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Functional Properties, Nutritional and Sensory Qualities of Wheat Biscuit Fortified with Defatted *Dioclea reflexa* Seed Flours

[1]Akoja, S.S. and [1*]Coker, O. J
[1]Department of Food Technology, The Federal Polytechnic Ilaro, Ogun State Nigeria
**Corresponding Author: Coker, O.J*

Abstract: *Dioclea reflexa was processed into flour and used to supplement wheat flour in the percentages of 0, 2.5, 5, 7.5, 10, 12.5 and 15 for biscuit production. Flour blends were evaluated for functional and pasting characteristics, while biscuits were analysed for proximate composition and sensory qualities. Proximate analysis results showed significant (p≤0.05) increase in protein (9.83 – 13.85%), fat (3.86 – 4.72%), fiber (2.03 - 3.84%), while moisture (10.43 -9.83%) and carbohydrate (70.49-60.95) content decreased with inclusion of Dioclea reflexa. No significant differences (p≥0.05) occurred in the sensory qualities of products from 100% wheat and 92.5: 7.5 flour blend. Hence acceptable biscuit from 92.5: 7.5 (wheat: Dioclea reflexa) blend have been formulated, which could enhance the nutritional wellness of the target consumers.*
Keywords: *Dioclea reflexa, Wheat flour, Proximate Composition, Functional Properties, Sensory Evaluations.*

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I. Introduction

Biscuit is a small thin crispy cake made from unleavened dough. Biscuits have been suggested as a better use of composite flour than bread due to their ready to eat form, wide consumption, relatively long shelf life, and good eating quality [1]. It is produced from a mixture of flour and water which contain fat, sugar and other ingredients mixed together into dough which is rested for a period and passed between rollers to make a sheet [2]. It provides an excellent means of improving the nutritional quality of foods through incorporation of less expensive high quality protein, minerals, vitamins and has been employed in food product enrichment [3]. The consumption of which is steady and increasing in Nigeria. It is however, relatively expensive, being made from imported wheat that is not cultivated in the tropics for climatic reasons. Wheat importation represents an immense drain on the economy, while also suppressing and displacing indigenous cereals, with a resultant detrimental effect on agricultural and technological development.

The need for strategic development and use of inexpensive local resources in the production of popular foods such as biscuits has been recognized by organizations such as the Food and Agricultural Organization [4], the International Institute for Tropical Agriculture (IITA), Nigeria and the Federal Institute for Industrial Research, Oshodi (FIIRO) Nigeria. The use of composite flour has been encouraged since it reduces importation of wheat

Supplementation of cereal-based food with legume for the production of bakery product to improve their nutrient quality has been reported [5], [6], [7], [8]. These works showed that composite flour produced bakery products that were higher in nutrient quality compared with the 100% wheat products. This is because legume protein is high in lysine; an essential limiting amino acid in most cereals. Cereals on the other hand are high in methionine and cystine which are deficient in legumes [4]. Therefore, blending legume with cereals will provide desirable protein pattern that would help to enhance nutritional status of the population. Moreover, the high mineral and vitamin content of these food crops are responsible for the increased nutritive quality of the supplemented products [9], [10]. In particular, the functional properties of composite flour have been found to be suitable for the production of bakery products [11], [12], [8].

The major problem facing the bakery industry in sub-Saharan Africa is the total dependence on importation of wheat to sustain its production. It is therefore imperative that alternatives to wheat which is traditionally used for bakery products be developed either as an extension or a replacement.

Dioclea reflexa (DR) called marble vine is a legume belonging to the sub-family *papilionoideae* is grown in the tropics. *Dioclea reflexa,* with its protein content which range between 15 and 30% [13], [14] is highly desirable as a protein supplement to cereal-based diets. The desired spice elements is the seed and the powdered cotyledon is used in preparing a special soup which is valued because of its delicious aroma and sharp taste that increases appetite [13].

There is no available report in the literature on the use of composite flour produced from *Dioclea reflexa* and wheat flour for the production of bakery products. Incorporation of protein rich marble vine seed flour in biscuit production will increase the nutritional quality of the baked product.

The aim of this work was to produce and evaluate the functional, pasting, nutritional and sensory qualities of wheat based biscuit supplemented with *Dioclea reflexa* seed flour.

II. Materials and Methods

Matured dried *Dioclea reflexa* seeds were purchased from Sayedero, a local market in Ilaro, Ogun State, Nigeria. Other ingredients such as wheat flour, margarine, sugar, eggs and baking powder were bought from Sango-Ota main market, Ogun State Nigeria.

2.1 Preparation of samples

Dioclea reflexa flour was produced as described by [13], the seeds of *Dioclea reflexa* were split into two, the hard husks were removed and the seed pulverized. The flour was defatted using n – hexane.

2.2 Formulation and Production of Biscuits with *Dioclea reflexa*

Wheat flour and *Dioclea reflexa* were mixed at different proportions to obtain various flour preparations as in table 1.

The recipe used to produce the composite biscuit is shown in Table 2. Seven blends from a mixture of wheat flour and *Dioclea reflexa* seed flour were mixed separately with the same quantity of other ingredients. The fat was creamed with sugar until fluffy, the other dry ingredients were added, and water was added to obtain the desired dough and the dough was vigorously kneaded with a dough mixer for 30min [16]. The dough was placed on a flat rolling table and kneaded lightly for 5min as to acquire the required thickness. It was cut into round shapes with the aid of a manual biscuit cutter. The cut doughs were arranged on greased trays and baked in the oven at 200^{o}C for 10minutes. The hot baked biscuits were allowed to cool for 15mins and packaged in polyethylene bags, sealed and stored in air tight container for further analysis.

2.3 Determination of Functional Properties of Wheat–*Dioclea reflexa* Flour Blends

2.3.1 Bulk Density

The bulk density of wheat–*Dioclea reflexa* flour blends was determined using a standard laboratory method [17]. Sample blends were weighed (7 g) into a 50 ml graduated measuring cylinder. The cylinder was tapped gently against the palm of the hand until a constant volume was obtained. Bulk density was calculated as:

$$\text{Bulk density (g/ml)} = \frac{\text{Weight of sample}}{\text{Volume of sample after tapping}}$$

2.3.2 Water Absorption Capacity and Oil Absorption Capacity

Water Absorption Capacity (WAC) and Oil Absorption Capacity (OAC) were determined using the method reported by [18]. Exactly10 ml of distilled water for WAC and 10 ml of edible oil for OAC were mixed with 1g of flour each and blended for 30 seconds. The samples were allowed to stand for 30 minutes and centrifuged at 1300rpm for another 30 min at room temperature (27 ± 2°C). The supernatant was decanted. The weight of water or oil absorbed by the flour was calculated and expressed as percentage WAC or OAC.

2.3.3 Swelling Capacity

This was determined by using the method reported by [19]. Flour samples (10g) were placed in a washed, dried and weighed graduated measuring cylinder. Distilled water (100 ml) was added, stirred and allowed to stand for 1 hour. The supernatant was discarded and the cylinder with its content was weighed to obtain the weight of the net sample.

The swelling capacity was calculated as:

$$Swelling\ Capacity\ (\%) = \frac{Final\ volume - Initial\ Volume}{Initial\ Volume} \times 100$$

2.3.4 Dispersibility

The method reported by [20] was used. Exactly 10 g of flour was suspended in a 100 ml measuring cylinder and distilled water was added to reach a volume of 100 ml. The set-up was stirred vigorously and allowed to settle for three hours. The volume of settled particles was recorded and subtracted from 100. The difference was reported as percentage dispersion.

2.3.5 Emulsification Capacity and Stability

Emulsification capacity (EC) was determined using the method described by [21]. Flour sample (2 g) was blended with 25 ml distilled water at room temperature for 30 seconds in a warring blender at 1,600 rpm. After complete dispersion, 25 ml vegetable oil was added gradually. The blending continued for another 30 seconds and the emulsion was transferred to a centrifuge tube and centrifuged at 1,600 rpm for 5 minutes. The volume of oil separated from the sample after centrifuging was read directly from the tube. Emulsion capacity was expressed as the amount of oil emulsified and held per gram of sample. The emulsion stability was estimated after heating the emulsion contained in calibrated centrifuge tube at 80 % for 30 minute. The emulsion stability expressed as percentage and was calculated as the ratio to the height of emulsified layer to the total height of the mixture

2.3.6 Foaming capacity and foam stability

Foaming capacity (FC) was determined by the method of [22]. A weighed sample (250 mg) was mixed with 250 ml distilled water and the pH adjusted to 2, 4, 6, 8, and 10. This solution was whipped for 3 minutes in a stainless GS Blender (model 38 BL45, Dynamic Corporation, Auburn Hills, MI, USA). The whipped solution was then poured into a 100 ml graduated cylinder. The total sample volume was taken at 0 minutes for foam capacity and at 10 minutes intervals, up to 60 minutes for foam stability. Foam capacity and foam stability were then calculated thus:

$$Foam\ Capacity\ (FC)\% = \frac{(volume\ after\ whipping - volume\ before\ whipping)ml}{(volume\ before\ whipping)ml} \times 100$$

$$Foam\ Stability\ (FS)\% = \frac{(volume\ after\ standing - volume\ before\ whipping)ml}{(volume\ before\ whipping)ml} \times 100$$

2.3.7 Gelation Temperature

Gelation temperature was determined by the method described by [23]. One gram flour sample was weighed accurately in triplicate and transferred to 20ml screw capped tubes. Ten ml of water was added to each sample. The samples were heated slowly in water bath until they formed a gel. At complete gel formation, the respective temperature was measured and taken as gelatinization temperature.

2.4 Pasting Characteristic

The pasting characteristics were determined by using Rapid Visco-Analyzer (RVA) (model 3D RVA, Newport Scientific Pvt. Ltd, Narrabeen, Australia). A suspension of 4 g (14% wet basis) sample in 25 ml was made of distilled water the RVA can and inserted into the tower, which was lowered into the system. The suspension was heated from 50 to 95°C and then cooled back to 50°C within 12 minutes, rotating the can at a speed of 160 rpm with continuous stirring of the contents with a plastic paddle. Parameters determined were peak viscosity, trough, breakdown, setback, final viscosity, peak time and pasting temperature.

2.5 Determination of Proximate Composition of wheat-*Dioclea reflexa* Biscuits

Moisture, ash, fat, protein, and fiber contents were determined using the official methods [17]. Carbohydrate was determined by difference (100–[sum of moisture, ash, fat, protein, and fiber contents]). Atwater factor was used to estimate the energy values (4 x % carbohydrate + 4 x % protein + 9 x % fat) in kcal/100 g.

2.6 Sensory Evaluation of Biscuit

A 9-point hedonic preference scale and multiple comparison tests were used to test the acceptability of biscuit samples. This was achieved by evaluating the samples with 40 panelists, comprising of 22 males and 18 females between the ages 15–31 who are staff, students, and members of the community. After seeking the consent of the panelist (including that of the teenagers and their parents), they were all screened with respect to their interest and ability to differentiate foods sensory attributes in three sections. The panelists were later presented with randomly coded samples each and were asked to score each attribute based on color, taste, aroma, shape, crispiness, and overall acceptability using a 9-point hedonic scale, where 1
corresponded to like extremely and 9 corresponded to dislike extremely.

2.7 Statistical Analysis

Data generated were subjected to one-way analysis of variance (ANOVA). Means obtained from triplicate determinations were separated with the Duncan Multiple Range Test (DMRT) at 0.05 significant levels using the Statistic Package for Social Sciences (SPSS version 23) for Windows.

III Results and Discussion

3.1 Functional Properties

The mean values of the functional properties obtained for different flour blends containing wheat and *Dioclea reflexa* are shown in Table 3 below. There were significant differences ($p \leq 0.05$) in the functional property of wheat and *Dioclea reflexa* flour blends. The Foam Capacity (FC), Foam Stability (FS), Emulsion Capacity (EC), Emulsion Stability (ES), Swelling Power (SP), Dispersibility (DP) and Gelation Temperature (GT) values increased with an increased in the level of inclusion of *Dioclea reflexa* in the wheat flour. However, there was a decrease in values obtained for Water Absorption Capacity (WAC), Oil Absorption Capacity (OAC).

3.1.1 Bulk Density (BD)

The results obtained for bulk density revealed a decreased in bulk density with an increase in *Dioclea reflexa*. Bulk density is an index of the heaviness of flour materials and expresses the relative volume of packaging material needed. The bulk density is generally affected by the particle size. It has relevant application in packaging, transportation and raw material handling [20]. The bulk densities of flour ranged from 0.675 g/ml to 0.745 g/ml; with control sample Co (100:0) having the highest while sample F (85:15) flour blends had the lowest. Values obtained for all the flour blends were lower than those reported for wheat-rice-green gram and potato flour blends 0.762g/ml-0.820g/ml and wheat-bambara-cassava flour blends 0.74g/ml-0.83g/ml [24] and [25] respectively. The present study revealed that bulk density depends on the particle size and initial moisture content of flour. The low bulk density would be an advantage in the formulation of complementary foods [26] and will occupy more space if packed in a packaging material [27].

3.1.2 Water Absorption Capacity (WAC)

The water absorption capacity ranged from 136% to 185%. The WAC was observed highest in sample A (100:0) 185% and lowest in F (85:15) 136%. The results suggest that addition of *Dioclea reflexa* flour affected the amount of water absorption. This could be due to molecular structure of *Dioclea reflexa* starch which inhibited water absorption, as could be seen from the lower values of WAC with increase in proportions of *Dioclea reflexa* flours to wheat flours. Similar observation was reported by [28] and [24]. [29] reported that lower WAC in some flour may be due to less availability of polar amino acids in flours. The WAC values recorded were similar to values recorded for wheat-rice-green gram and potato flour [24]. The increase in the WAC has always been associated with increase in the amylase leaching and solubility and loss of starch crystalline structure. The flour with high water absorption may have more hydrophilic constituents such as polysaccharide. Protein has both hydrophilic and hydrophobic nature and therefore they can interact with water in foods. The observed variation in different flours may be due to different protein concentration, their degree of interaction with water and conformational characteristics [30].

3.1.3 Oil Absorption Capacity (OAC)

The OAC ranged between 133±0.02 to 148±0.01%. The OAC decreased as the levels of inclusion of *Dioclea reflexa* increased. The possible reason for decrease in the OAC of composite flours after incorporation of *Dioclea reflexa* flour is the variation in the presence of non-polar side chain, which might bind the hydrocarbon side chain of the oil among the flours. [31]. OAC is the ability of a food or food ingredient to absorb oil or fat. The ability of protein to bind fat is important, since fats act as flavor retainers and increases the mouth feel of foods, improve palatability and extend the shelf life of bakery or meat products, meat extender, doughnuts, pancakes, baked goods and soup mixes.

3.1.4 Foaming Capacity and Stability

Formability is related to the rate of decrease in the surface tension of the air-water interface caused by absorption of protein molecules [32]. Foam capacity and foam stability increased as the levels of inclusion of *Dioclea reflexa* are increasing. The values were in the range 13.51±0.03 to 17.51±0.02 and 2.10±0.04 to 6.53±0.01% respectively, for FC and FS. These results were significantly ($p \leq 0.05$) different between all the samples, with sample F (85:15) having the highest and (A) 97:5:2:5 flour blends the lowest within the fortified wheat flour blends. There was an inverse relationship between foam capacity and foam stability, flour with high foaming ability could form large air bubbles surrounded by a thinner less flexible protein film. This air bubbles might be easier to collapse and consequently lowered the foam stability [31]. Protein being the surface active agents can form and stabilize the emulsion by creating electrostatic repulsion on oil droplet surface [27].

3.1.5 Emulsion Capacity and Stability

Emulsion Capacity (EC) of different flours ranged between 44.21 and 47.93%. The highest EC for 85:15 flour is 47.93% and lowest for Co (100:0) flour is 44.21%. Highest ES was observed for sample F (85:15) flour (47.93%) and lowest for wheat flour 100:0. The EC and ES of composite flours were found to be significantly increased with decrease in the proportions of wheat flour. Emulsion stability can be greatly increased when highly cohesive films are formed by the absorption of rigid globular protein molecules that are more resistant to mechanical deformation [24]. Increasing emulsion capacity (EC), emulsion stability (ES) and fat binding during processing are primary functional properties of protein in such food as comminuted meat products, salad dressing, frozen desserts and mayonnaise. All composite flours showed relatively good capacity of emulsion activity.

3.1.6 Swelling Capacity (SC)

Swelling capacity of different flours ranged between 8.60 to 12.73%. Values obtained increased with increasing substitution of wheat flour with *Dioclea reflexa*. It is clear that lowest value of swelling capacity was observed in 100:0 (8.60%) whereas the maximum in 85:15(12.73%). Swelling power is the volume of expansion of molecules in response to water uptake, which is possessed until a colloidal suspension is achieved or until further expansion and uptake are prevented by intermolecular forces in the swollen particles [33]. The swelling capacity of flours depends on size of particles, types of variety and types of processing methods or unit operation. Values obtained for all the flour blends were lower than those reported for wheat-rice-green gram and potato flour blends [24].

3.1.7 Dispersibility (DP)

Dispersibility (DP) is an index of the ease of reconstitution of the flour samples in water. The percentage DP ranged from 48.10 to 55.21%, with sample (F) 85:15 flour blends having the highest while sample A (97.5:2.5) flour blends had the lowest. This showed that the sample with F (85:15) flour blends has the ability to disperse more easily and faster in aqueous solution or during food processing than other samples.

3.1.8 Gelatinization Temperature (GT)

The temperature at which gelatinization of starch take place is known as the gelatinization temperature [34]. The results obtained for GT revealed an increase in GT with an increase in *Dioclea reflexa* flour inclusion. The GT ranged from 60.75 to 71.31^{o}C, with the control sample (100:0%) having the least temperature while sample with 85:15% flour blends had the highest GT. The study revealed that the flour which was higher in starch content had the lowest temperature for gelatinization. Therefore GT of the composite flour increased with decrease in the incorporation ratio of wheat flour.

3.2 Pasting Properties of Wheat-*Dioclea reflexa* Flour Blends

The pasting properties of the flour samples are shown in table 4. The pasting properties of flour are used in assessing the suitability of its application as functional ingredient in food and other industrial products [35]. Usually, starch when heated increases in viscosity as a result of swelling of the starch granules and the quantity of water absorbed depends on the duration of cooking and starch content [36].

The most important pasting characteristics is its amylographic viscosity [37] the peak viscosity, which is the maximum viscosity developed during or soon after the heating portion. The peak viscosity of Co 100:00 is 1964.05 RVU at a temperature of 63.75 in 6.07min. The wheat-*Dioclea reflexa* flours had lower values in the range of 1915.15-1958.13RVU. This suggests that the presence and interaction of components like fats and protein (from *Dioclea reflexa*) with starch lowers its peak viscosity [27], [38]. High peak viscosity reflects fragibility of the swollen granules, which first well and then breakdown under the continuous mixing of the Rapid Visco Analyzer. The apparent gelatinization (pasting) temperature of Co 100:0 flour was 63.75ºC while those of wheat-*Dioclea reflexa* flours varied from 65.15-68.55. This may be due to the buffering effect of fat (from *Dioclea reflexa*) on starch which interferes with the gelatinization process [38]. The pasting temperature is one of the pasting properties which provide an indication of the minimum temperature required for sample cooking, energy cost involved and other components stability [37].

It is clear from the results that the control sample Co (100:0) will cook faster and less energy consumed, thereby saving cost and time compared to other samples because of its lower pasting temperature. Trough Viscosity is the maximum viscosity at the constant temperature phase of the RVA profile and the ability of the phase to withstand breakdown during cooling. The trough or holding strength showed that there was a significant difference ($p \leq 0.05$) in all the samples, 100% wheat had the highest value of 847.01 RVU. The addition of *Dioclea reflexa* flour in general lowers the trough of wheat flour, which implies that the blends may not find good application in the food system, where high paste stability during cooking is required.

The breakdown viscosity of 100:0 is 1117.04(RVU). The wheat-*Dioclea reflexa* flours had lower value in the range of 1102.09-1113.11(RVU). [19] reported that the higher the breakdown in viscosity, the lower the ability of the sample to withstand heating and shear stress during cooking. Hence, sample 85:15 might be able to withstand heating and shear stress compared to other samples because of its low breakdown value.

The final viscosity ranged from 2109.11-2372.12 RVU. The control sample 100:0 had the highest (2372.5 RVU) final viscosity, while sample F (85:15) had the lowest. [39] reported that final viscosity is used to indicate the ability of starch to form various paste or gel after cooling and that less stability of starch paste is commonly accompanied with high value of breakdown. This implies that sample Co 100:0 will be less stable after cooling compared to wheat-*Dioclea reflexa* flours blend. The variation in the final viscosity might be due to the simple kinetic effect of cooling on viscosity and the re-association of starch molecules in the samples.

The extent of increase in viscosity on cooling to 50ºC reflects the retrogradation tendency of the products. Off the wheat-*Dioclea reflexa* flours studied, sample A 97.5:2.5 had the highest retrogradation tendency 1387.15 RVU followed by B (95:5%, 1377.11 RVU) and C (92.5:7.5) 1363.12 RVU while F (85:15) had the lowest value 1294.14 RVU. The increase in the set back values in wheat-*Dioclea reflexa* flours may be due to increased hydrogen bonding during cooling and the high amylase content of the starch of wheat [40]. This increased hydrogen bonding activity may be due to the hydrothermal treatment and the interaction between the polysaccharide and protein (peptide bonds). This leads to the growth of gel unicellar region, hence increase in index of retrogradation [41], making entrapped water more prone to expression.

3.3 Proximate Composition of Biscuit from Wheat-*Dioclea reflexa* Flour Blends

Proximate composition of biscuits samples produced form varying proportions of wheat flour and *Dioclea reflexa* blends are presented in table 5, Significant variation ($p \leq 0.05$) was obtained in each of the biscuit samples with varying proportion of the *Dioclea reflexa*.

The ash (3.36-4.22%), fiber (2.03-3.84%), protein (9.83-13.85%), fat (3.86-6.72%) contents increased while moisture (70.49-60.95%) content decreased with increase in substitution level of *Dioclea reflexa* in the product. The increase in the protein content could be attributed to high protein contents reported earlier for *Dioclea reflexa* [14]. Protein content is one of the most important qualities of any food. The sample F (85:15) had the highest protein content of 13.85% while 100% wheat had the lowest value 9.83%. The improvement of the protein content of *Dioclea reflexa* incorporated wheat flour based biscuits is similar to that reported elsewhere for biscuits obtained by replacing progressively and up to the rate of 20% of wheat flour by that of lentil seeds [42] and wheat- biscuits fortified with defaulted Macrotermes subhyalinus [41].

The fat content ranged from 3.86 to 6.72%. The values of the fat contents were lower to that reported for lentil flour fortified biscuit [42] and wheat biscuits fortified with defatted *Macrotermes subhyalinus* [41]. The ash content indicated that incorporation of *Dioclea reflexa* may enhance the amount of minerals in food products made from wheat-*Dioclea reflexa* flour blends [44]. The moisture content ranged from 9.92-10.43% with the sample (100:0) having the highest value of 10.43 while sample A (97.5:2.5) had the least value of 9.68%. Moisture content is used as a quality parameter of food products as it influences the shelf stability of foods. The lower the moisture, the better the storage potential of the food product [20]. The moisture content of any food is an index of its water activity (aw). High water activity encourages the growth of fungi. This is an indication that the biscuit sample will store for a longer time due to its low moisture content. The carbohydrate content of biscuits decreased significantly from 70.49 to 60.95% with increase of *Dioclea reflexa* in formulations and it’s consistent with previous works of (42] and [45].

3.5 Organoleptic Characteristics of Biscuits

Table, 6 shows the result of organoleptic characteristics of biscuits. There were significant differences ($p \leq 0.05$) between the color, texture, taste, crispiness and overall acceptability of the control (100% wheat biscuit) and the wheat-*Dioclea reflexa* based biscuits. The colour of sample C (92.5:7.5) was most preferred by the panelist having the highest score of 8.50 followed by sample A 97.5:2.5 formulation (7.5) while 85:15 formulation was the least preferred with a mean sensory score 6.00.

Wheat snack containing 85% wheat and 15% *Dioclea reflexa* was the least preferred in the terms of all the sensory attributes under investigation. However, substitutions up to 10% with *Dioclea reflexa* into the wheat flour were still acceptable in terms of the entire sensory attributes without having a negative impact on the acceptability of the products.

IV Tables

Formulation Tables

Table 1: Proportion of Wheat Flour and *Dioclea reflexa* Flour

Sample Code	Wheat Flour (%)	*Dioclea reflexa* (%)
Control	100	0
A	97.5	2.5
B	95	5
C	92.5	7.5
D	90	10
E	87.5	12.5
F	85	15

TABLE 2: Recipe for the production of composite biscuit from *Dioclea reflexa* and wheat flour

Ingredients	Co	A	B	C	D	E	F
Dioclea reflexa flour (g)	-	2.5	5	7.5	10	12.5	15
Wheat flour (g)	100	97.5	95	92.5	90	87.5	85
Baking fat margarine (g)	35	35	35	35	35	35	35
Granulated sugar (g)	25	25	25	25	25	25	25
Baking powder (g)	2	2	2	2	2	2	2
Egg colour (g)	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Results Tables

Table 3, Functional Properties of Flour Blends made from Composite of Wheat and *Dioclea reflexa* Flours

Parameters	Co	A	B	C	D	E	F
BD(g/ml)	$0.745^{a}\pm0.01$	$0.738^{b}\pm0.05$	$0.726^{c}\pm0.03$	$0.718^{d}\pm0.03$	$0.712^{e}\pm0.01$	$0.691^{f}\pm0.01$	$0.675^{g}\pm0.03$
WAC(g/g)	$185^{a}\pm0.01$	$173^{b}\pm0.03$	$163^{c}\pm0.04$	$152^{d}\pm0.07$	$147^{e}\pm0.04$	$140^{f}\pm0.03$	$136^{g}\pm0.01$
OAC(g/g)	$148^{a}\pm0.01$	$145^{b}\pm0.02$	$143^{bc}\pm0.04$	$141^{c}\pm0.01$	$138^{d}\pm0.03$	$136^{e}\pm0.02$	$133^{f}\pm0.02$
FC (%)	$13.51^{g}\pm0.03$	$13.93^{f}\pm0.03$	$14.25^{e}\pm0.02$	$15.10^{d}\pm0.03$	$15.8^{c}\pm0.01$	$16.50^{b}\pm0.01$	$17.51^{a}\pm0.02$
FS (%)	$2.10^{g}\pm0.04$	$2.93^{f}\pm0.05$	$4.05^{e}\pm0.06$	$4.17^{d}\pm0.04$	$4.86^{c}\pm0.03$	$5.43^{b}\pm0.04$	$6.53^{a}\pm0.01$
EC (%)	$44.21^{g}\pm0.01$	$44.30^{f}\pm0.02$	$45.31^{e}\pm0.02$	$45.85^{d}\pm0.03$	$46.51^{c}\pm0.01$	$47.21^{b}\pm0.03$	$47.93^{a}\pm0.04$
ES (%)	$38.53^{g}\pm0.02$	$38.85^{f}\pm0.02$	$39.35^{e}\pm0.03$	$39.93^{d}\pm0.02$	40.41 ± 0.02	$40.95^{b}\pm0.01$	$41.43^{a}\pm0.01$
SC (%)	$8.60^{g}\pm0.03$	$9.50^{f}\pm0.02$	$10.31^{e}\pm0.03$	$10.86^{d}\pm0.03$	$11.51^{c}\pm0.03$	$12.02^{b}\pm0.03$	$12.73^{a}\pm0.14$
DP (%)	$48.50^{f}\pm0.14$	$48.10^{g}\pm0.14$	$50.05^{e}\pm0.07$	$50.50^{d}\pm0.14$	$52.40^{c}\pm0.12$	$54.40^{b}\pm0.14$	$55.21^{a}\pm0.14$
GT (°C)	$60.75^{g}\pm0.12$	$59.96^{f}\pm0.11$	$60.53^{e}\pm0.010$	$60.96^{d}\pm0.14$	$70.35^{c}\pm0.08$	$70.85^{b}\pm0.11$	$71.31^{a}\pm0.09$

Values are means of three replicates and are represented in mean ± standard deviation. Means in the same column with different superscripts are significantly different ($p\leq0.05$). BD= Bulk density, WAC= Water absorption capacity, OAC= Oil absorption capacity, FC= Foaming capacity, FS= Foaming Stability, EC= Emulsion capacity, ES= Emulsion stability, SC= Swelling capacity, DP= Dispersibility, GT= Gelation temperature. Wheat: *Dioclea reflexa* ratio, Co (Control) = 100:0%, A= 97.5:2.5%, B=95:5%, C=92.5:7.5%, D=90:10%, E87.5:12.5%, F=85:15%.

Table 4, Pasting Properties of Flour Blends made from Composite of Wheat and *Dioclea reflexa* Flours.

Parameters	CO	A	B	C	D	E	F
PEAK VISCOSITY (RVU)	$1964.05^{e}\pm0.01$	$1958.13^{d}\pm0.02$	$1945.23^{c}\pm0.01$	$1930.14^{bc}\pm0.05$	$1923.11^{b}\pm0.01$	$1922.22^{b}\pm0.01$	$1915.15^{a}\pm0.01$
TROUGH VISCOSITY (RVU)	$847.01^{f}\pm0.02$	$845.02^{e}\pm0.02$	$835.03^{d}\pm0.01$	$825.02^{c}\pm0.05$	$820.01^{b}\pm0.02$	$820.02^{b}\pm0.02$	$813.06^{a}\pm0.02$
BREAKDOWN VISCOSITY (RVU)	$1117.04^{bc}\pm0.01$	$1113.11^{b}\pm0.03$	$1110.20^{b}\pm0.02$	$1105.12^{ab}\pm0.02$	$1103.10^{a}\pm0.03$	$1102.20^{a}\pm004$	$1102.09^{a}\pm0.03$
FINAL VISCOSITY (RVU)	$2372.12^{f}\pm0.02$	$2227.14^{c}\pm0.01$	$2215.09^{b}\pm0.05$	$2164.08^{e}\pm0.01$	$2189.10^{g}\pm0.01$	$2153.12^{d}\pm0.01$	$2109.11^{a}\pm0.01$
SETBACK VISCOSITY (RVU)	$1398.02^{g}\pm0.03$	$1387.15^{f}\pm0.04$	$1377.11^{e}\pm0.05$	$1363.12^{d}\pm0.02$	$1354.13^{c}\pm0.01$	$1310.10^{b}\pm0.02$	$1294.14^{a}\pm0.02$
PEAK TIME (MINUTES)	$6.07^{c}\pm0.01$	$6.27^{d}\pm0.01$	$5.93^{b}\pm0.05$	$5.93^{b}\pm0.04$	$5.87^{a}\pm0.02$	$6.07^{c}\pm0.03$	$5.80^{a}\pm0.01$

PASTING TEMPERATURE (ºC)	63.75^{a}±0.02	65.15^{b}±0.02	65.55^{bc}±0.03	65.65^{bc}±0.02	67.64^{c}±0.02	68.55^{d}±0.02	68.55^{d}±0.03

Values are means of three replicates and are represented in mean ± standard deviation. Means in the same column with different superscripts are significantly different (p≤0.05). Wheat: *Dioclea reflexa* ratio, Co (Control) = 100:0%, A= 97.5:2.5%, B=95:5%, C=92.5:7.5%, D=90:10%, E87.5:12.5%, F=85:15%.

Table 5, Proximate Composition of Flour Blends made from Composite of Wheat and *Dioclea reflexa*

Parameters	Co	A	B	C	D	E	F
MOISTURE (%)	10.43^{b}±0.04	9.68^{a}±0.04	9.73^{a}±0.01	9.73^{a}±0.01	9.68^{a}±0.02	9.83^{a}±0.03	9.92^{a}±0.03
ASH (%)	3.36^{a}±0.01	3.43^{b}±0.05	3.48^{b}±0.04	4.50^{c}±0.02	4.50^{c}±0.03	4.68^{c}±0.01	4.72^{cd}±0.04
FIBRE (%)	2.03^{a}±0.07	2.43^{b}±0.05	3.05^{c}±0.02	3.15^{d}±0.05	3.15^{d}±0.02	3.63^{e}±0.02	3.84^{f}±0.01
PROTEIN (%)	9.83^{a}±0.06	10.53^{b}±0.03	11.35^{c}±0.01	11.82^{d}±0.07	12.28^{e}±0.01	13.05^{f}±0.01	13.85^{f}±0.01
FAT (%)	3.86^{a}±0.01	4.30^{b}±0.01	4.45^{b}±0.01	4.53^{b}±0.01	4.75^{c}±0.01	5.60^{d}±0.05	6.72^{e}±0.01
CHO (%)	70.49^{g}±0.07	69.63^{f}±0.01	67.94^{e}±0.03	66.27^{d}±0.05	65.64^{c}±0.01	63.21^{b}±0.01	60.95^{a}±0.03

Values are means of three replicates and are represented in mean ± standard deviation. Means in the same column with different superscripts are significantly different (p≤0.05). Wheat: *Dioclea reflexa* ratio, Co (Control) = 100:0%, A= 97.5:2.5%, B=95:5%, C=92.5:7.5%, D=90:10%, E87.5:12.5%, F=85:15%.

Table, 6 Sensory Evaluation of Flour Blends made from Composite of Wheat and *Dioclea reflexa*

Parameters	Co	A	B	C	D	E	F
TASTE	7.40^{a}±0.01	7.40^{a}±0.01	7.32^{a}±0.01	7.45^{a}±0.01	6.60^{b}±0.01	6.70^{c}±0.12	6.60^{c}±0.10
TEXTURE	7.10^{a}±0.02	7.10^{a}±0.02	7.00^{a}±0.02	7.40^{b}±0.02	7.50^{c}±0.02	6.20^{c}±0.13	6.70^{c}±0.11
COLOUR	7.40^{a}±0.01	7.50^{a}±0.03	7.00^{a}±0.01	8.50^{b}±0.02	7.10^{c}±0.15	6.80^{d}±0.14	6.00^{c}±0.15
CRISPINESS	7.00^{a}±0.02	7.30^{a}±0.03	7.20^{a}±0.02	7.70^{b}±0.03	7.20^{c}±0.12	6.80^{d}±0.11	6.30^{c}±0.13
OVERALL ACCEPTABILITY	7.00g±0.03	7.30^{a}±0.01	6.90^{b}±0.05	6.90^{b}±0.04	6.50^{c}±0.11	6.30^{d}±0.14	6.00^{e}±0.14

Values are means of three replicates and are represented in mean ± standard deviation. Means in the same column with different superscripts are significantly different (p≤0.05). Wheat: *Dioclea reflexa* ratio, Co (Control) = 100:0%, A= 97.5:2.5%, B=95:5%, C=92.5:7.5%, D=90:10%, E87.5:12.5%, F=85:15%.

V. Conclusion

The results from this study revealed that incorporation of *Dioclea reflexa* seed flour significantly improved the nutritional values and sensory characteristics of the biscuit samples. Although, an increase in the level of substitution of the wheat flour with *Dioclea reflexa* resulted in a reduction of the acceptance level in all the sensory attributes considered. Biscuits with a higher nutritional content can be made with composite blends of wheat flour and *Dioclea reflexa*. The maximum levels of replacement which were acceptable were from 2.5 to 7.5% *Dioclea reflexa* blends.

In addition to the aforementioned, there would be an increase in demand and utilization of *Dioclea reflexa* by the processor of biscuits; hence this would eventually encourage the cultivation of more hectares by the farmers for the crop and more income on returns. The cultivation of more farmland will require additionally capable hand, thus, create job opportunities. *Dioclea reflexa*, being a leguminous crop, will encourage nitrogen fixation activities in the soil by bacteria.

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