafter, the cookies were cooled at room temperature (30±2^{0}C) and divided into two (2) lots. The first lot was subjected to sensory evaluation after 24 h. The second lot was milled and used for chemical analyses. In addition, the cookies made with 100% wheat flour were similarly prepared and used as control.

Chemical Analysis

The moisture, crude protein, fat, ash and crude fibre contents of the cookies were determined in triplicate according to standard analytical methods (AOAC, 2006). Carbohydrate was obtained by difference of moisture, protein, fat and ash from 100% (Onwuka, 2005). The potassium and iron contents of the cookies were determined after ashing by the use of a flame photometer (Model 405, Corning, UK) according to the method of Ndie *et al.* (2010). The calcium and magnesium contents of the samples were determined using atomic absorption spectrophotometer (Perkin-Elmer, Model 1033, Norwalk, CT, USA) according to the method of AOAC (2006). Phosphorus was determined by the vanadomolybdate colorimetric method of Giami (2005).

Sensory Analysis

Semi-trained consumer taste panelists comprising of twenty (20) staff and students selected from the University Community were used to evaluate the sensory attributes of the cookies. During the sensory test, the cookies were individually coded and served in white ceramic plates of uniform sizes to the panelists at room temperature (30±2^{0}C) with cold water for rinsing. The panelists were asked to taste, assess and rate the samples for attributes of crust colour, taste, flavour, texture and overall acceptability using a nine-point Hedonic scale with 1 and 9 representing dislike extremely and like extremely, respectively (Okaka, 2010).

Statistical Analysis

The data generated were analyzed statistically by the use of analysis of variance (ANOVA) and difference between means separated. A completely randomized block design was used in this experiment. SPSS software (Version 16.0) was used to determine significant differences ($p \leq 0.05$) among the sample means. Significant means were separated using Duncan's New Multiple Range Test (DNMRT).

RESULTS AND DISCUSSION

Proximate Composition

Table 1 shows the proximate composition of wheat – African yam bean composite cookies. The moisture content was between 8.59-941% for the control sample (wheat flour cookies) and cookie samples with 50% African yam bean flour

Table 1. Proximate composition (%) of wheat-African yam bean composite cookies.

Samples	Moisture	Crude Protein	Fat	Ash	Crude Fibre	Carbohydrate
A	$8.59^{f}\pm0.04$	$9.87^{f}\pm0.02$	$3.84^{f}\pm0.03$	$4.84^{f}\pm0.03$	$3.84^{e}\pm0.03$	$72.86^{a}\pm0.06$
B	$8.65^{e}\pm0.01$	$10.56^{e}\pm0.05$	$4.32^{e}\pm0.08$	$4.89^{e}\pm0.10$	$3.95^{d}\pm0.04$	$71.56^{b}\pm0.04$
C	$9.21^{d}\pm0.02$	$11.29^{d}\pm0.05$	$4.41^{d}\pm0.02$	$4.93^{d}\pm0.06$	$4.01^{c}\pm0.04$	$70.17^{c}\pm0.05$
D	$9.27^{c}\pm0.02$	$11.89^{c}\pm0.04$	$4.47^{c}\pm0.01$	$5.00^{c}\pm0.03$	$4.13^{b}\pm0.01$	$69.37^{d}\pm0.09$
E	$9.35^{b}\pm0.04$	$12.26^{b}\pm0.06$	$4.54^{b}\pm0.05$	$5.14^{b}\pm0.04$	$4.17^{b}\pm0.02$	$68.72^{e}\pm0.07$
F	$9.41^{a}\pm0.03$	$13.06^{a}\pm0.10$	$4.63^{a}\pm0.07$	$5.21^{a}\pm0.06$	$4.22^{a}\pm0.04$	$67.69^{f}\pm0.11$

Values are mean ± standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly different ($p\leq0.05$).
A – Cookies made with 100% wheat flour, B – Cookies made with 90% wheat flour and 10% African yam bean flour, C – Cookies made with 80% wheat flour and 20% African yam bean flour, D – Cookies made with 70% wheat flour and 30% African yam bean flour, E- Cookies made with 60% wheat flour and 40% African yam bean flour, F – Cookies made with 50% wheat flour and 50% African yam bean flour.

substitution. The moisture content of the wheat flour cookies was significantly the lowest. This could be due to low moisture and water absorption capacity (13.52 and 58.02%) of wheat flour (Deshmukh and Yenag, 2016) as compared with that of African yam bean flour (13.94 and 86.42%, respectively) (Eke, 2002). The moisture content of wheat-African yam bean composite cookies was comparable with reports on moisture contents of cookies and moisture contents above 10% are likely to cause the spoilage of the products through increased microbial action (Okpala *et al.*, 2013, Barber and Obinna- Echem, 2016).

The protein content of wheat flour cookies (control samples) was the lowest, while those with African yam bean flour substitutions had higher protein contents. This showed that the addition of African yam bean flour resulted in increase in the protein content of the cookies. This observation is not in doubt because African yam bean had been reported to be a good source of protein (Uguru and Madukaife, 2001; Adeparusi, 2001; Okoye *et al.,* 2015). There has been similar report on the increase in protein content of bakery products substituted with pigeon pea flour (Eneche, 2006). The fat content of the cookies increased as the proportion of African yam bean flour increased. This observation is in line with reports that African yam bean has high oil content (Obatolu, *et al*., 2007; Onwuka *et al.,* 2009; Nwosu, 2013). The ash content of the control samples (100% wheat flour cookies) was the least, while those substituted with African yam bean flour had higher ash contents. This signified that the addition of African yam bean flour resulted in increase in the ash content of the cookies. The high ash content of the samples with African yam bean flour substitutions is an indication that African yam bean is a rich source of ash (Ojukwu *et al.,* 2012). The fibre content of the cookies ranged from 3.84 to 4.22%. The values obtained in this study were within the recommended FAO/WHO (1994) level of not more than 5% for both children and adults. The carbohydrate contents of all the test cookie samples were lower than the control. Okaka *et al*. (2009) reported a decrease in carbohydrate content of biscuits with increasing substitution of brown bean flour. The substitution of wheat flour with African yam bean flour in the production of cookies greatly improve their protein, fat, ash and fibre contents.

Mineral Composition

Table 2 shows the mineral content of wheat – African yam bean cookies. The calcium content of the wheat flour cookies was the least, while those with African yam bean flour substitutions had higher calcium contents. This revealed that the calcium content of the samples increased as the proportion of African yam bean flour increased. The observation is in agreement with the report that African yam bean is a rich source of calcium (Uguru and Madukaife, 2001). The potassium content of the samples increased as the level of substitution of the cookies with African yam bean flour increased. This is in line with the report that African yam bean has high potassium content (Eke, 2002; Asoiro and Ani, 2011). The phosphorus content of the cookies which ranged from 3.38 to 4.13mg/100g increased significantly ($p\leq0.05$) as the level of inclusion of African yam bean in the products increased. There has been similar report on the increase in phosphorus content of biscuits substituted with bambara groundnut flour (Otunola *et al*., 2004). The iron content of the wheat flour cookies was the lowest, while the iron content of the cookie samples substituted with African yam bean flour increased as the proportion of African yam bean flour increased. This observed increase in the iron

Table 2. Mineral content of wheat – African yam bean composite cookies.

Samples	Calcium (mg/100g)	Potassium (mg/100g)	Phosphorus (mg/100g)	Iron (mg/100g)	Magnesium (mg/100g)
A	$10.28^{f}\pm0.05$	$4.22^{f}\pm0.03$	$3.38^{e}\pm0.04$	$3.77^{f}\pm0.07$	$3.55^{f}\pm0.05$
B	$10.37^{e}\pm0.07$	$4.40^{e}\pm0.03$	$3.56^{d}\pm0.06$	$3.91^{e}\pm0.09$	$3.70^{e}\pm0.04$
C	$10.72^{a}\pm0.09$	$4.61^{d}\pm0.04$	$3.88^{c}\pm0.08$	$4.01^{d}\pm0.04$	$3.78^{d}\pm0.04$
D	$11.24^{c}\pm0.04$	$4.89^{c}\pm0.05$	$4.04^{b}\pm0.03$	$4.08^{c}\pm0.03$	$3.95^{c}\pm0.04$
E	$11.40^{b}\pm0.05$	$5.01^{b}\pm0.04$	$4.09^{a}\pm0.02$	$4.14^{b}\pm0.05$	$4.05^{b}\pm0.03$
F	$11.65^{a}\pm0.06$	$5.08^{a}\pm0.03$	$4.13^{a}\pm0.01$	$4.14^{b}\pm0.05$	$4.11^{a}\pm0.01$

Values are mean ± standard deviation of triplicate determinations. Means in the same column with different superscripts are significantly different ($p\leq0.05$).
A – Cookies made with 100% wheat flour, B – Cookies made with 90% wheat flour and 10% African yam bean flour, C – Cookies made with 80% wheat flour and 20% African yam bean flour, D – Cookies made with 70% wheat flour and 30% African yam bean flour, E- Cookies made with 60% wheat flour and 40% African yam bean flour, F – Cookies made with 50% wheat flour and 50% African yam bean flour.

Table 3. Sensory properties of wheat – African yam bean composite cookies

Samples	Colour	Flavor	Taste	Texture	Overall acceptability
A	$6.35^{e}\pm0.05$	$7.35^{a}\pm0.08$	$7.10^{a}\pm0.14$	$7.55^{a}\pm0.08$	$7.75^{a}\pm0.09$
B	$6.45^{d}\pm0.07$	$6.50^{b}\pm0.10$	$6.65^{b}\pm0.11$	$6.70^{b}\pm0.07$	$7.36^{b}\pm0.08$
C	$6.65^{c}\pm0.11$	$6.35^{c}\pm0.05$	$6.55^{c}\pm0.10$	$6.65^{c}\pm0.11$	$6.85^{c}\pm0.06$
D	$6.68^{c}\pm0.10$	$6.36^{c}\pm0.05$	$6.40^{d}\pm0.14$	$6.55^{d}\pm0.10$	$6.75^{d}\pm0.07$
E	$6.75^{b}\pm0.07$	$6.32^{c}\pm0.06$	$6.30^{e}\pm0.06$	$6.45^{e}\pm0.07$	$6.65^{e}\pm0.11$
F	$6.86^{a}\pm0.06$	$6.26^{d}\pm0.05$	$6.25^{f}\pm0.05$	$6.35^{f}\pm0.05$	$6.50^{f}\pm0.10$

Values are mean ± standard deviation of twenty (20) semi-trained judges. Mean in the same column with different superscripts are significantly different ($p\leq0.05$).
A – Cookies made with 100% wheat flour, B – Cookies made with 90% wheat flour and 10% African yam bean flour, C – Cookies made with 80% wheat flour and 20% African yam bean flour, D – Cookies made with 70% wheat flour and 30% African yam bean flour, E- Cookies made with 60% wheat flour and 40% African yam bean flour, F – Cookies made with 50% wheat flour and 50% African yam bean flour.

content of the cookies is an indication that African yam bean is a rich source of iron (Oshodi *et al*., 1995). The magnesium content of the samples increased significantly ($p\leq0.05$) as the proportion of African yam bean flour increased. This showed that African yam bean has high magnesium content (Eke, 2002). In effect, the use of wheat – African yam bean composite flours in the preparation of cookies had greater effect in enhancing their mineral contents.

Sensory Properties

Table 3 shows the sensory properties of wheat – African yam bean cookies. The wheat flour cookies used as control were rated significantly ($p\leq0.05$) higher than the test cookie samples with 10 to 40% African yam bean flour substitutions for the attributes of taste, texture, flavour and overall acceptability. The cookie samples with 50% African yam bean flour substitution were significantly ($p\leq0.05$) different from the control in colour. This showed that the level of likeness of the cookies reduced gradually with improvement in colour as substitution with African yam bean flour increased when compared with the traditional wheat flour cookies. The substitution of wheat flour with African yam bean flour in the production of cookies at a level up to 50% produced good and acceptable results.

Conclusion

The proximate composition and the mineral content of the wheat – African yam bean cookies investigated in this study showed that African yam bean flour can be used successfully as a partial substitute for wheat flour in the production of cookies at the levels of 10 to 50%. The test cookie samples with African yam bean flour substitutions generally had higher protein, ash, fibre and mineral contents than the wheat flour cookies. The cookies substituted with 50% African yam bean flour were the most preferable in terms of colour, while the control (wheat flour cookies) was rated higher than the rest of the cookies in flavour, texture, taste and overall acceptability. However, further studies should be done to determine the vitamin and amino acid profiles, nutritional quality and the storage stability of the wheat – African yam bean composite cookies.

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