Journal of Materials and Environmental Science
ISSN : 2028-2508
e-ISSN : 2737-890X
CODEN : JMESCN

J. Mater. Environ. Sci., 2025, Volume 16, Issue 10, Page 1877-1892

http://www.jmaterenvironsci.com

Chemical analysis and evaluation of quality characteristics of cake from wheat and defatted *Enterolobium cyclocarpum* seed flour blends

***Emmanuel N. Ifedi [1], Oreofeoluwatomi, A. Lawal[3], Ibironke A. Ajayi[2] and Shiva S. Kaki[4]**

[1]*Department of Chemical Sciences, Faculty of Applied Sciences, KolaDaisi University, Ibadan, Nigeria*
[2]*Department of Food Technology, Faculty of Technology, University of Ibadan, Ibadan, Nigeria*
[3]*Industrial Unit, Chemistry Department, Faculty of Science, University of Ibadan, Ibadan, Nigeria*
[4]*Centre for Lipid Science and Technology, CSIR-Indian Institute of Chemical Technology, Hyderabad 500 007, India*
* Email: ifedi79@yahoo.com

Received *25 June 2025,*
Revised *24 Sept 2025,*
Accepted *26 Sept 2025*

Keywords:
- ✓ *Enterolobium cyclocarpum;*
- ✓ *Wheat flour;*
- ✓ *Cake;*
- ✓ *functional food;*
- ✓ *haematology evaluation*

Citation*: Ifedi E. N., Lawal O. A., Ajayi I. A. and Kaki S. S. (2025). Chemical analysis and evaluation of quality characteristics of cake from wheat and defatted Enterolobium cyclocarpum seed flour blends. J. Mater. Environ. Sci.,16(10), 1877-1892.*

Abstract: The safety, quality and acceptability of cakes produced from wheat and defatted *Enterolobium cyclocarpum* seeds (DECS) flour blends were investigated. Five cake samples, produced with different formulations (wheat flour, wheat/DECS flour blends (100:00, 90:10, 80:20, 70:30, 00:100) and DECS flour were respectively analysed for chemical, functional and pasting properties using established methods. Cakes products were subjected to physical properties and sensory evaluation by a 15 member sensory panel. The effect of the cake on growth and blood haematological indices was examined using rats for three weeks. Significant ($p<0.05$) increase in protein and ash contents of the wheat/DECS flour blends was recorded with increasing concentration of DECS flour with the highest (23.56% and 2.39%) in 70:30 wheat/DECS flour blend. Carbohydrate and moisture contents decreased significantly. Mg, K, Na and Zn were prominently found higher in 70:30 wheat/DECS than in others. Water and oil absorption capacities were comparable. Pasting properties decreased gradually with increasing concentration of DECS flour. Cakes weights were slightly higher in 70:30 wheat/DECS flour blends than those in oter flour blends. Sensory evaluation showed higher preference and acceptance in cakes from 70:30 wheat/DECS. Hematological parameters of rats fed on cakes samples were comparable. Weight gain and survival rate of the rats decreased considerably with increasing level of DECS flour. DECS flour might be effectively used in cake production at 10% substitution.

1. Introduction

Cakes are suitable food products which are conveniently baked from the combination of wheat flour, sugar, shortening, baking powder and egg as principal ingredients (Atef *et al*., 2011). The wheat, the most important ingredient is cultivated in several parts of the world, but imported by countries with unfavorable climatic conditions such as Nigeria and some other African countries that spend a lot of foreign exchange on its importation (Dambazau, *et al*., 2021). There is an important need to develop an adequate replacement for wheat, as the demand and price of this product could further be increased by the unstable exchange rates. Additionally, the increasing trend for functional food products among consumers has greatly influenced the use of composite flours in which flours from locally grown crops and high protein seeds replace a portion of wheat flour for use in cake production (Olatunde *et al*., 2019; Loukili *et al*., 2024; Eid *et al*., 2025). In the quest for a wheat substitute, flour with better nutritional quality than wheat would be highly desirable, especially in developing countries where malnutrition is prevalent. The suitability of wheat in the production of many confectionary products (cake. snacks, bread) is as a result of its good gluten content with which is a protein that facilitates excellent dough formation and elasticity; a characteristic feature absent in other flours (Ibitoye *et al*., 2013).

Enterolobium cyclocarpum, commonly known as *guanacaste, carocaro,* or elephant-ear tree, is a species of flowering tree in the pea family, *Fabaceae*, native to tropical regions of America, from central Mexico, south to northern Brazil and Venezuela. It has been introduced into many other tropical areas of the world such as Nigeria, Indonesia, and Australia (Orwa *et al.*, 2009). *E. cyclocarpum* leaves, pods, seeds and fruits contained considerable amount of nutrients (proximate composition, vitamins and minerals) in both the fresh and dried forms and most in quantities within range for normal physiological productivity functions of farm animals. The mineral content of *E. cyclocarpum* seeds suggests that this legume could be used as an alternative human food source, and high quality forage for cattle (Ramirez *et al*., 2021). Although, the seeds having high protein content are not widely used due to large concentration of anti-nutritional chemicals (tannins, saponins, oxalate, phytate, hydrocyanic acid, trypsin inhibitors and alkaloids) found in the leave, roots and seeds. The presence of anti-nutrient factors especially in the seeds of *E. cyclocarpum* could be a major constraint in their use as food for poultry (Ekanem *et al*., 2020). These Secondary bioactive substances present in *E. cyclocarpum* are reduced during processing and preservation to satisfactory levels and digestible by ruminant animals (Ekanem *et al*., 2022).

Graded levels (0, 10, 20, and 30%) of toasted *E. cyclocarpum* seeds were fed to WAD rams to assess their growth performance and nutrient digestion. Rams fed diet 2 (10% toasted *Enterolobium cyclocarpum* seed meal diet) had the highest daily weight gain of 58.93 g/d compared to diet 1 (57.72 g/d), diet 3 (56.55 g/d) and diet 4 (47.62 g/d). Similarly, diet 2 (10% inclusion level) recorded the best feed conversion ratio (Idowu *et al*., 2013). *Enterolobium cyclocarpum* seeds were fed to rat at different substitution level (0, 10, 20 and 30%) to evaluate the suitability of the seed flour for nutritional purposes and the effect on the growth performance, feed intake, blood parameters and histological status. The seed flour at 10% might be properly employed in reinforcing conventional seed flours that are low in protein (Ifedi and Ajayi, 2021). *E. cyclocarpum* seeds could be a source of protein for food or forage, because its' crude protein content is comparable to that reported for seeds of other edible legumes such as common bean, chick-pea and green pea. Its amino acid profile is similar to that of soy protein, although at lower concentrations (Ramirez *et al*., 2021). There has recently been an unswerving modification in the dietary preferences of various individuals seeking to enhance their nutritional intake with safe food options and to improve their overall health and well-being. Consequently, specialists in the food industry have gradually embraced formulations of ingredients; using innovative technologies to make safe food products with enhanced nutritional values that align with consumers' demands (Akajiaku, *et al*., 2024). Despite all research carried out on *Enterolobium cyclocarpum* seeds flours, much has not been reported on its application in dietary food formulation. This study therefore, evaluated the potentials of flour blends of wheat and *Enterolobium cyclocarpum* seeds in the production of cake as a way of extenuating the problems associated with the economic implication of over dependence on wheat flour for baking, celiac disease, underutilization of locally grown foods and low nutrient baked foods. The quality characteristics and sensory properties of cake produced from wheat and defatted *Enterolobium cyclocarpum* seeds flour blends equally evaluated.

2. Methodolog

2.1. *Collection of Materials*

Enterolobium cyclocarpum seeds were collected within the Department of Veterinary Medicine, University of Ibadan, Nigeria. The fruits and seeds were first identified in the Herbarium Unit of the Botany Department, University of Ibadan and later authenticated at the Forest Research Institute of Nigeria (Ibadan) where Voucher specimen was deposited in the Herbarium Unit. The kernels were pulverized to fine powder and divided into two portions. Oil was extracted from one portion of the seed flour by soxhlet extraction using n-hexane (b.pt 67-68 °C) as the solvent continuously for 8 h to obtain the seed cake. The seed flour and cake were both stored in a properly labeled glass container for further analysis.

2.2 Preparation of defatted Enterolobium cyclocarpum seed flour

The seeds were removed from the pod, cleaned and kept at room temperature. They were air dried and milled using a laboratory scale hammer miller prior to extraction. The kernels were removed and pulverized to fine powder. Oil was extracted by Soxhlet extraction method using n-hexane as the solvent from the seed flour. The seed residue obtained after the oil extraction was again air dried, re-pulverized and passed through a 200 mesh size sieve to obtain fine powder of uniform particle size labeled DECS.

2.3 Preparation of composite flour blends for cake production

Wheat flour was mixed with defatted *E. cyclocarpum* seed (DECS) at different inclusions levels (0, 10, 20 and 30%) Table 1. Five different composites flour blends (100:0, 90:10, 80:20, 70:30 and 0:100) were obtained while diet (100:0) % made from wheat flour without DECS was considered as control. A digital weighing balance and blender were used for weighing and mixing the flours, respectively. A portion of each of the flour blends was reserved for various analyses.

2.4 Proximate composition of wheat/defatted E. cyclocarpum flour blends

The proximate parameters such as fat, crude fibre, moisture and ash contents of different flours blends were evaluated using standard method (AOAC, 2012). Micro-Kjeldahl method as described in AOAC was used to determine nitrogen content (AOAC, 2012). Factor of 6.25 was used to multiply the nitrogen content for the determination of the crude protein value.

2.5 Mineral analysis

Minerals such as copper, zinc, iron, magnesium, calcium, sodium, potassium and manganese were all determined. The mineral analyses were carried out after digestion of 2 g of each flour blend (sample) with 20 ml mixture of nitric acid (70% v/v) and perchloric acid (90% v/v) in the ratio 2:1 respectively (Ajayi, *et al.*, 2006). The digests, filtered into 100 ml standard bottle were made up to mark with deionized water. Sodium and potassium were determined using a flame photometer (Model, 405, Corning, UK) while others by atomic absorption spectro-photometry (Perkin - Elmer Model 703, Norwalk CT, USA).

Table 1. The recipe used for dietary cake production (%)

Ingredients	A	B	C	D	E
	100:00	**90:10**	**80:20**	**70:30**	**00:100**
Wheat flour (%)	100	90	80	70	0.00
Seed residues (%)	0.00	10	20	30	100
Fat (margarine) (%)	50	50	50	50	50

Sugar (%)	40	40	40	40	40
Baking powder (%)	2	2	2	2	2
Salt (%)	0.5	0.5	0.5	0.5	0.5
Eggs (whole)	2	2	2	2	2

Sourced from Onuegbu *et al*. (2013) with modification

2.6 *Functional properties of wheat/defatted E. cyclocarpum flour blends*

2.6.1 Bulk Density

The bulk density (loose and packed) of the flour samples was evaluated following the procedure in Chinma *et al.* (2008). A known weight of the flour was taken into a previously weighed (W_1) measuring cylinder and the weight of the cylinder (W_2) as well as the volume of the flour (V_1) was noted. Loose bulk density (LBD) was then calculated in g/ml as LBD = $(W_2 - W_1)/V_1$. The cylinder was tapped gently to eliminate air spaces between the particles of the flour. The new volume (V_2) of the sample and weight of the cylinder (W_3) were noted. Packed bulk density (PBD) was calculated in g/ml as PBD = $(W_3 - W_1)/V_2$.

2.6.2 Swelling Index

The swelling index of each flour sample was determined as the ratio of swollen volume of a unit weight of each sample to its initial volume in a graduated measuring cylinder. One gram of each of the flour samples was weighed out with a weighing balance and dispensed or added into a 20 ml measuring cylinder in each case. Then, this was followed by the addition of 10 ml of distilled water in each measuring cylinder. The volumes of the samples were noted. They were then allowed to stand undisturbed for 1 hour before their volumes were taken again and recorded accordingly. The swelling index of each flour sample was calculated as SI = V_2/V_1. (Kolawole and Chidinma, 2015). {Initial volume occupied by sample (V_1) and Final volume occupied by the sample after swelling (V_2)}.

2.6.3 Water absorption capacity

Distilled water (15 mL) was added to 1 g of the flour in a weighed 25 mL centrifuge tube. The tube was agitated on a vortex mixer for 2 min. It was centrifuged at 4000 rpm for 20 min. The clear supernatant was decanted and discarded. The adhering drops of water was removed and then reweighed. Water absorption capacity was expressed as the weight of water bound by 100 g dried flour (Kolawole and Chidinma, 2015).

2.7 *Determination of pasting properties*

Pasting properties of flours were determined using a Rapid Visco Analyzer (Model RVA-4; Newport Scientific Pty. Ltd, Warriewood, Australia). Three grammes of the flour samples were weighed into a dried empty canister; 25 mL of distilled water was dispensed into the canister containing the sample. The mixture was systematically stirred and the canister was fitted into the RVA as per manufacturer's instructions. The slurry was heated from 50 to 95 °C with a holding time of 2 min followed by cooling to 50 °C with 2 min holding time. The rate of heating and cooling were at a steady rate of 11.25 °C min^{-1}. The pasting profile was determined with the aid of Thermocline for Windows Software connected to a computer (Kolawole and Chidinma, 2015).

2.8 Production of dietary cake from wheat/defatted E. cyclocarpum flour blends

Cakes were prepared immediately after flour preparation following a standard formulation as described by Onuegbu *et al.* (2013) with little modification. The composite flours were blended with other baking ingredients as listed in (Table 1) in a mixer. Cake samples were listed in ratios of wheat flour/DECS of 100:0, 90:10, 80:20, 70:30 and 0:100. Creaming method of cake preparation described by Kiin-Kabari and Banigo, (2015). The mixed batter was baked in a pre-heated oven at 200 ^{o}C for 20 min. Cakes produced were allowed to cool, packaged and stored at room temperature for chemical investigation. .

2.9 Physical properties of cakes from wheat/defatted E. cyclocarpum flour blends

The physical characteristics of the cakes produced such as: weight, height, volume and specific volume were measured after baking using the method described by Giami and Barker (2004). The cake volume was calculated with the formula: {Volume of cake (cm^3) = πh (d^2 + db + b^2)}, where d and b are upper and lower diameters of cake. The specific volume was determined by dividing the cake volume by the weight (Nwosu *et al*., 2014).

2.10. Sensory evaluation of cakes from wheat/defatted *E. cyclocarpum flour blends*

Sensory evaluation of the cakes was carried out after baking following the method described by Giami and Barker, (2004). Fifteen (15) experienced panelists, regular producers of cakes were selected to evaluate the samples. The properties such as appearance, colour, taste, texture, aroma, crumbliness and overall acceptability were evaluated using 9-point hedonic scale with 1 representing the least score (extremely dislike) and 9 the highest score (extremely like), (Kiin-Kabari and Banigo, 2015). Panelists were selected based on their interest and ability to make a distinction in food sensory properties. They rinsed their mouths with drinkable water after each evaluation as precautions to prevent carryover flavour from one sample to another while tasting.

2.11 Effect of the cakes from wheat/defatted *E. cyclocarpum* flour blends on weight gain, survival rate and specific growth rate of wistar rats.

Twenty five matured eight weeks old wistar rats weighing between 80-100g used in this rat experiment were procured from Anatomy Department, University of Ibadan. The animals were separated into five different groups (A, B, C, D and E) of five animals each according to their weights. The animals were allowed to acclimatize for one week and maintained on standard diet with water *ad-libitum* in the animal house under normal room condition before the commencement of the experiment. After acclimatisation period, they were fed for a period of three weeks with the cakes produced as diets. The rats in their different experimental groups were respectively fed with 100:0(A), 90:10(B), 80:20(C), 70:30(D) and 0:100(E) prepared cakes with unrestricted access to water. The physical appearance, survival rate and growth of the rats were monitored. The rats' body weights were documented weekly throughout the experimental period. The animals were examined for clinical, morbidity and mortality signs on a daily basis. The animal study was approved by the Ethical Committee of the Institute for Advanced Medical Research and Training, College of Medicine, University of Ibadan, Nigeria (approval number UI/EC/15/208) and conducted in compliance with international guidelines on animal experimentation and biodiversity rights.

2.12 Effect of cakes from wheat/defatted E. cyclocarpum flour blends on haematological parameters of wistar rats' blood

Blood samples were collected by the orbital technique and stored into EDTA bottles for haematological analyses. The sample bottle was shaken gently to mix up the blood with EDTA to prevent clotting. The values of RBCs count, WBCs count, PCV, Hb, MCV, and MCHC were all determined according to the methods of Jain (1986) and (Mbaka *et al.*, 2010).

2.13 Statistical analysis

All experimental results were expressed as mean values and standard deviation of three determinations. Data were analysed using a one-way analyses of variance (ANOVA) in the Statistical Package for Social Science (SPSS) version 20.0 software (version 2010) to test the level of significance (P≤0.05). Duncan New Multiple Range Test was used to separate the means where significant differences existed.

3. Results and Discussion

3.1 Proximate composition of wheat/DECS flour blends

The proximate composition of the flour samples is shown in Table 2. The 100% DECS had the highest protein content of 37.18%. This was followed by the flour blend of 23.56 % (70:30); 18.80 % (80:20); 16.23 % (90:10) and 14.51 % (100 % wheat flour). The gradual increase in the protein content with the increase level of DECS in the flour blends is majorly due to the high protein in DECS flour. There is also a gradual increase in the crude fibre and the ash content of the various flour blends. 100 % DECS had the highest value while 100 % wheat had the lower value. High fiber is of huge advantage to the body, as it aids to lower blood cholesterol level and control blood sugar level. Crude fibre enhancement is desirable in cake products, because it adds bulk to the cake and thereby helps to increase bowel movements which are essential in the prevention of diseases in human beings (Dawi *et al*., 2022).

The slight reduction observed in moisture contents across the experimental flour blends is helpful because reduction in moisture content will lessen the proliferation of spoilage organisms particularly mold, thus, improving the shelf stability of the product (Ocheme *et al*., 2018). The carbohydrate (%) value in 100 % wheat (72.75) compared favourably to that of 90:10 % whet/DECS (70.24). The metabolism energy (1.49-1.49 x 10^3 Kj/100g) compared favourably within all the groups. This could be a reflection of the high protein or carbohydrate as the major contributors of the energy in DECS flour. The result in Table 2 revealed that carbohydrate decreased while protein content, crude fibre and ash contents increased with the increasing concentration of DECS substitution. The varying protein content of the samples is as a result of the use of varying amounts of wheat and DECS flour in the formulations. This increase was expected because of the high protein content of DECS compared with wheat flour hence the observed synergistic effects of protein complementation. A related finding was reported by Dharsenda *et al*. (2020).

Table 2: Proximate composition (%) wheat/DECS flour blends

Parameters	Wheat flour	90:10	80:20	70:30	100 % DECS
Wheat/*E. cyclocarpum* seed cake blends					
Dry matter	89.07±0.41^f	89.05±0.47^e	89.29±0.05^d	89.73±0.03^c	91.42±0.03^c
Moisture	10.92±0.04^a	10.94±0.05^a	10.71±0.05^b	10.27±0.04^c	8.56±0.03^d
Protein	14.51±0.11^f	16.23±0.05^e	18.80±0.51^d	23.56±0.04^c	37.18±0.05^a
Fat	0.19±0.01^e	0.68±0.02^b	0.39±0.02^c	0.29±0.01^d	0.39±0.11^c
Crude fibre	0.01±0.01^d	0.19±0.00^c	0.18±0.01^c	1.19±0.01^b	1.19±0.01^b
Ash	1.59±0.02^f	1.70±0.15^e	2.11±0.51^d	2.39±0.17^c	4.30±0.15^a
Carbohydrate	72.75±0.11^a	70.24±0.10^b	67.80±0.02^c	62.20±0.04^d	48.21±0.27^f
Energy	1.49±0.42^b	1.49±6.95^b	1.48±6.14^b	1.47±2.37^c	1.47±3.91^c

Values are expressed as mean ± SD. Values on the same row having the same letter as superscripts are not significantly different (P ≤ 0.05). DECS: defatted *E. cyclocarpum* seed

3.2 Mineral analysis of wheat/DECS flour blends.

Mineral elements play fundamental function in metabolic processes; among which consist of regulation of muscle contractions, transmitting of impulses, bone formation, maintenance of osmotic pressure among others (Peters *et al.,* 2019). The mineral analysis of wheat flour and defatted *E. cyclocarpum* flour blends, determined for copper, zinc, iron, magnesium, calcium, sodium, potassium and manganese were shown in Table 3. The results point out that DECS flour has high level of potassium (1090.55 mg/100mg), followed by magnesium (324.65 mg/100mg), sodium (46.45 mg/100mg), calcium (3.50 mg/100mg) and iron (3.45 mg/100mg). Potassium is an essential mineral element which is involved in regulating the blood pressure, while calcium is required in building strong teeth and bone, muscle concentration, blood clotting, regulating heart beat and fluid balance within cells (Grace *et al.,* 2015). Magnesium works with calcium to sustain healthy bones and hearth. Defatted *E. cyclocarpum* seed flour can be good source of potassium, magnesium and sodium. Food compounded with DECS flour might help to avert deficiency of those minerals since the seed are rich in them (Ifedi and Ajayi, 2021). There was a gradual increase in the concentration of Mg, K, Na and Fe with the increased level of DECS flour in the various composite flours. Others like Zn, Mn and Ca were in moderate concentrations within all the groups. Magnesium contents of the sample ranged from 55.50 mg/100g (90:10) to 103.55 mg/100g (70:30). There was a significant increase ($p<0.05$) in the magnesium content between the samples blends. Potassium contents were 231.75 mg/100g, 295.10 mg/100g and 367.60 mg/100g for 90:10, 80:20 and 70:30 composite flours respectively. Potassium has been earlier revealed to play critical roles in maintaining fluid balance and proper functioning of the essential organs such as the brain, nerves, heart and muscle (Asouzu *et al.,* 2020). The gradual increase in the concentrations of these minerals with the increase level of DECS in the flour blends is majorly due to their abundance in DECS flour and might improve the nutritional composition of the end product if properly incorporated and processed.

Table 3. Mineral composition of wheat/DECS flour blends seed

Minerals (mg/100g)	Wheat flour	90:10	80:20	70:30	100% DECS
Ca	4.10	4.06	3.99	3.76	3.50
Mg	30.40	55.50	71.85	103.55	324.65
K	160.70	231.75	295.10	367.60	1090.55
Na	28.95	27.00	28.95	31.15	46.45
Mn	1.00	0.93	1.00	0.88	1.205
Fe	2.10	3.16	2.815	2.54	3.45
Cu	0.335	0.38	0.56	0.40	1.015
Zn	2.51	2.38	2.48	2.66	2.795
Na/K	0.18	0.12	0.015	0.08	0.04

100% wheat flour (100:00), 90 % wheat flour and 10% DECS (90:10), 80 % wheat flour and 20% DECS (80:20) , 70 % wheat flour and 30% DECS (70:30), 100 % DECS (00:100). DECS: defatted *E. cyclocarpum* seed

3.3 Functional properties of wheat/DECS flour blends

The functional properties of the wheat flour and other composite flours were displayed on **Table 4**. Functional properties of food materials help in determining its level of interaction with other food products. Food materials with good functional properties can be easily incorporated into other foods in order to produce good quality and acceptable end products (Ocheme *et al.,* 2018). Table 4 showed significant differences among the values recorded in the control and the experimental groups. In the wheat flour and wheat/DECS composite flour, the loose bulk density was higher in 90:10 substitutions than other groups while the lowest was seen in the control and 80:20 groups. The packed bulk density values compared favourably with each other within the groups. The water absorption capacity increased gradually from 1.38 g/g in the control (100:0) to 1.45 g/g in 70:30. Onuegbu *et al.* (2013) reported an increase in water absorption capacity that ranged from 2.05 g/g (100% wheat flour) to 2.52 g/g (80:20) in wheat/maize blend. The water absorption capacity showed that DECS flour can be incorporated into food formulations, especially those involving dough or batter handling as well as beverage. These findings agreed with the findings of Ubbor and Nwagogu, (2010). The oil absorption capacity decreased gradually as the level of substitution increases. The water absorption capacity values of 1.23 g/g, 1.24 g/g, 1.23 g/g and 1.22 g/g were correspondingly found for 100% wheat flour, 90:10, 80:20 and 70:30 in wheat/DECS flour blends. The swelling index decreased gradually from 1.43 g (90:10) to 1.05 g (wheat flour). The swelling index is the measure of the ability starch to absorb water and swell at room temperature. It is equally associated with the pattern of water-binding within the starch granules of the micelle network (Kolawole *et al.*, 2016). Consequently, the variation observed in the swelling index of the four blends might have resulted from different degree of associative forces in their starch granules and relationship with other macromolecules (Kolawole *et al.*, 2016). Similar outcomes were already revealed on defatted groundnut paste blends *by* Dauda *et al.* (2018).

Table 4. Functional properties of wheat/DECS flour blends

Parameters	Wheat flour	90:10	80:20	70:30	100% DECS
defatted *E. cyclocarpum* /wheat flours blends					
LBD (g/cm^3)	0.39±0.00^c	0.47±0.01^a	0.39±0.01^c	0.43±0.03^b	0.43±0.01^b
PBD (g/cm^3)	0.60±0.03^b	0.64±0.04^a	0.55±0.01^c	0.59±0.03^b	0.62±0.01^a
SI (g)	1.05±0.00^d	1.43±0.57^a	1.33±0.00^b	1.18±0.07^c	1.19±0.01^c
WAC	1.38±0.04^b	1.40±0.05^b	1.43±0.02^b	1.45±0.04^b	1.61±0.15^a
OAC	1.23±0.04^a	1.24±0.05^a	1.23±0.03^a	1.22±0.01^a	1.21±0.21^a

Values are expressed as mean ± SD. Values on the same row having the same letter as superscripts are not significantly different ($P \leq 0.05$). 100% wheat flour (100:00), 90% wheat flour and 10% DECS (90:10), 80% wheat flour and 20% DECS (80:20), 70% wheat flour and 30% DECS (70:30), 100% DECS (00:100). DECS: defatted *E. cyclocarpum* seed.

3.4 Pasting properties of wheat/DECS flour blends

The pasting properties of a food refer to the changes arising in the food as a result of the application of heat in the presence of water. These changes affect texture, digestibilitiy and end use of the application of heat in the presence of water. These changes affect texture, digestibility and end use of the food product. It is an important index in determining the cooking and baking qualities of flours (Gomez *et al.*, 2008), relating to the ability of food item to act in paste-like manner (Otegbayo *et al.*, 2006). The pasting properties of the wheat flour with DECS and other composite flours were displayed on **Table 5.** The addition of DECS flours significantly reduced the peak viscosity, trough, breakdown, final viscosity and set back value of the composite flours. This could be attributed to the reduction in starch gelatinization (Gomez *et al.*, 2008).

The peak viscosity represents the pastes strength from gelatinization; the maximum viscosity attained by gelatinized starch during heating in water (Adebowale *et al.*, 2011). The peak viscosity of various wheat/DECS flour blends ranged from 430.00 RVU (100% DECS) - 2116.67 RVU (100% wheat). 1118.00 RVU was obtained in 90:10; wheat/DECS blends while others were lower. The peak viscosity has been reported to be closely associated with the degree of starch damage. High starch damage results in high peak viscosity and starch binding capacity of the granules. High peak viscosity is an indication of the suitability of the blends for products requiring high gel strength and elasticity (Ojo *et al*., 2017). The reduction observed in the peak viscosity could be due to reduction of the starch content as well as interactions between the starch, fat, and protein contents of the blends. 90:10; wheat/DECS blends might then be more suitable viscosity related productions than the other substitutions.

Low breakdown viscosity was exhibited by the blends and is an indication of their ability to withstand breakdown during heating and shearing. According to Adebowale *et al.* (2008), high breakdown viscosity could reduce the ability of flour to withstand heating and shear stress during cooking. Breakdown viscosity ranged from 380.33 RVU (100% DECS) - 986.00 (100% Wheat) RVU. Breakdown viscosity values of 704.67 RVU, 634.33 RVU and 530.33 RVU were respectively obtained for 90:10 Wheat/DECS, 80:20 Wheat/DECS and 70:30 Wheat/DECS flour blends. The breakdown viscosity thus decreased with increasing levels of DECS in the flour substitution. This implies that the composite flours would not breakdown on heating and as such can find applications in foods processed by heating at high temperatures. Breakdown viscosity is the measure of the tendency of swollen starch granules to rupture when held at high temperatures and continuous shearing (Patindol *et al*., 2005). The decreased in Breakdown viscosity with increasing levels of DECS in the flour substitution is pinpointing the degree of paste stability (Akanbi *et al*., 2009).

Table 5. Pasting and rheological properties of wheat/DECS. flour blends

Parameters	**Wheat flour**	**90:10**	**80:20**	**70:30**	**100% DEC**
Peak viscosity (RVU)	2116.67±21.78[a]	1118.00±16.09[b]	885.00±5.57[c]	719.00±264[d]	430.00±2.00[e]
Trough viscosity(RVU)	1215.33±10.50[a]	413.67±10.69[b]	248.67±3.51[c]	187.33±1.53[d]	391.20±4.58[e]
Break Down (RVU)	896.00±26.51[a]	704.67±5.50[b]	634.33±0.57[c]	530.33±3.51[d]	380.33±2.51[e]
Final viscosity (RVU)	2786.33±2.51[a]	1056.00±3.44[b]	618.33±6.65[c]	437.67±3.21[d]	416.67±1.15[d]
Set back viscosity(RVU)	1568.00±7.21[a]	651.99±21.00[b]	368.00±3.46[c]	249.66±1.53[d]	180.33±1.52[e]
Peak Time (min)	6.12±0.00[b]	6.07±0.03[b]	4.97±0.03[c]	4.92±0.00[c]	6.30±0.13[a]
Pasting temperature (°C)	88.80±0.00[a]	83.70±0.48[c]	83.70±0.48[c]	83.57±0.45[c]	86.27±0.09[b]

Values are expressed as mean ± SD. Values on the same row having the same letter as superscripts are not significantly different ($P \leq 0.05$). 100% wheat flour (100:00), 90 % wheat flour and 10% DECS (90:10), 80% wheat flour and 20% DECS (80:20), 70% wheat flour and 30% DECS (70:30), 100% DECS (00:100). DECS: defatted *E. cyclocarpum* seed.

The final viscosity is the ability of starch to form a viscous paste on cooling. The final viscosity of composite flours in this study ranged from 416.67 to 2786.33 RVU. This viscosity was highest in wheat flour (2786.33 RVU) as compared to 1056.00 RVU obtained in the 90:10 (wheat/DECS) blends. The final viscosity decreased with increasing level of DECS flour substitution. 1056.00 RVU, 618.33 RVU and 437.67 RVU were respectively obtained in 90:10 (wheat/DECS), 80:20 (wheat/DECS) and 70:30 (wheat/DECS) blends. The decrease in final viscosity might be due to weak aggregation of amylose molecules which is indicative of slow retrogradation of the molecules.

The Pasting time is the measure of the cooking time. It is equally referred to as the time at which the peak viscosity occurred in minutes (Adebowale *et al*., 2005). The pasting time obtained in this study varied from 6.30 (100% DECS) to 4.92 min (70:30; wheat/DECS flour blend). The values of 6.30, 6.12 and 6.07 mins were respectively obtained in 100% DECS, 100% wheat flour and 90:10 (wheat/DECS flour blend). The peak time of the composite flour decreased with an increasing level of DECS flour substitution. Low peak time observed in the flour blends may be due to reduced starch content as a result of DECS flour substitution. However, low peak time is indicative of its ability to cook fast

(Ikegwu *et al*., 2010). The gradual reduction observed in pasting parameters (peak, trough, breakdown, set back, and final viscosities) of the various flour blends might have resulted from a decrease in their carbohydrate content in addition to the higher protein value attributed to the composite flour. Protein forms complex with starch thereby preventing it from releasing exudates which then lower the viscosity of the flour (Chinma *et al*., 2012). Similar findings were reported by Ohizua *et al.* (2017) and Kiin-Kabari *et al*. (2015).

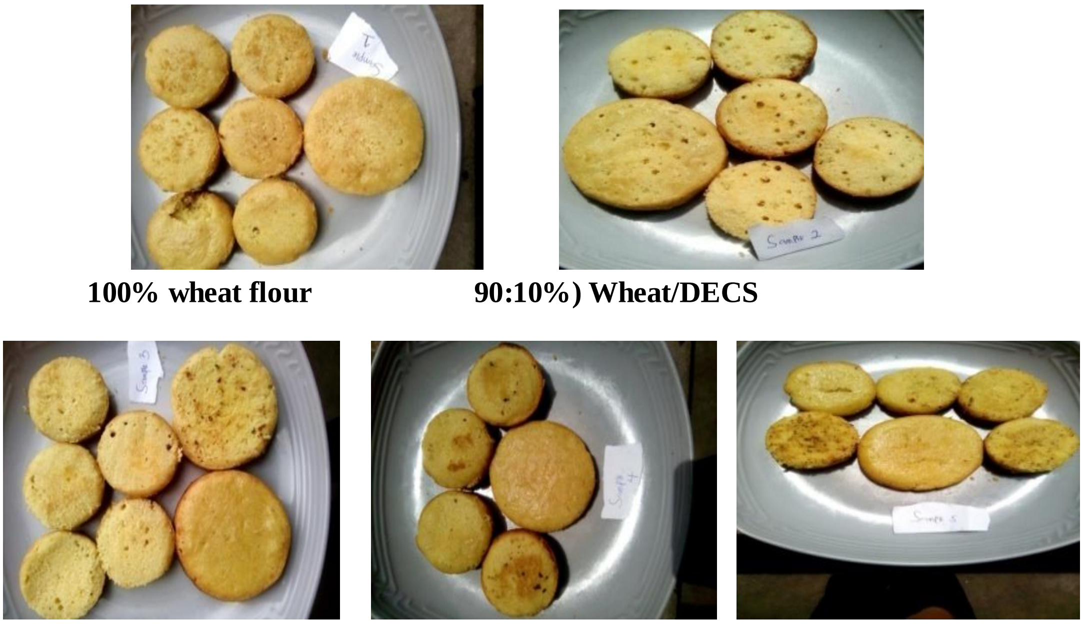
3.5 The physical properties of the cakes from wheat/DECS flour blend

The physical characteristics of the cakes produced such as: weight, height, volume and specific volume measured after baking are shown on **Table 6**. The cake samples were presented in **Fig.1.** Significant differences were observed among the cake samples in terms of their physical properties. The weight of the cake samples ranged from 24.83 g (90:10; wheat/DECS) to 25.66 g (100 % DECS) while 25.12 g, 25.31 g and 25.66 g were respectively recorded in 80:20, 70:30 and 100 % wheat. The highest weight of 25.66 g from cake made from 100% DECS flour is an indication that DECS flour is heavier than wheat flour and other composite flours. The heights of the cakes were 2.28 cm and 2.15 cm in 100% wheat and 90:10. (wheat/DECS) cakes while others were 2.10 cm, 2.10 cm and 1.90 cm (80:20, 70:30 and 100% DECS).

Table 6: Physical properties of cakes from wheat/DECS flour blends

Parameters	100:00	90:10	80:20	70:30	00:100
		Wheat flour/*E. cyclocarpum* seed cake			
Weight (g)	25.02±0.48^{b}	24.83±0.63^{b}	25.12±0.74^{b}	25.31±0.40^{a}	25.66±0.90^{a}
Height (cm)	2.28±0.12^{a}	2.15±0.18^{a}	2.10±0.12^{a}	2.10±0.12^{b}	1.90±0.18^{b}
Volume (cm^{3})	606.28±19.98^{a}	606.21±31.04^{a}	604.96±32.18^{a}	600.45±49.43^{b}	577.09±22.21^{c}
Specific volume(cm^{3}/g)	24.23±0.74^{b}	24.41±1.74^{a}	24.06±1.04^{bc}	23.71±1.39^{bc}	22.50±1.04^{d}

Values are expressed as mean ± SD. Values on the same row having the same letter as superscripts are not significantly different ($P \leq 0.05$). 100% wheat flour (100:00), 90 % wheat flour and 10% DECS (90:10), 80% wheat flour and 20% DECS (80:20), 70% wheat flour and 30% DECS (70:30), 100% DECS (00:100).



100% wheat flour **90:10%) Wheat/DECS**

(80:20%) Wheat/DECS **(70:30%) Wheat/DECS** **100% DECS**

Figure 1. Sample of cakes produced from wheat/DECS flour blends. DECS: defatted *E. cyclocarpum* seed

The slight decrease observed in the height of the cakes might be because of the high content of gluten present in wheat that promotes the rising of the cake in the presence of heat. A similar observation was reported by Emmanuel *et al*. (2012) and Ubbor *et al*. (2022) for cakes made from wheat/beniseed and wheat/red banana flour blends. There were no significant differences at $P \leq 0.05$ among the volumes (606.28 cm^3, 606.21 cm^3, 604.96 cm^3 and 600.45 cm^3) of the cakes produced from 100% wheat flour, 90:10, 80:20 and 70:30 wheat/DECS flour blends respectively while the 100% DECS flour had the lowest (577.09 cm^3). The difference in the cake volume was minimal with the increasing level of DECS flour. The specific volume of substituted cake decreases with increasing substitution level of DECS flour, 24.23 cm^3/g was obtained for cake produced from wheat flour while 24.41 cm^3/g, 24.06 cm^3/g and 23.71 cm^3/g were respectively observed for cakes made from 90:10, 80:20 and 70:30 wheat/DECS flour. Cake from 90:10 (wheat/DECS flour) with highest specific volume (24.41 cm^3/g), similar to that of wheat (24.23 cm^3/g) might be better than those in 80:20 and 70:30 wheat/DECS flour.

3.6 Sensory evaluation of cakes from wheat/DECS flour blends

Table 7 revealed the sensory evaluation and general acceptability of different cakes produced from wheat/DECS flour blended. The parameters studied such as taste, appearance, aroma and overall acceptability were significantly different at $p \leq 0.05$ in various cake samples as observed in the sensory attributes. The cake with 30% DECS substitution had high values for taste, appearance, and texture while the lowest values are obtained in cake prepared with 100% wheat flour. The slight changes in colour might be due to thermal effect on reactions between amino acids and sugars (Be-miller and Whistler, 1996; Alobo, 2001). The texture acceptable values increased from 5.70 (100% Wheat flour) to 7.25 (70:30; wheat/DECS flour). Other values were 6.15 and 6.70 in 90:10 and 80:20 (DECS/wheat flour). The significant differences observed with regard to texture might be attributed to the reduction of gluten due to the increase in the incorporation of DECS flour on the cake. The overall acceptability was 7.55 (70:30; wheat/DECS blend); 7.20 (80:20; wheat/DECS flour blend); 6.90 (100% wheat flour); and 6.70 (90:10; wheat/DECS flour blend).

Table 7. Sensory evaluation of cakes from whet/DECS flour blends

Parameters	100:00	90:10	80:20	70:30	00:100
Taste	6.10 ± 1.74^{ab}	6.90 ± 2.07^{ab}	7.50 ± 1.23^{a}	7.80 ± 1.60^{a}	4.15 ± 2.75^{c}
Colour	7.00 ± 1.65^{a}	7.05 ± 1.43^{a}	7.65 ± 0.93^{a}	7.85 ± 0.93^{a}	7.10 ± 1.65^{a}
Appearance	7.00 ± 1.65^{a}	7.15 ± 1.35^{a}	7.15 ± 1.09^{a}	7.60 ± 1.18^{a}	7.15 ± 1.22^{a}
Texture	5.70 ± 1.68^{b}	6.15 ± 1.81^{ab}	6.70 ± 1.68^{ab}	7.25 ± 1.37^{a}	6.95 ± 1.60^{a}
Crumb colour	6.70 ± 1.78^{b}	6.80 ± 1.67^{b}	7.30 ± 1.30^{a}	7.50 ± 1.14^{a}	6.85 ± 1.42^{b}
Crust colour	6.70 ± 1.28^{c}	7.10 ± 1.55^{ab}	8.00 ± 1.02^{a}	7.90 ± 1.16^{a}	7.00 ± 1.52^{bc}
Aroma	6.60 ± 0.34^{a}	6.25 ± 1.86^{a}	6.25 ± 1.97^{a}	6.65 ± 1.26^{a}	6.15 ± 2.10^{a}
Overall acceptability	6.90 ± 1.41^{ab}	6.70 ± 1.59^{ab}	7.20 ± 1.28^{ab}	7.55 ± 1.14^{a}	6.50 ± 1.79^{b}

Values are expressed as mean ± SD. Values on the same row having the same letter as superscripts are not significantly different ($P \leq 0.05$). 100% wheat flour (100:00), 90% wheat flour and 10% DECS (90:10), 80% wheat flour and 20% DECS (80:20), 70% wheat flour and 30% DECS (70:30), 100% DECS (00:100).

The incorporation of DECS flour resulted in better aroma, taste, appearance and overall acceptability of the cake made from 70:30; wheat/DECS flour blend. The observed overall acceptability from the panelist might be due to the high nutrients contents of *E. cyclocarpum* seeds and fruits (Babayemi, 2006; Ojo *et al*., 2018; Ekanem *et al*., 2022). The seeds were equally reported to have good nutritional potentials (Ojo *et al*., 2018). The results of the sensory evaluation of the various cakes as revealed in **Table 4**, showed better and higher acceptability in the cake made from 70:30 wheat/DECS flour bend.

It was equally observed that the sensory parameters of cake produced from 90:10 wheat/DECS flour bend compared favourably with that from 100% wheat flour. *E. cyclocarpum* seed flour was suggested in a previous report to be suitably used at 10% inclusion level to fortify conventional seed flour having little amount of protein (Ifedi and Ajayi, 2021). DECS might be therefore considered up to 30% as a potential substitute for nutritionally enriched baked products if properly processed.

3.7 Haematology analysis of the blood of rat fed on cakes from wheat/DECS flour blends

Cakes produced from wheat and DECS blends were used to feed rats and their effect on the blood haematology of the rats was recorded on **Table 8.** The parameter investigated include, PVC, Hb, RBC, WBC, Platelets, MCV, MCH and MCHC. The study revealed no significant discrepancies among the tested groups regarding the parameters mentioned above, as they had good comparison. In the rat fed with dietary cakes from wheat/DECS flour blends, PVC values of 41.33%, 41.33%, 42.33% and 43.33% were respectively recorded for 100% wheat, 90:10, 80:20 and 70:30 with/DECS flour blends. There was a slight increase in PVC from 41.33 (90:10) to 43.33 (70:30). The similarity observed from this haematology results revealed that the cakes produced from wheat/DECS flour blends had no abnormal effect on the blood as well as on the organs of the rats. DECS might be therefore considered as safe potential substitute for nutritionally enriched baked products.

Table 8. Haematology analysis of the blood samples from rat fed with cakes from wheat/DECS flour blends

Parameters	100 % Wheat flour	90:10	80:20	70:30	100% Sample
Haematology of rat fed with cakes produced from defatted *E. cyclocarpum*/wheat flours blends					
PCV (%)	41.33±0.57[a]	41.33±1.52[a]	42.33±0.57[a]	43.33±3.70[a]	40.67±0.57[a]
Hb (mg/dl)	13.70±0.60[a]	13.87±0.56[a]	14.43±0.75[a]	14.13±1.33[a]	13.53±0.15[a]
RBC (10^6/µl)	6.31±1.54[a]	6.84±0.31[a]	7.24±0.22[a]	7.06±0.49[a]	6.56±0.15[a]
WBC (10^3/µl)	7.76±2.1[a]	6.16±1.46[a]	7.20±2.30[a]	6.80±1.61[a]	6.86±1.20[a]
Platelets(10^3/µl)	141.00±36.59[a]	125.67±5.50[a]	159.67±32.13[a]	134.00±7.21[a]	127.33±13.05[a]
MCV (%)	68.30±17.63[a]	59.63±2.30[a]	58.83±1.38[a]	61.00±1.73[a]	61.93±1.80[a]
MCH (%)	22.53±5.31[ab]	20.24±0.15[a]	19.93±0.40[a]	19.96±0.55[a]	20.63±0.70[a]
MCHC (%)	33.13±1.00[a]	33.55±0.79[a]	34.08±1.29[a]	32.59±0.29[a]	33.28±0.54[a]

Values are expressed as mean ± SD. Values on the same row having the same letter as superscripts are not significantly different (P ≤ 0.05). 100% wheat flour (100:00), 90 % wheat flour and 10% DECS (90:10), 80 % wheat flour and 20% DECS (80:20), 70 % wheat flour and 30% DECS (70:30), 100 % DECS (00:100).

3.8 Effect of cakes from wheat/DECS flour blends on the weight gain and survival rate of rats

The impact of cakes made from wheat/DECS flour blends on the performance of rats was presented in **Figure 2**. No significant differences were observed in the survival rate of the rats across all experimental groups, as none of them died. This is an indication that the various cakes produced were not in any way toxic to the rat as buttressed by the blood haematological studies. There were significantly differences at p≤0.05 in the growth parameters. There was a gradual decrease in the weight gain, percentage weight gain and specific growth rate as the substitution of DECS increases. The group with 30% DECS had the lowest weight gain, percentage weight gain and specific growth rate. This is an indicating that *E. cyclocarpum* seed might contain some antinutrients that adversely affected the rats' weight when present in higher concentrations in the cakes. It might be as a result of secondary metabolites (tannins, saponins, oxalate, phytate, hydrocyanic acid, trypsin inhibitors and alkaloids) which are present in varying quantities in *E. cyclocarpum* seeds (Ekanem *et al.*, 2020). Therefore, it is not recommended to use DECS at 30% substitution level in the production of dietary cakes without proper refining process, except in situations where weight loss benefits an individual's health. The percentage weight gain of 62.78, 58.53, 56.35 and 51.11 were obtained in 100% wheat flour; 90:10; DECS/wheat blend); 80:20; DECS/wheat blend and 70:30; DECS/wheat flour blend respectively. Similar results were obtained on daily weight gain when graded levels (0, 10, 20, and 30%) of toasted *E. cyclocarpum* seeds were fed to WAD rams to assess their growth performance and nutrient digestion (Idowu *et al.*, 2013).

Enterolobium cyclocarpum seeds in a previous work were fed to rat at different substitution levels (0, 10, 20 and 30%) to evaluate the suitability of the seed flour for nutritional purposes and the effect on the growth performance, feed intake, blood parameters and its histological status. Rats on diet with 10% *E. cyclocarpum* seeds had a higher % weight gain than those fed on diet 20 % and 30%. A gradual decrease in the % weight gain was reported with increasing level of *E. cyclocarpum* seeds flour in the feeds (Ifedi and Ajayi, 2021).

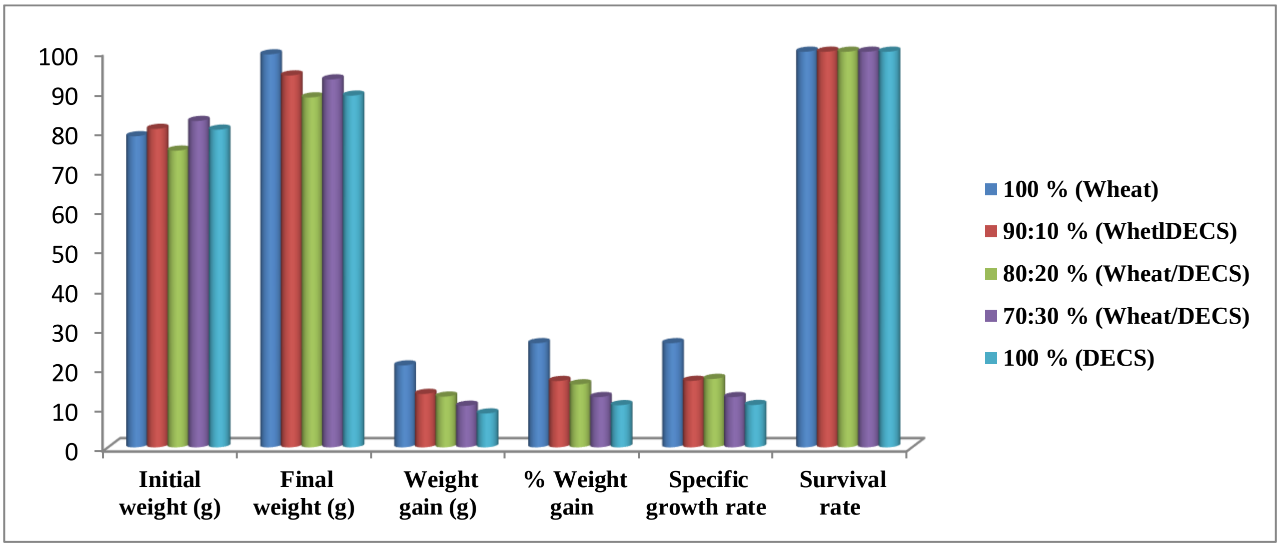


Figure 2: Effect of cakes from wheat/DECS flour blends on the body weight gain and survival rate of rats DECS: defatted *E. cyclocarpum* seed.

4.0 Conclusion

Rising awareness of health and nutrition has increased demand for affordable, nutrient-rich foods. Modifying existing products with locally available raw materials offers a practical solution. Wheat/DECS flour blends showed improved proximate composition, mineral content, and functional properties compared to 100% wheat flour, with the best sensory qualities observed in cakes made from a 70:30 DECS/wheat blend. Slight reductions in cake weight, height, and volume occurred as DECS level increased. The haematological analysis revealed no adverse effects on blood or organs of rats fed with the cakes, though a gradual decrease in weight was observed at 30% substitution. The decrease might be likely due to the antinutritional factors present in *E. cyclocarpum* seeds (Ekanem *et al.*, 2020). 10% DECS/wheat blend revealed good pasting and rheological properties, highest percentage weight gain, and some physical properties of cakes (volume, height, volume) comparable to those obtained in the control (Wheat/DECS flour blends). These results suggest that DECS flour could be a valuable ingredient in bakery products without any adverse effect at 10%. Further research should optimize processing, assess nutritional composition, and explore functional uses of defatted *E. cyclocarpum* flour at inclusion level greater than 10%. This work builds on our previously published study investigating the effects of defatted *E. cyclocarpum* seed meal on the growth, haematological, and histological characteristics of Wistar rats (Ifedi and Ajayi, 2021).

Conflict of interest statement

We declare that we have no conflict of interest in the cause of this experiment.

Acknowledgements

The author wishes to acknowledge the Department of Chemistry, Faculty of Science and Veterinary Pathology unit, Faculty of Veterinary, University of Ibadan, Ibadan, Nigeria for making their facilities available for this study.

Compliance with Ethical Standards: The animal study was approved by the Ethical Committee of the Institute for Advanced Medical Research and Training, College of Medicine, University of Ibadan, Nigeria (approval number UI/EC/15/208) and conducted in compliance with international guidelines on animal experimentation and biodiversity rights.

References

Adebowale, A. A., Sanni, L. O. and Fadahunsi, E. L. (2011). Functional and pasting properties of cassava-sweet potato starch blends. *African Journal of Root Tuber Crop*, 9(1), 6-10.

Adebowale, A. R. A., Sanni, S. A. and Oladapo, F. O. (2008). Chemical, functional and sensory properties of instant yam-breadfruit flour. *Nigerian Food Journal*, 26(1), 2-12.

Adebowale, Y. A., Adeyemi, I. A. and Oshodi, A. A. (2005). Variability in the physicochemical, nutritional and antinutritional attributes of six *Mucuna* species. *Food Chem.* 89, 37-48.

Ajayi, I. A., Oderinde, R. A., Kajogbola, D. O. and Uponi, J. I. (2006). Oil content and fatty acid composition of some underutilised legumes from Nigeria. *Food Chemistry* 9.9, 115-120.

Akajiaku, L. O., Nwabueze, T. U. and Onwuka, G. I. (2024). Functional and pasting properties of mechanically dehulled toasted African breadfruit (*Treculia africana*) seed flour as affected by pretreatments. *Mathews Journal of Nutrition* and *Dietetics*. 7(1),1-12.

Akanbi, T. O., Nazamid, S., Adebowale, A. A. (2009). Functional and pasting properties of a tropical breadfruit (*Artocarpus altilis*) starch from Ile-Ife, Osun State, Nigeria. *International Food Research Journal*, 16, 151-157.

Alobo A.P (2001). Effect of sesame seed flour on millet biscuit characteristics plant. *Food Human Nutrition*, 56,195-200.

AOAC (2012). Official methods of analysis of AOAC International (19th ed.), Gaithersburg, M.D. USA. Asouzu, N. N., Oly-Alawuba, A. I. and Umerah, N. M. (2020). "Functional properties and chemical composition of composite flour made from cooking banana (*Musa Paradisiaca*) and yellow maize (Zea Mays)." *Res. J. Food Nutr*. 4(2), 6-12.

Atef, A. M. A., Mostafa, T. R. and Samia, A. A. (2011). Utilization of faba bean and cowpea flours in gluten free cake production. *Australian Journal of Basic and Applied Sciences*, 5(12), 2665-2672.

Babayemi, O. J. (2006). Anti-nutritional factors, nutritive value and in vitro gas production of foliage and fruit o f *Enterolobium cyclocarpum*. *World Jour. of Zoology*, 1(2), 113- 117.

Banua, M., Kaur, J., Bhadariya, V., Singh, J. and Sharma, K. (2021). Role of consumption of composite flour in the management of lifestyle disorders. *Plants Achives*, 21(2), 201-214.

Be-miller J.N and Whistler R.L (1996). Carbohydrates. In, Fernnema O.R. (ed) Food Chemistry 3rd Ed. New York. *Marcel Dekker Inc.* 157-253.

Chinma , C. E., Alemede, I. C., and Emelife, I. G. 2008. Physicochemical and functional properties of some Nigerian cowpea varieties. *Pakistan Journal of Nutrition* 7.1, 186-190.

Chinma, C. E., Igbabul, B. D. and Omotayo, O. O. (2012). Quality characteristics of cookies prepared from unripe plantain and defatted sesame flour blends. *Am. J. Food Technol*, 7, 398-408.

Dambazau, S.A., Jayasree, K.M. and Tajuddeen, A. (2021). Contemporary Issues of Wheat Production in Nigeria, A Review. International Journal of Agricultural Economics and Rural Development, 11(1), 12-21.

Dauda, A. O., Abiodun, O. A., Arise, A. K. and Oyeyinka, S. A. (2018). Nutritional and consumers' acceptance of biscuit made from wheat four fortified with partially defatted groundnut biscuit made from wheat four fortifed with partially defatted groundnut paste. LWT Food Sci Technol, 90,265-269. https,//doi.org/10.1016/j.lwt.2017.12.039.

Dawi, A. W., Okpo, N. O., Alalade, O. M and Tahir, Z. H. (2022). Proximate, Functional and Sensory Evaluation of Cake Produced from Composite Mixture of African Locust Bean Fruit Pulp (*Parkia Biglobosa*) Flour and Wheat Flour. *Dutse Journal of Pure and Applied Sciences* (DUJOPAS), 8 (2a), 245-255.

Dharsenda, T. L and Dabhi, M. (2020). "The effect of peanut (Arachis hypogaea L.) flour on the quality and sensory analysis of cookies." *Mod. Technol. Agric. For. Biotechnol. Food Sci*, 9(2), 403-406.

Eid, W.A.M., Abdelgalil, Z.A.H., Abd-Elsattar, H.H. et al. (2025). Evaluation of the Quality of Wheat and Millet Composite Flour and Application for Production Biscuits Fortified with White Sweet Potato Flour. *Food Anal. Methods* 18, 657–669, https://doi.org/10.1007/s12161-024-02739-x

Ekanem, N. J., Inyang, U. A. and Ikwunze, K. (2022). Chemical composition, secondary metabolites and nutritive value of elephant-ear tree (Enterolobium cyclocarpum (Jacq.) Griseb), A review. *Nig. J. Anim. Prod*, 49(2), 277-286.

Ekanem, N. J., Okah, U. Ahamefule, F. O., Ifut, O. J., Ikwunze, K., Udoh, E. F., Edet, H. A. and Orok, A. M. (2020). Effect of method of preservation on the chemical composition of Enterolobium cyclocarpum leaves. *Nigerian Journal of Animal Produc*, 47(1), 246-256.

Giami, S. Y and Baeber, L. I (2004). Utilization of protein concentrates from ungerminated and germinated fluted pumpkin (*Telforiria occidentalis*. Hook) seeds in cookies formulation. *Journal of the Science of Food and Agriculture*, 84, 1901-1907.

Gomez, M., B. Oliete, C. M., Rosell, V. and Fernandez, E. (2008). Studies on cake quality made of wheat-chickpea flour blends. *LWT-Food Sci. Technol*, 41, 1701-1709.

Grace, U., Elijah, A. and Nicholas, A. (2015). "Vitamin and mineral evaluation of mixed fruit jam from blends of pineapple, orange and sourplum." *Pakistan J. Food*, 25(3), 137-143.

Guyih, M. D., Dinnah, A. and Eke, M. O. (2020). "Production and quality evaluation of cookies from wheat, almond seed and carrot flour blends." *Int. J. Food Sci. Biotechnol*. 5(4)55.

Ibitoye, W. O., Afolabi, M. O., Otegnayo, B. O. and Akintola, A. C. (2013). Preliminary studies of the chemical composition and sensory properties of sweet potato starch wheat flour blend noodles. Nigeria Food Journal, 31(2), 48-51.

Idowu, O. J., Arigbede, O. M., Dele, P. A., Olanite, J. A., Adelusi, O. O., Ojo, V. O. A. and Sunmola, A. S. (2013). Nutrient intake performance and nitrogen balance of West African Dwarf sheep fed graded levels of toasted Enterolobium cyclocarpum seeds as supplement to Panicum maximum. *Pakistan Journal of Biological Sciences*, Pp. 1-5.

Ifedi, E. N. and Ajayi, A. I. (2021). Physical, chemical analyses and possible effect of *E. cyclocarpum* seed meal on growth, haematological and histological properties of wistar rat. *Annals of Food Science and Technology*, 22(3), 378-389.

Ikegwu, O. J., Okechukwu, P. E., and Ekumankana, E. O. (2010). Physico-chemical and pasting characteristics of flour and starches from Achi Brachystegia seed. *Journal of Food Technology* 8(2), 58-66.

Ikpeme-Emmanuel, C. A., Ekpeyoung, I. O. and Igile, G. O. (2012). Chemical and Protein Quality of Soybean and Tigernut (Cyperus esculentus) Based weaning food. *Journal of Food Research*,1(2), 246-2

Jain, N. L. (1986). Schalme's Veterinary Haematology, 4th Edition, Lea and Ferbiger, Philadelphia, pp 28

Kiin-Kabari, D. B., Eke-Ejiofor, J., & Giami, S. Y. (2015). Functional and pasting properties of wheat/plantain flours enriched with Bambara groundnut protein concentrate. International *Journal of Food Science and Nutrition Engineering*, 5(2), 75-81.

Kolawole O. F. and Chidinma A. O. (2015). Physical, functional, and pasting properties of flours from corms of two Cocoyam (*Colocasia esculenta* and *Xanthosoma sagittifolium*) cultivars. *Journal of Food Science and Technology*, 52(6),3440-3448.

Kolawole, F. L, Balogun, M. A, Usman, F. D., Akeem, S. A. (2016). Efect of drying methods on the chemical and functional properties of potato (*Solanum tuberosum*) and sweet potato (*Ipomoea batatas*) varieties. *Nig J Agric Food Environ*,12(4), 151-6.

Loukili E.H., Merzouki M., Taibi M., Elbouzidi A., Hammouti B., Yadav K. K., Khalid M., Addi M., Ramdani M., Kumar P., Choi J. R. (2024), Phytochemical, biological, and nutritional properties of the prickly pear, Opuntia dillenii: A review, *Saudi Pharmaceutical Journal*, 32(10), 102167, ISSN 1319-0164, https://doi.org/10.1016/j.jsps.2024.102167

Mbaka, G. O., Adeyemi, O. O. and Oremosu, A. A. (2010). Acute and sub-chronic toxicity studies of the ethanol extract of the leaves of Sphenocentrum jollyanum (Menispermaceae). *Agricultural Biology Journal of North America*, 1, 265-272.

Nwosu, U. L., Elochukwu C. U. and Onurah C. O. (2014). Physical Characteristic and Sensory Quality of Bread Product from Wheat/African oil Bean flour Blends. *African Journal of Food Science*, 8(6), 351-355.

Ocheme, O. B., Adedeji, O. E., Chinma, C. E., Yakubu, C. M. and Ajibo, U. H. (2018). Proximate composition, functional, and pasting properties of wheat and groundnut protein concentrate flour blends. *Food Science and Nutr*, 6(5),1173-1178.

Ohizua, E. R., Adeola, A. A.. Idowu, M. A., Sobukola, O. P., Afolabi, T. A., Ishola, R. O., Ayansina, S. O., Oyekale, T. O. and Falomo, A. (2017). Nutrient composition, functional, and pasting properties of unripe cooking banana, pigeon pea, and sweet potato flour blends. *Food Science Nutrition*, 5(3), 750-762.

Ojo, M. O., Ariahu C. C. and Chinma, E. C. (2017). Proximate, functional and pasting properties of cassava starch and mushroom (*Pleurotus Pulmonarius*) flour blends*." American Journal of Food Science and Technology*, 5.1, 11-18.

Ojo, V. O., Akinade, G. A., Fasae, O. A. and Akinlolu, A. O. 2018. Effect of treatment methods on the nutritive quality of elephant-ear seeds (*Enterolobium Cyclocarpum* Jacq Griseb) as feed for ruminant production. *Journal of Tropical Agricultural Science*. 41.1, 453-462.

Olatunde, S. J., Ajayi, O. M., Ogunlakin, G. O. and Ajala, A. S. (2019). Nutritional and sensory properties of cake made from blends of pigeon pea, sweet potato and wheat flours. *Food Research* 3 (5), 456-462.

Onuegbu, N. C., Ihediohanma, N. C., Odunze, O. F and Ojukwu, M. (2013), Efficiency of wheat, maize composite flour as affected by baking method in bread and cake production. *Sky Journal of Food Science*, 2(8), 005-013.

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R. and Anthony, S. (2009). Agrofores tree Database, a tree reference and selection guide version 4.0 (http,//www.worldagroforestry.org/ sites/treedbs/treedatabases.asp).

Otegbayo, B. O., Aina, J.O. and Asiedu, R. (2006), Effect of Storage on the Pasting Characteristics of Yam Starches. *Proceedings of 30th annual Conference of Nigerian Institute of Food Science and Technology*, P. 187-188.

Patindol, J., Wang, Y. and Jane, J. (2005). Structure-Functionality Changes in Starch following Rough Rice storage. *Starch/starke*, 57, 197-207.

Peters, H., Mgbang, J. E., Essien, N. A., Ikpeme, C. E. (2016). Nutritional Evaluation of Breadfruit and Beniseed Composite Flours. *American Journal of Food Science and Technology*, 4(6), 182-187.

Ubbor, S. C and Nwagogu, C. F. (2010), production and evaluation of noodles from flour blend of cocoyam, bread fruit and wheat. *Nigerian Food journal*, 28(1), 173-198.

Ubbor, S. C., Ezeocha, V. C., Arukwe, D. C., Ekeh, J. I., Iguh, B. N. and Jackson, A. S. (2022). Production and quality evaluation of cake from wheat and red banana flour blends. *Science World Journal*, 17(3), 413-420.

Vargas-Radillo, J. J., Ramírez, R. R. and Ramírez, L. B. (2021). "Chemical Composition of Seed *Enterolobium cyclocarpum* (Jacq.) Griseb from Jalisco, México". *Acta Scientific Veterinary Sciences*, 3(4), 44-49.