

Nutritional composition and sensory evaluation of cookies supplemented with defatted coconut and tiger nut flour

Olasunmbo A. Ajayi*, and Anjolaoluwa M. Adekunle-Aremu

Food Science and Technology Programme, College of Agriculture, Engineering and Science, Bowen University, P. M. B. 284, Iwo, Osun State, Nigeria.

*Corresponding author. Email: olasunmbo.ajayi@bowen.edu.ng

Copyright © 2025 Ajayi and Adekunle-Aremu. This article remains permanently open access under the terms of the [Creative Commons Attribution License 4.0](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Received Date: 24 January 2026 | Accepted Date: 20 February 2026 | Published Date: 30 April 2026

ABSTRACT: Cookies are ready-to-eat snacks, popularly consumed between meals. However, cookies are high in calories but low in nutritional value. The overall objective of this research is to produce more nutritious cookies. Five cookie samples were produced, using a composite of defatted tigernut, defatted coconut and wheat flour blend. Namely, WFC= 100 % wheat cookies; CTWC= 5:5:90 coconut: tiger nut: wheat cookies; TWC= 20:80 tiger nut: wheat cookies; CWC= 20:80 coconut: wheat cookies; and CTC= 50:50 coconut: tiger nut cookies. The functional properties of the composite flour, physical, nutritional, and water activity properties of cookies were analysed using standard methods. Water, oil absorption capacity, bulk density, foaming capacity and swelling index of the composite flour ranged from (0.31 to 0.78 g/mL); (0.36 to 0.73 g/mL); (0.44 to 0.66 g/mL); (5.6 to 12.7 %); and (10.0 to 11.0 mL), respectively. Moisture, protein, fat, fibre and ash contents ranged from (5.70 to 8.10 %); (14.88 to 17.94 %); (10.90 to 14.13 %); (2.14 % to 2.58 %) and (1.60 to 2.66 %) respectively. Water activity ranged from 0.23 to 0.35, and sample CTC had the lowest value. Sensory scores indicated that panellists preferred samples WFC and CTWC, which were rated best overall in most of the parameters assessed. Shelf-life study showed that cookie samples stored for 3 months at refrigeration temperature (9±2°C) had all organoleptic properties intact. Conclusively, the nutritional content of ready-to-eat cookies is improved by the addition of defatted coconut and tiger nut flour.

Keywords: Cookies, composite flour, defatted coconut, defatted tigernut.

INTRODUCTION

Many individuals, including children, travel long distances for education or employment and may not have enough time to prepare a meal; therefore, they rely on snack foods (Nehir *et al.*, 2018). Among ready-to-eat snacks are cookies, which are widely consumed by the young and old (Noah, 2018). Cookies can be produced from single or composite flours with the addition of other ingredients such as fat, sugar, egg, salt, baking powder and milk, to improve the properties of the flour and nutritional composition of the cookies (Puglisi and Fernandez, 2022; Ruxton *et al.*, 2010). Cookies can also be fortified to contain digestive and dietary fibre and minerals of vital importance (Olaoye *et al.*, 2019). However, there are some drawbacks to the excessive consumption of cookies, since they tend to be high in refined sugar and saturated fats. They are generally considered unhealthy, and excessive consumption can be

a risk factor for developing type II diabetes, obesity, and Alzheimer's disease (Laveena and Rupali, 2013). Further, across the globe, more than 1.6 billion people over 15 years old are overweight or obese (Llopis and Haros, 2025).

Wheat (*Triticum aestivum*) is the third most important cereal crop after maize and rice, with world production of 695 million metric tons annually (Tamirat and Mekides, 2020). Wheat farming has proven complicated in Nigerian agriculture, due to the high environmental temperatures; hence, wheat is imported mostly (Haruna *et al.*, 2017). Furthermore, some individuals are also considered to be gluten intolerant. Protein plays an essential role in human nutrition, since it provides energy and contributes to repairing tissues. Hence, consumption of high-quality protein is vital in a diet. Although wheat contains a

significant amount of protein, it is low in lysine and threonine and mostly gluten (Urošević *et al.*, 2023). The addition of gluten-free tigernut and coconut flour can greatly improve the nutritional quality of the resulting baked product.

Tiger nut (*Cyperus esculentus* L.) is an edible perennial grass-like plant and a lesser-known vegetable, which produces sweet nut-like tubers known as “earth almonds” (Coskuner *et al.*, 2002). *C. esculentus* has been reported to be a “healthy” food since its consumption can help prevent heart disease and thrombosis and is said to activate blood circulation (Gambo and Da’u, 2014). Tiger nut has also been found to assist in reducing the risk of colon cancer (Edo *et al.*, 2023). This tuber is rich in energy content (starch, fat, sugar, and protein), minerals (mainly phosphorus and potassium), and vitamins E and C, thus making it suitable for diabetics and for those intending to lose weight (Sánchez-Zapata *et al.*, 2012). By-products from the tiger nut tuber include tiger nut milk, tiger nut oil, and tiger nut flour (Sánchez-Zapata *et al.*, 2012).

Coconut (*Cocos nucifera* L.) is an important fruit tree in the world, consumed by individuals and often called the “tree of life” (DebMandal and Mandal, 2011; Noah, 2018). Coconut flour is from coconut residue, a by-product of coconut milk extraction. Furthermore, coconut flour provides not only value-added income to the industry but also a nutritious and healthy source of dietary fibre, free of trans-fatty acids and low in digestible carbohydrates. It plays a role in controlling cholesterol and sugar levels in the blood (Gunathilake *et al.*, 2009).

As previously mentioned, cookies are high in carbohydrates and fats and are popularly consumed by young and older adults to pacify hunger and can be made more nutritious by improving the nutritional content. Efforts are ongoing to improve the nutritional composition of cookies by using composite flours from various grains and tubers, which are locally and readily available raw materials and minimise wheat importation and usage. Hence, the focus of this research was to produce more nutritious cookies from defatted coconut, defatted tigernut and wheat flour, and to evaluate the nutritional composition of the resulting cookies.

MATERIALS AND METHODS

About 200 g tiger nut tubers (dried tiger nut) (*Cyperus esculentus*), three fresh coconut fruits (*Cocos nucifera*) (31; 31; and 36 g), and 250 g eggs were purchased at the open market. Other ingredients such as wheat flour (1 kg), sugar (300 g), margarine (500 g), powdered milk (500 g), and baking powder (15 g) were purchased in Ibadan, Oyo State, Nigeria.

Preparation for defatted tiger nut flour

Dried tiger nut seeds were sorted to remove stones and

damaged seeds. The resulting seeds were washed in saline solution to remove adhering impurities and re-dried using a dehydrator (NutriChef, China) at 60°C for 7 h 30 min, milled in an electric blender (Panasonic AC MX-AC300-H 550-Watt Mixer Grinder, India) and then sieved (1.8 mm mesh) to obtain fine homogenised particles. The resulting 182 g tiger nut powder was transferred into a 1000 mL conical flask, and 400 mL of n-hexane was added, and agitated for 5 h to extract the fat in the tiger nut powder. It was then filtered using a 125 mm Whatman filter paper. The filtrate was spread on a clean flat tray in open air for 24 h to allow complete evaporation of n-hexane, packaged and stored at room temperature (31±2°C) until used.

Preparation of defatted coconut flour

Freshly procured mature coconuts were subjected to pre-processing operations of deshelling, pairing and removal of coconut water. The skin of the white coconut kernels was peeled, then grated using an electric blender (Panasonic AC MX-AC300-H 550-Watt Mixer Grinder, India) to enhance drying. The grated coconuts were defatted according to Adeniran *et al.* (2019). Briefly, the grated coconut was emptied into a 1000 mL beaker, followed by adding 400 mL of water. The 1000 mL beaker was placed into a water bath set at 100°C for 45 min to extract fat from the grated coconut, and the process was repeated three times. The defatted coconut was dried in a dehydrator (NutriChef, China) at 60°C for 24 h, milled, sieved, and packaged in a Ziploc bag (polyethylene bag) and stored at room temperature (31±2°C) until used.

Formulation for cookies

The cookie formulation is shown in Table 1.

Cookie production with composite (coconut-tiger nut-wheat) flour blends

Cookies were prepared from the five formulations using the method described by Peter-Ikechukwu *et al.* (2017) with slight modifications. Defatted coconut, tigernut, and wheat flours, powdered milk, and baking powder were mixed in a bowl, while margarine and sugar were mixed properly in a separate bowl to give a fluffy texture. The eggs were added and mixed. The dry ingredients were then added and mixed thoroughly to form dough (Noah, 2018). The dough was rolled and flattened to a uniform thickness of approximately 3.5 mm before being cut into a round shape. Cut cookie doughs were placed in a greased baking pan and baked in an oven (45 L Electronic Oven, Singapore) at a temperature of 220°C for 20 min. The cookies were allowed to cool for 30 min in the open air and stored in polyethylene (Ziploc bags) for further analysis. All analyses were performed in triplicate.

Table 1. Formulation of composite flour for cookies, dry (g) materials.

Blends	WF*	DCF ¹	DTF ²	Margarine	Sugar	Egg	Baking powder	Powdered milk
WF	200	0	0	80	60	50	2	30
CTWF	190	5	5	80	60	50	2	30
TWF	180	0	20	80	60	50	2	30
CWF	180	20	0	80	60	50	2	30
CTF	0	100	100	80	60	50	2	30

WF*= wheat flour; DCF¹= defatted coconut flour; DTF²= defatted tiger nut flour; WF (control) = 100 % wheat flour; CTWF = 5:5:90 defatted coconut: defatted tiger nut: wheat flour; TWF = 20:80 defatted tiger nut: wheat flour; CWF = 20:80 defatted coconut: wheat flour; CTF= 50: 50 defatted coconut: defatted tiger nut flour.

Determination of functional properties of the flour blends

The bulk density was determined according to Nwosu (2013) with slight modification. Foaming capacity (FC), water absorption capacity (WAC), and oil absorption capacity (OAC) were determined according to the method described by Onwuka (2005). The swelling index was determined according to Suresh and Samsher (2013) with slight modification. For wettability, gelation temperature and emulsification capacity of the composite flours, the AOAC (2006) method was used.

Evaluation of the physical properties of cookies

Determination of the diameter and weight of cookies

The diameter of each randomly selected cookie was measured, using a calibrated ruler in triplicate, and the average was calculated in centimetres. The weight (g) of the baked cookies was found by weighing each cookie unit on an electronic weighing balance (Kerro, India), according to Peter-Ikechukwu *et al.* (2017). For the spread ratio, the method of Giami *et al.* (2005) was followed. The thickness of the cookies was according to McWatters *et al.* (2003).

Determination of the nutrient composition of cookies

The moisture, ash, protein, fat, and crude fibre contents were determined according to the AOAC (2023) method. Carbohydrate was by difference. Energy (kcal/100 g) was calculated by using Atwater factors, multiplying the crude fat, protein, and carbohydrate values by 9, 4, and 4, respectively. The mineral content (Ca, K, and Fe) was according to Tuncturk *et al.* (2015), with slight modification.

Sensory evaluation

The sensory evaluation of the cookie samples was conducted using 20 untrained Bowen University graduate

and undergraduate students as panellists, who are familiar with the products. The age range of the panellists was 20 to 30 years. Cookies were evaluated based on taste, aroma, crunchiness, appearance, crumbling, mouthfeel, colour, and overall acceptability using a five-point Hedonic scale, where 1 stands for “extremely dislike” and 5 stands for “extremely like” (Noah, 2018).

Physical analysis (colour determination) and water activity of cookies

Physical colour was measured using a colourimeter (Colour Tec PCMTM Colour Tec Associates, Konica Minolta Sensing, Inc., Japan) according to Lui-ping *et al.* (2005) method. The L*(lightness) a* (redness), b* (yellowness) values were recorded. Water activity was determined according to Zhang *et al.* (2017), with slight modification.

Shelf life of cookies

Cookies were stored at room temperature (31±2 °C) and refrigerator temperature (9±2 °C) for three months to study the shelf life. For each month, colour, aroma, texture, and fungal growth were observed.

Statistical analysis

The statistical analyses were conducted with Statistical Package for Social Sciences (SPSS, 2011) using one-way ANOVA (analysis of variance) procedures. Statistical differences were tested for at $p \leq 0.05$. Duncan's test was used to differentiate between the mean values.

RESULTS AND DISCUSSION

Functional properties of composite flours used in cookie production

The results of the functional properties of composite flour blends are in Table 2. The water absorption capacity

Table 2. Result of functional properties of composite flour blends.

Samples	WAC (g/mL)	OAC (g/mL)	SI (mL)	Wettability (sec.)	BD (g/mL)	FC (%)	GT (° C)	EC (%)
WF	0.57±0.09 ^a	0.73±0.14 ^a	10.00±0.00 ^b	72.50±2.12 ^b	0.66±0.01 ^a	5.60±2.6 ^b	69.00±1.41 ^c	48.00±2.82 ^{ab}
CTWF	0.78±0.31 ^a	0.67±0.06 ^a	10.50±0.00 ^{ab}	17.00±2.83 ^c	0.62±0.01 ^{ab}	11.20±1.6 ^{ab}	71.00±1.41 ^c	49.47±0.75 ^{ab}
TWF	0.69±0.19 ^a	0.69±0.19 ^a	10.50±0.71 ^{ab}	87.50±3.54 ^a	0.58±0.01 ^b	10.70±0.0 ^{ab}	72.00±0.00 ^{bc}	41.00±1.41 ^c
CWF	0.78±0.32 ^a	0.56±0.00 ^{ab}	11.00±0.00 ^a	24.00±4.24 ^c	0.62±0.04 ^{ab}	12.70±3.8 ^a	76.50±3.54 ^{ab}	46.00±2.83 ^{bc}
CTF	0.31±0.04 ^a	0.36±0.04 ^b	10.00±0.28 ^b	6.50±0.71 ^d	0.44±0.00 ^c	11.10±0.6 ^{ab}	80.00±0.00 ^a	52.01±1.40 ^b

Mean ± SD with different superscripts within the same column were significantly ($p \leq 0.05$) different, using Duncan separation. WF (control) = 100 % wheat flour; CTWF = 5:5:90 defatted coconut: defatted tiger nut: wheat flour; TWF = 20:80 defatted tiger nut: wheat flour; CWF = 20:80 defatted coconut: wheat flour; CTF = 50: 50 defatted coconut: defatted tiger nut flour.

ranged from 0.31±0.04 to 0.78±0.32 g/mL. CTF (50:50 defatted coconut flour: defatted tiger nut flour) composite flour had the lowest value, while CTWF (5:5:90 defatted coconut: defatted tiger nut: wheat flours) and CWF (20:80 defatted coconut: wheat flour) had the highest values. The oil absorption capacity values for the composite flour blends ranged from 0.36±0.0 g/mL in CTF to 0.73±0.1 g/mL in WF. The swelling index of the flour samples ranged from 10.0±0.0 to 11.0±0.0 mL. WF and CTF had the lowest swelling index value, while CWF (20:80 defatted coconut flour: wheat flour) had the highest swelling index value. Wettability of the composite flour samples ranged from 6.5 s in CTF to 87.5 s in TWF. Composite flour samples containing defatted coconut flour (CTWF, CWF, and CTF) had shorter wettability time, and flour samples containing wheat flour (WF) and wheat flour plus defatted tiger nut flour (TWF) had longer wettability time. The bulk density ranged from 0.44±0.0 to 0.66±0.01 g/mL. The highest was observed in WF (0.66 g/mL) and the lowest in CTF (0.44 g/mL). There were significant differences ($p \leq 0.05$) in the bulk density of the composite flours. Bulk density was observed to reduce as the substitution level of defatted flour increased. Foaming capacity ranged from 5.6±2.6 to 12.7±3.8 %, with flour sample CWF having the highest value, while flour sample WF (5.6 %) had the lowest, due

to it being refined wheat flour. There were also significant differences ($p \leq 0.05$) in the foaming capacity of the composite flour blends. The wheat flour (WF) had the least gelation temperature of 69.0±1.41 °C, while the composite flour sample (CTF) had the highest gelation temperature of 80.0±0.0 °C. The emulsion capacity of the composite flour samples ranged from 41.0±1.41 % in flour sample TWF to 52.0±1.40 % in flour sample CTF. The substitution level of wheat flour with defatted coconut and tiger nut flour varied in the emulsifying capacity of the composite flour. There were statistically significant differences ($p \leq 0.05$) between the emulsion capacity of all the flour samples. Water absorption capacity is the ability of protein in a product to associate and retain water (Madu, 2007), and it was observed to increase with the addition of defatted coconut and tiger nut flours compared with only wheat flour. The substitution of wheat flour with defatted coconut or tiger nut flour reduced the oil absorption capacity. The result observed for wheat flour is within the range of Ubbor *et al.* (2022) report of 0.900 g/mL for wheat. The higher the oil absorption capacity of a flour sample, the better the cookie quality, mouthfeel and flavor retention of cookies (Peter-Ikechukwu *et al.*, 2017), contributing to the soft texture of cookies (Jacob and Leelavathi, 2007). Peter-Ikechukwu *et al.* (2017) reported the wettability time range of (13

to 40 sec) for composite flour (whole wheat and date palm fruit pulp). The substitution of coconut flour was observed to influence wettability in this study. The result of the bulk density was within the range of the report of Suresh and Samsher (2013), of 0.720 g/cc for wheat. Low bulk density of flour has been reported to be useful for food formulation when used, and such products have less retrogradation (Oladele *et al.*, 2009). Foaming capacity is the ability of flour to produce a stable foam when whipped or beaten with water or other liquids. It is essential in creating light and airy textures in cookies (Kinsella, 1976). This result may imply that sample CWF with the highest foaming capacity had strong gluten-forming proteins, and this tends to increase the foaming capacity of flour during whipping (Suresh and Samsher, 2013). Emulsification capacity result is within the range of Ubwa *et al.* (2012) report, with emulsification capacity ranging from 38 to 48 % in wheat and red banana flour blends. The result for functional properties is shown in Table 2.

Physical properties of cookies

The diameter of the cookies ranged from 4.30 cm in sample CTC to 4.43 cm in sample CWC (Table 3). In this study, slight increases were observed in

Table 3. Physical properties of cookies produced from composite flour blends

Samples	Physical Properties (cm)			Weight (g)
	Diameter	Spread ratio	Thickness	
WFC	4.37±0.06 ^{ab}	6.28±0.15 ^{ab}	0.69±0.01 ^c	7.67±0.58 ^a
CTWC	4.40±0.00 ^{ab}	6.53±0.10 ^a	0.73±0.02 ^b	8.00±0.00 ^a
TWC	4.37±0.08 ^{ab}	5.92±0.07 ^b	0.74±0.01 ^{ab}	8.33±0.58 ^a
CWC	4.43±0.06 ^a	6.12±0.34 ^b	0.76±0.02 ^a	8.00±0.00 ^a
CTC	4.30±0.10 ^b	6.06±0.15 ^b	0.73±0.01 ^b	8.00±0.00 ^a

Mean ± SD with different superscripts within the same column were significantly ($p \leq 0.05$) different, using Duncan separation. WFC = 100 % wheat flour cookies; CTWC = 5:5:90 defatted coconut: defatted tiger nut: wheat cookies; TWC = 20:80 defatted tiger nut: wheat cookies; CWC = 20:80 defatted coconut: wheat cookies; CTC = 50: 50 defatted coconut: defatted tiger nut cookies.

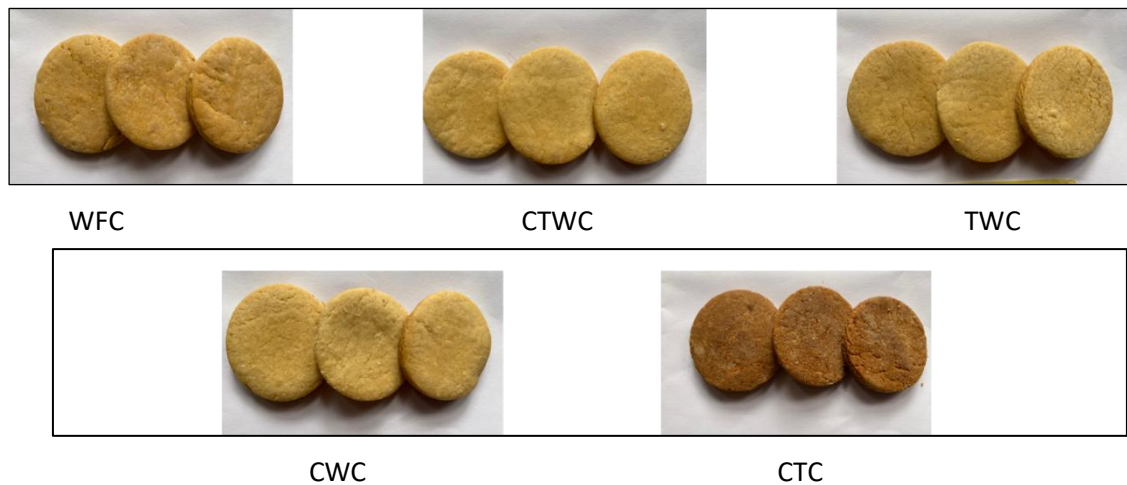


Figure 1. Cookie samples from composite flours. WFC (control) = 100 % wheat cookies; CTWC = 5:5:90 defatted coconut: defatted tiger nut: wheat cookies; TWC = 20:80 defatted tiger nut: wheat cookies; CWC = 20:80 defatted coconut: wheat cookies; CTC = 50:50 defatted coconut: defatted tiger nut cookies.

the cookies, except for CTC (coconut-tigernut cookies). The spread ratio was lowest in sample TWC and highest in sample CTWC, with values of 5.92 ± 0.07 and 6.53 ± 0.10 cm, respectively. The cookie's thickness ranged from 0.69 ± 0.01 cm in sample WFC to 0.76 ± 0.02 cm in sample CWC. The weight of the cookie samples ranged from 7.67 ± 0.58 in sample WFC to 8.33 ± 0.58 g in sample TWC. There was no significant difference ($p < 0.05$) in the weights of all the samples. Previous studies, Sengeve *et al.* (2015), Pasha *et al.* (2002), and Singh *et al.* (2008) show a decrease in the diameter of cookies as wheat flour is substituted by various flours. Cookies having higher diameters and spread ratios are considered the most desirable quality attributes (Handa and Siddhu, 2012). The report of Peter-Ikechukwu *et al.* (2017), spread ratio ranging from 4.6 to 5.6 cm, concurs with the result in this study, and is within the range of Sengeve *et al.* (2015), who observed 4.8 to 8.2 cm. The increase in the thickness of cookies with an increase in defatted coconut and tiger nut flour substitutions could be because of the swelling and binding of the cookie components due to water absorption

(Sengeve *et al.*, 2015). The thinner the cookies, the more reduced their ability to withstand stress (Peter-Ikechukwu *et al.*, 2017). Crunchiness is one of the important organoleptic properties of cookies, which stands a better chance of improving the marketability of the product (Oluwafemi and Ikuomola, 2016). The 5 cookie samples produced are as shown in Figure 1. The result for physical properties of cookie is shown in Table 3.

Sensory evaluation

The scores of the sensory evaluation of cookies produced from composite flour blends are shown in Figure 2. The mean scores of colours, taste, flavour, aroma, mouthfeel, crispness, crumbling, and overall acceptability for the cookies were significantly different ($p \leq 0.05$). The mean scores of the cookies ranged from 3.2 to 4.1 for appearance; 3.4 to 4.0 for colour; 3.6 to 3.8 for aroma; 3.5 to 4.2 for crunchiness; 3.2 to 3.7 for crumbling; 3.2 to 4.2 for taste; 3.3 to 4.0 for mouthfeel; and 3.4 to 3.9 for overall

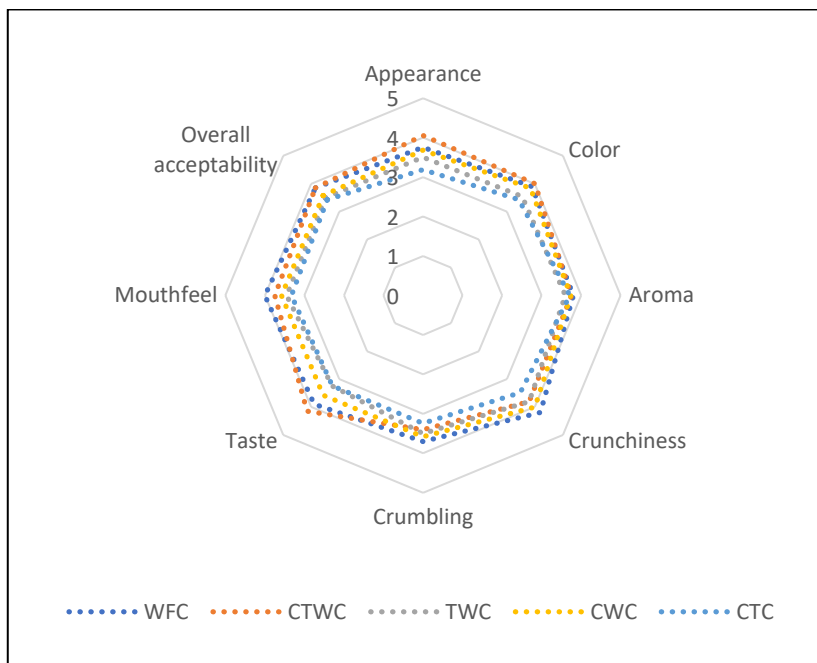


Figure 2. Result of sensory evaluation of cookie samples. WFC = 100 % wheat flour cookies; CTWC = 5:5:90 defatted coconut: defatted tiger nut: wheat cookies; TWC = 20:80 defatted tiger nut: wheat cookies; CWC = 20:80 defatted coconut: wheat cookies; CTC= 50: 50 defatted coconut: defatted tiger nut cookies.

acceptability. Sample WFC had the highest scores in aroma, crunchiness, crumbling, and mouthfeel, while sample CTWC had the highest scores in appearance, colour, and taste compared to other samples. The preference for cookies varied as the level of substitution of defatted coconut and tiger nut flour increased. The appearance of cookie samples was significantly different ($p \leq 0.05$) across the samples, where sample CTWC was rated the best (4.1) and sample CTC was the least rated (3.2). Sample WFC had the highest score for aroma with 3.8, but there was no significant difference ($p \leq 0.05$) across the samples. This implies that samples substituted with defatted coconut flour and those substituted with both defatted coconut and tiger nut flour were highly rated in terms of aroma compared to samples substituted with defatted tiger nut flour. Sample WFC was scored the highest in terms of crumbling (3.7), and there was no significant difference ($p \leq 0.05$) in the samples as the substitution level varied. From the results of the overall acceptability of the samples, samples WFC (3.9) and CTWC (3.9) were both acceptable to the panellists compared to samples CWC (3.6), TWC (3.5), and CTC (3.4). However, there was no significant difference ($p \leq 0.05$) in the overall acceptability of the samples. This indicates that 100 % wheat flour cookies and 5: 5: 90 %: defatted coconut flour: defatted tiger nut flour: wheat flour cookies were preferred. The result for sensory analysis is shown in Figure 2.

Proximate analysis of cookies

The results of the proximate composition of cookies on a dry weight basis are presented in Table 4. The dry matter of the cookie samples ranged from 98.19 ± 0.00 to 98.94 ± 0.00 and were significantly different ($p \leq 0.05$) from each other. CWC (20:80 defatted coconut: wheat flour) cookies had the highest dry matter content, while WFC (100:0 wheat flour cookies) had the lowest. The ash content of the cookie samples ranged from 1.75 to 2.85 %. There were significant differences ($p \leq 0.05$) in the ash content of all the samples. Ubbor *et al.* (2022) and Peter-Ikechukwu *et al.* (2017) reported ash contents of 1.2 to 2.3 % and 1.6 to 3.1 %, respectively, for cookies produced from various composite flours, and these are within the range of the results in this study. The fat content ranged from 11.8 to 15.1 %. The protein value ranged from 15.8 to 19.5 %. Sample WFC had the highest protein content (19.5 %), and sample CWC had the lowest protein content (15.8 %). The highest values for ash and fat contents were observed in sample CTC (50:50 defatted coconut flour: defatted tiger nut flour). This could be because of the defatting process of coconut and tiger nut flour, and subsequent addition of margarine to the batter for the cookies. Alebiosu *et al.* (2020) also reported comparable results of fat content of 9.6 to 11.2 % for cookies produced from wheat, sorghum and defatted coconut flour blends. Fat plays a significant role in the shelf life of food products,

Table 4. Proximate composition of cookies on dry weight basis.

Parameters	Cookie sample				
	WFC	CTWC	TWC	CWC	CTC
Dry Matter	98.19±0.0 ^d	98.92±0.0 ^c	98.93±0.0 ^b	98.94±0.0 ^a	98.93±0.0 ^b
Ash	1.75±0.02 ^e	1.96±0.03 ^d	2.47±0.05 ^b	2.17±0.04 ^c	2.85±0.02 ^a
Fat	14.8±0.1 ^b	11.8±0.04 ^d	13.2±0.41 ^c	12.1±0.0 ^d	15.1±0.03 ^a
Protein	19.5±0.1 ^a	16.5±0.1 ^d	17.5±0.0 ^b	15.8±0.0 ^e	16.9±0.1 ^c
Fibre	2.3±0.03 ^d	2.4±0.02 ^c	2.6±0.0 ^b	2.5±0.02 ^b	2.8±0.07 ^a
CHO	60.54±0.13 ^d	66.25±0.1 ^a	63.22±0.41 ^b	66.37±0.1 ^a	61.26±0.12 ^c
Energy Kcal	453.2	436.9	441.4	437.4	449.0

Mean ± SD with different superscripts within the same column were significantly ($p \leq 0.05$) different, using Duncan separation. WFC = 100 % wheat flour cookies; CTWC = 5:5:90 defatted coconut: defatted tiger nut: wheat cookies; TWC = 20:80 defatted tiger nut: wheat cookies; CWC = 20:80 defatted coconut: wheat cookies; CTC = 50: 50 defatted coconut: defatted tiger nut cookies.

Table 5. Mineral composition of cookies produced from composite flour blends.

Samples	Mineral Content (mg/100 g)		
	Calcium	Potassium	Iron
WFC	56.62±0.13 ^e	242.15±0.35 ^c	4.61±0.30 ^b
CTWC	62.45±0.08 ^b	222.08±0.04 ^d	3.90±0.03 ^d
TWC	60.34±0.36 ^c	206.15±0.04 ^e	4.31±0.05 ^c
CWC	63.58±0.20 ^a	254.91±0.04 ^b	4.63±0.02 ^b
CTC	58.18±0.20 ^d	256.82±0.61 ^a	5.22±0.04 ^a

Mean ± SD with different superscripts within the same column were significantly ($p \leq 0.05$) different, using Duncan separation. WFC = 100 % wheat flour cookies; CTWC = 5:5:90 defatted coconut: defatted tiger nut: wheat cookies; TWC = 20:80 defatted tiger nut: wheat cookies; CWC = 20:80 defatted coconut: wheat cookies; CTC = 50: 50 defatted coconut: defatted tiger nut cookies.

and as such, high fat content could be undesirable in baked food products, because it promotes rancidity in foods (Ihekoronye and Ngoddy, 1985). The control, wheat cookies, had the highest protein content. It is possible that while defatting the coconut and tiger nut flours, there was also denaturation of protein structure, which could have resulted in reduced protein content of the composite cookies (Senarathna and Malalgoda, 2024). The crude fibre ranged from 2.3 to 2.8 % in cookie samples. Sample CTC, not surprisingly, had the highest crude fibre content, while sample WFC had the lowest. From the results, cookies from the composite flours are an excellent source of crude fibre compared to the plain wheat cookies. The fibre content of all the cookies was within the daily recommended allowance, which should not exceed 5 g dietary fibre per 100 g dry matter (Okak and Ene, 2005). The carbohydrate content of cookies ranged from 60.5 to 66.37 %. There were significant differences ($p \leq 0.05$) in the carbohydrate content of the samples because of the different substitution levels of composite flour blends. The energy content of the cookies ranged from 436.9 kcal/100 g in sample CTWC to 453.2 kcal/100 g in sample WFC. The carbohydrate content of the cookie samples is comparable to that of Alebiosu *et al.* (2020). Carbohydrates provide the energy needed for body metabolism. The high dry matter content of cookies prevents spoilage and growth of pathogenic organisms

(Ochieng *et al.*, 2023), and this helps to increase the shelf life and keeping qualities of cookies. The result for the nutritional content of the cookie is shown in Table 4.

Mineral composition of cookies

The substitution of defatted coconut and tiger nut flour blends into wheat flour is a reliable source of minerals (Table 5). Calcium, potassium, and iron are the predominant mineral elements present in the wheat-based composite cookies. Calcium (Ca) content ranged from 56.6 mg/100 g in WFC (100 % wheat flour) to 63.6 mg/100 g in CWC, and was significantly different from other cookies. As the level of wheat substitution increased, the calcium content increased. The potassium content of the samples ranged from 206.2 mg/100 g in sample TWC to 256.8 mg/100 g in sample CTC. Cookies sample CTC had the highest potassium content (256.8 mg/100 g). Alebiosu *et al.* (2020) had a similar result for potassium and iron content, ranging from 188.3 to 333.5 mg/100 g and 3.7 mg/100 g to 6.5 mg/100 g, respectively. The iron (Fe) content of the cookies ranged from 3.9 mg/100 g in CTWC to 5.2 mg/100 g in CTC, which is lower than the recommended daily allowance (RDA) of 10 mg of iron per day (Arinathan *et al.*, 2003). The result for the mineral composition of the cookie is shown in Table 5.

Table 6. Colour properties of cookies produced from composite flour blends.

Cookie samples	Physical colour properties			Water activity (a_w)
	L*	a*	b*	
WFC	67.55±0.07 ^a	4.87±0.09 ^c	25.15±0.06 ^c	0.35±0.01 ^a
CTWC	67.39±0.05 ^a	4.35±0.08 ^d	25.29±0.06 ^c	0.35±0.01 ^a
TWC	65.67±0.15 ^b	6.82±0.07 ^b	25.63±0.06 ^b	0.28±0.01 ^b
CWC	64.35±0.24 ^c	6.82±0.02 ^b	25.51±0.15 ^b	0.23±0.01 ^c
CTC	49.22±0.19 ^d	8.94±0.06 ^a	20.51±0.08 ^d	0.34±0.01 ^a

Mean ± SD with different superscripts within the same column were significantly ($p \leq 0.05$) different, using Duncan separation. L* = lightness; a* = redness; b* = yellowness. WFC = 100 % wheat flour cookies; CTWC = 5:5:90 defatted coconut: defatted tiger nut: wheat cookies; TWC = 20:80 defatted tiger nut: wheat cookies; CWC = 20:80 defatted coconut: wheat cookies; CTC = 50: 50 defatted coconut: defatted tiger nut cookie.

Table 7. Shelf-life study of cookies produced from composite flour blends

Samples	Storage Temperature	Length of storage in (Month)	Observed changes in cookies			
			Colour	Aroma	Texture	Mould growth
WFC	31±2°C	1	NO	NO	NO	NO
		2	NO	NO	Yes (soft)	<1
		3	NO	NO	Yes (softer)	<1
CTWC		1	NO	NO	NO	NO
		2	NO	NO	Yes (soft)	<1
		3	NO	NO	Yes (softer)	<1
TWC		1	NO	NO	NO	NO
		2	NO	NO	Yes (soft)	<1
		3	NO	NO	Yes (softer)	<1
CWC	1	NO	NO	NO	NO	
	2	NO	NO	Yes (soft)	<1	
	3	NO	NO	Yes (softer)	<1	
CTC	1	NO	NO	NO	NO	
	2	NO	NO	Yes (soft)	<1	
	3	NO	NO	Yes (chewy)	<1	
WFC	9± 2°C	1	NO	NO	NO	NO
		2	NO	NO	NO	NO
		3	NO	NO	NO	NO
CTWC		1	NO	NO	NO	NO
		2	NO	NO	NO	NO
		3	NO	NO	NO	NO
TWC		1	NO	NO	NO	NO
		2	NO	NO	NO	NO
		3	NO	NO	NO	NO
CWC	1	NO	NO	NO	NO	
	2	NO	NO	NO	NO	
	3	NO	NO	NO	NO	
CTC	1	NO	NO	NO	NO	
	2	NO	NO	NO	NO	
	3	NO	NO	NO	NO	

Physical colour properties of cookies

The result of the colour analysis of cookies is presented in Table 6. The L value of samples ranged from 49.2 in sample CTC to 67.55 in sample WFC. There was a

significant difference ($p \leq 0.05$) in the lightness of samples. As the wheat flour substitution increased, the L (lightness) value decreased. The redness (a*) of samples ranged from 4.35 in sample CTWC to 8.94 in sample CTC, while the yellowness (b*) of samples ranged from 20.51 in

sample CTC to 25.63 in sample TWC.

Water activity of cookies

Water activity value for the samples ranged from 0.23 in sample CWC to 0.35 in samples WFC and CTWC, as shown in Table 6. According to Sandulachi (2012), the average water activity value for cookies is less than 0.60, and the organisms that grow at this level are osmophilic yeasts. The low water activity values for cookie samples in this study imply increased shelf life of the cookies. The cookie samples were stored successfully for approximately 3 months at refrigeration ($9\pm 2^{\circ}\text{C}$) temperature with the organoleptic properties intact, whereas cookies kept at room ($31\pm 2^{\circ}\text{C}$) temperature could be stored for about 1 month (Table 7). The results for the water activity and shelf-life study are shown in Tables 6 and 7.

Conclusion

The result from this study shows that the supplementation of wheat flour with defatted coconut and tiger nut flour improved the nutritional values (such as crude fibre, ash, carbohydrate, and mineral contents) of cookies, indicating that cookies consumed in between meals, by children, young and older adults, throughout the world, can be nutritionally improved by adding essential macronutrients and micronutrients. Cookie samples also had very low water activity level, which limits the growth of microorganisms, extending the shelf-life of the cookies. The sensory evaluation shows that 100 % wheat cookies scored higher in crunchiness, crumbling and mouthfeel, while sample CTWC (5:5:90 defatted coconut: defatted tiger nut: wheat cookies) scored higher in appearance, color, and taste than others, and was acceptable by all consumers. This suggests that both coconut and tigernut flours could be incorporated into snack foods and accepted by consumers.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

REFERENCES

- Adeniran, O. Y., Oyewale, M. B., Aderibigbe, E. O., Metibomu, D. S., & Ariyo, O. J. (2019). Proximate and organoleptic evaluation of 30% defatted coconut flour supplemented bread. *Research Journal of Food and Nutrition*, 3(3), 6-14.
- Alebiosu, M. O., Akinbode, B. A., Oni, I. S., & Oladele, J. O. (2020). Quality evaluation of cookies produced from wheat, sorghum and defatted coconut flour blends. *Asian Food Science Journal*, 17(3), 11-21.
- Arinathan, V., Mohan, V. R., & John De Britto, A. (2003). Chemical composition of certain tribal pulses in South India. *International Journal of Food Sciences and Nutrition*, 54(3), 209-217.
- Association of Official Analytical Chemists (AOAC) (2006). *Official Methods of Analysis*. 15th edition. AOAC press, Washington DC, USA. pp 78-90.
- Association of Official Analytical Chemists (AOAC) (2023). *Official Methods of Analysis*. 22nd edition, The Association of Official Analytical Chemists, Gaithersburg, MD, USA.
- Coskuner, Y., Ercan, R., Karababa, E., & Nazlican, A. N. (2002). Physical and chemical properties of chufa (*Cyperus esculentus* L) tubers grown in the Cukurova region of Turkey. *Journal of Science Food Agriculture*, 82, 625-631.
- DebMandal, M., & Mandal, S. (2011). Coconut (*Cocos nucifera* L.: Arecaceae): in health promotion and disease prevention. *Asian Pacific Journal of Tropical Medicine*, 4(3), 241-247.
- Edo, G. I., Onoharigho, F. O., Jikah, A. N., Oloni, G. O., Samuel, P. O., Rapheal, O. A., Ikpekoru, O., Akpogheli, P. O., Agbo, J. J., Ekokotu, H. A., & Akpogheli, E. O. (2023). *Cyperus esculentus* (tiger nut): An insight into its bioactive compounds, biological activities, nutritional and health benefits. *Food Chemistry Advances*, 3, 100511.
- Gambo, A., & Da'u, A. (2014). Tiger nut (*Cyperus esculentus*): composition, products, uses and health benefits – A Review. *Bayero Journal of Pure and Applied Science*, 7(1), 56-61.
- Giami, S. Y., Achinewhu, S. C., & Ibaakee, C. (2005). The quality and sensory attributes of cookies supplemented with fluted pumpkin (*Telfairia occidentalis* Hook) seed flour. *International Journal of Food Science and Technology*, 40(6), 613-620.
- Gunathilake, K. D. P. P., Yalagama, C., & Kumara, A. A. N. (2009). Use of coconut flour as a source of protein and dietary fibre in wheat bread. *Asian Journal of Food and Agro-Industry*, 2(3), 386-395.
- Handa, C. G., & Siddhu, A. (2012). Physicochemical properties and sensory evaluation of fructooligosaccharide enriched cookies. *Journal of Food Science Technology*, 49, 192-200.
- Haruna, S. A., Adejumo, B. A., Chukwu, O., & Okolo, C. A. (2017). Getting out of the Nigerian "wheat trap": a multi disciplinary approach. *International Journal of Engineering Research and Technology*, 6(7), 672-681.
- Ihekoronye, A. I., & Ngoddy, P. O. (1985). *Integrated Food Science and Technology for the Tropics*. Macmillan Publishers Limited. London. Pp. 285-293.
- Jacob, J., & Leelavathi, K. (2007). Effect of fat-type on cookie dough and cookie quality. *Journal of Food Engineering*, 79 (1), 299-305.
- Kinsella, J. E. (1976). Functional properties of protein in food - A survey. *Journal of Food Science and Nutrition*, 5, 219-220.
- Laveena, M. T., & Rupali, S. (2013). Multigrain healthy cookies for diabetes mellitus. *International Journal of Science and Research*, 5(8), 1360-1365.
- Llopis, J.M.L., & Haros, C.M. (2025). *Can cookies be healthy? Ingredients are key*. EL PAÍS English. Retrieved August 22, 2025 from <https://english.elpais.com/science-tech/2023-03-28/can-cookies-be-healthy-ingredients-are-key.html>.
- Lui-ping, F., Min, Z., Gong-nian, X., Jin-cai, S., & Qian, T. (2005). The optimization of vacuum frying to dehydrate carrot chips. *International Journal of Food Science and Technology*, 40(9), 911-919.
- Madu, H. (2007). Chemical composition, properties and baking potentials of African breadfruit kernel and wheat flour blends. *International Journal of Food Science and Technology*, 39, 223-229.

- McWatters, K. H., Ouedraogo, J. B., Resurreccion, A. V., Hung, Y. C., & Phillips, R. D. (2003). Physical and sensory characteristics of sugar cookies containing mixtures of wheat, fonio (*Digitaria exilis*) and cowpea (*Vigna unguiculata*) flours. *International Journal of Food Science and Technology*, 38(4), 403-410.
- Nihir, S., Anant, S. K., & Luv, P. (2018). Studies on development of high protein cookies. *International Journal of Chemical Studies*, 6(6), 439-444.
- Noah, A. A. (2018). Production, nutrient and sensory qualities of biscuits produced from wheat-coconut-almond flour blend. *Journal of Food Science and Nutrition*, 3(6), 302-315.
- Nwosu, J. N. (2013). Production and evaluation of biscuits from blends of bambara groundnut and wheat flour. *Agricultural and Food Sciences*, 2(1), 40-44.
- Ochieng, B. O., Anyango, J. O., Khamis, F. M., Ekesi, S., Egonyu, J. P., Subramanian, S., Nduko, J. M., Nakimbugwe, D., Cheseto, X., & Tanga, C. M. (2023). Nutritional characteristics, microbial loads and consumer acceptability of cookies enriched with insect (*Ruspolia differens*) meal. *LWT - Food Science and Technology*, 184, 115012.
- Okak, J. C., & Ene, G. L. (2005). *Food microbiology: method in food safety control*. Octanco Academic Publishers Enough. Pp. 262-265.
- Oladele, A. K., Ibanga, U. I., & Adebisin, O. L. (2009). Effect of substituting maize with tiger nut on the quality and acceptability of Dakuwa. In: *33rd Annual conference and General Meetings of Nigerian Institute of Food Science and Technology, Yola, Nigeria*.
- Olaoye, O. A., Onilude, A. A., & Oladoye, C. O. (2019). Breadfruit flour in biscuit making: Effects on product quality. *African Journal of Agriculture and Food Security*, 7(5), 001-004
- Oluwafemi, G. I., & Ikuomola, D. S. (2016). Production and quality evaluation of vegetable cookies from defatted almond seed-wheat flour blends. In *5th International Biannual Conference of School of Science and Computer Studies on Science and Technology as a Panacea for reshaping the Nigeria Economy to meet global challenges* (pp. 1-20).
- Onwuka, G. I. (2005). *Food analysis and instrumentation: Theory and practice*. Lagos, Nigeria. Naphtali Prints. Pp. 95-96.
- Pasha, I., Butt, M. S., Anjum, F. M., & Shahzadi, N. (2002). Effect of dietetic sweeteners on the quality of cookies. *International Journal of Agriculture and Biology*, 4(2), 245-248.
- Peter Ikechukwu, A., Okafor, D. C., Kabuo, N. O., Ibeabuchi, J. C., Odimegwu, E. N., Alagbaoso, S. O., Njideka, N. E., & Mbah, R. N. (2017). Production and evaluation of cookies from whole wheat and date palm fruit pulp as sugar substitute. *International Journal of Advancement in Engineering Technology, Management and Applied Science*, 4(4), 1-31.
- Puglisi, M. J., & Fernandez, M. L. (2022). The health benefits of egg protein. *Nutrients*, 14(14), 2904.
- Ruxton, C. H. S., Derbyshire, E., & Gibson, S. (2010). The nutritional properties and health benefits of eggs. *Nutrition & Food Science*, 40(3), 263-279.
- Sánchez-Zapata, E., Fernández-López, J., & Angel Pérez-Alvarez, J. (2012). Tiger nut (*Cyperus esculentus*) commercialization: health aspects, composition, properties, and food applications. *Comprehensive Reviews in Food Science and Food Safety*, 11(4), 366-377.
- Sandulachi, E. (2012). *Water activity concept and its role in food preservation*. Meridian Ingenieresc. Pp. 40-48.
- Senarathna, S. C., & Malalgoda, M. (2024). Impact of defatting method on oat protein isolate structure-function characteristics. *Journal of Cereal Science*, 117, 103876.
- Sengev, I. A., Gernah, D. I., & Bunde-Tsegba, M. C. (2015). Physical, chemical and sensory properties of cookies produced from sweet potato and mango mesocarp flours. *African Journal of Food, Agriculture, Nutrition and Development*, 15(5), 10428-10442.
- Singh, S., Riar, C. S., & Saxena, D. C. (2008). Effect of incorporating sweet potato flour to wheat flour on the quality characteristics of cookies. *African Journal of Food Science*, 2(6), 65-72.
- Suresh, C., & Samsher, S. (2013). Assessment of functional properties of different flours. *African Journal of Agricultural Research*, 8(38), 849-852.
- Tamirat, W., & Mekides, A. (2020). Review on the response of wheat (*Triticum aestivum* L.) grain yield to different planting methods in Ethiopia. *Food Science and Quality Management*, 101, 1-8.
- Tunçturk, M., Eryigit, T., Sekeroglu, N., & Ozgokce, F. (2015). Determination of nutritional value and mineral composition of some wild *Scorzonera* species. *American Journal of Essential Oils and Natural Products*, 3(2), 22-25.
- Ubbor, S. C., Ezeocha, V. C., Arukwe, D. C., Ekeh, J. I., Iguh, B. N., & Jackson, A. S. (2022). Production and quality evaluation of cake from wheat and red banana flour blends. *Science World Journal*, 17(3), 413-420.
- Ubwa, S. T., Abah, J., Asemave, K., & Shambe, T. (2012). Studies on the gelatinization temperature of some cereal starches. *International Journal of Chemistry*, 4(6), 22-28.
- Urošević, D., Knežević, D., Branković, G., Yu Novoselskaya- Dragovich, A., Kudryavtsev, A. M., Matković Stojšin, M., Mićanović, D., & Zečević, V. (2023). Protein content and amino acid composition in seed of bread wheat (*Triticum aestivum* L.). *Genetika*, 55(1), 301-318.
- Zhang, L., Sun, D. W., & Zhang, Z. (2017). Methods for measuring water activity (aw) of foods and its applications to moisture sorption isotherm studies. *Critical Reviews in Food Science and Nutrition*, 57(5), 1052-1058.