Food Science and Processing
https://www.sciltp.com/journals/fsp

Article

Nutritional, Physical and Sensory Qualities of Gluten-Free Biscuits Made from Orange-Flesh Sweet Potato and Okara Composite Flour

Okeosisi Grace Chisom [1,*], Henshaw Folake Olayinka [1], Olatunde Ganiyat Olayinka [1] and Olayiwola Ibiyemi Olasunbo [2]

[1] Department of Food Science and Technology, Federal University of Agriculture, Abeokuta P.M.B 2240, Abeokuta 111101, Nigeria
[2] Department of Nutrition and Dietetics, Federal University of Agriculture, Abeokuta P.M.B 2240, Abeokuta 111101, Nigeria
* Correspondence: okeosisigrace@gmail.com

How To Cite: Chisom, O.G; Olayinka, H.F.; Olayinka, O.G.; et al. Nutritional, Physical and Sensory Qualities of Gluten-Free Biscuits Made from Orange-Flesh Sweet Potato and Okara Composite Flour. *Food Science and Processing* **2025**, *1*(1), 7. https://doi.org/10.53941/fsp.2025.100007

Received: 24 October 2025
Revised: 5 December 2025
Accepted: 8 December 2025
Published: 11 December 2025

Abstract: The growing demand for gluten-free flour is driven by the increasing prevalence of celiac disease and the increasing desire for healthier alternatives rich in nutrients and phytochemicals. This study evaluated gluten-free biscuits prepared from eight different ratios of orange-flesh sweet potato (OFSP) (80–90%) and okara (OKR) (10–20%) composite flour. According to these findings, OFSP-OKR flour biscuits presented a notable decrease in the carbohydrate content (57.21–64.02%) and an increase in crude protein (13.99–17.50%), fat (6.96–7.62%), ash (2.65–2.82%), and fibre content (5.83–8.67%) with an increased proportion of okara flour. The addition of okara altered the physical qualities of the biscuits, reducing their thickness and weight while increasing their diameter and spread ratio. Sensory analysis revealed that the biscuits scored well above the threshold of acceptability (6.68–7.83). In conclusion, gluten-free biscuits made with orange-fleshed sweet potato and okara composite flour offer a promising alternative for individuals with gluten sensitivity or preferences because of their enhanced nutritional and sensory profiles.

Keywords: gluten-free; biscuits; orange-flesh sweet potato; qualities; nutritional; sensory

1. Introduction

Biscuits are the most important baked products and are widely accepted by both young and old individuals, in addition to bread. They are nutritious snacks created by transforming unappealing dough into appealing products through the use of heat in an oven [1]. Biscuits are usually made from refined wheat flour containing gluten proteins, which are structure-forming proteins that impart significant rheological properties to the dough [2]. Nevertheless, there has been an increase in the production of biscuits utilising gluten-free flours owing to gluten-related disorders, such as the increasing incidence of celiac diseases and consumer demand for nutrient-rich foods [3]. Natural gluten free staples such as cereals, vegetables, fruits, pseudo cereals and legumes are used to formulate gluten free flours. Such formulations are made to substitute gluten containing foods [4]. Gluten free flours are commonly used for baked products such as biscuits, pasta, bread, and cake [4,5]

In 2025, the global market for gluten free products was valued at USD 8.20 billion and is projected to expand from USD 8.60 billion in 2026 to USD 13.70 billion by 2034, with a compound annual growth rate (CAGR) of 5.9% from 2026–2034 [6]. The market expansion is propelled by high awareness of gluten-related disorders, increasing health-conscious consumers opting for gluten free options due to their perceived health benefits, even

Copyright: © 2025 by the authors. This is an open access article under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).
Publisher's Note: Scilight stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

without medical necessity, increasing consumer awareness of the health benefits of gluten free diets, and innovations in gluten free products [7].

In 2025, North America accounted for a leading portion of the global market with a market share of 41.38% attributed to its sophisticated retail systems, increasing occurrence of celiac diseases and substantial funding in gluten free innovations [6], based on the product category, the bakery products account for a leading portion of the global market in 2025 due to their widespread acceptance and the increasing availability of gluten free biscuits, bread, cookies and muffins [7].

Orange flesh sweet potato is a biofortified type of sweet potato that contains high levels of beta-carotene, which serves as a precursor to vitamin A [8]. This variety is an excellent source of nondigestible dietary fibre, essential minerals, various vitamins, and antioxidants [9]. The roots of OFSP can be transformed into flour for the creation of various food products, and this flour is classified as gluten-free due to the absence of gluten [10].

Okara is a gluten-free by-product of the soya bean produced during the processing of soymilk and tofu after the extraction of the liquid components [11]. The term "Okara" is of Japanese origin and is pronounced "oh-KAR-uh". It is also referred to as soya bean curd/dreg in some contexts, and in other languages, it is referred to as douzha or tofuzha (Chinese), and bejee (Korean). Okara is usually underexploited and discarded as waste, resulting in environmental issues and overlooked nutritional benefits due to its high moisture content, which makes it deteriorate rapidly, limiting its use in food formulations [12]. Reports by Santos et al. [13] state that the predominant component of okara is a substantial amount of protein (15–34%), dietary fibre (57–59%), lipid (6–16%), considerable amount of minerals such as calcium, iron, as well as 12–30% isoflavones [14]. Okara might be considered as one of the potential sources of dietary fibre and high quality protein (especially amino acids), the protein in okara is of better quality and has a superior protein efficiency ratio than that from other soy products [15]. Several studies have shown that dietary fiber in okara has been associated with its ability to lower blood lipid levels along with its effectiveness in reducing metabolic syndrome and providing prebiotic benefits [16–18]. Due to the prebiotic potential of okara, it is needed in improving mineral absorption such as iron, calcium, and magnesium, increased short-chain fatty acid synthesis, and helps to regulate gut motility and inflammation [19].

Most gluten free biscuit studies focus on single ingredient substitutions, e.g., rice flour, corn, or potato flour [20] while neglecting agro industrial by products like okara, which remains underutilized despite its high fiber and protein [15,21]. Utilizing okara, an agro industrial by product as a source of food ingredient can reduce disposal costs and environmental impact, thereby adding value to the soy milk industry [22]. However, there was no available information on the development of gluten free biscuits from okara and orange flesh sweet potato flour blends.

The use of gluten-free flours in the production of baked products such as biscuit can be a means of dietary diversification through the utilization and cultivation of locally grown crops and food by products which will create biscuits that are health oriented, reduce cost of importation and reliance on wheat, enhance food security [23], and provide affordable gluten-free baked products for gluten sensitive individuals [24].

Therefore, this study aimed to assess the nutritional, physical, and sensory qualities of gluten-free biscuits made with blends of orange-flesh sweet potato and okara flour

2. Materials and methods

Orange flesh sweet potato harvest time ranges from 3–6 months (90–180 days) after planting but in this case, Orange-fleshed sweet potatoes were purchased from Oke-Osun Agricultural Farm Settlement in Osogbo, Nigeria, and Soya beans were purchased from a local market in Abeokuta, Nigeria. Baking ingredients such as refined white sugar (Dangote), margarine (Napa Valley), and salt were procured from the local market in Abeokuta, Nigeria.

2.1. Preparation of Orange-Flesh Sweet Potato Flour

The method outlined by [25] was used to transform orange-flesh sweet potato roots into flour with slight modifications in terms of drying temperature and time. To remove dirt and debris, OFSP roots were sorted, graded, and washed with water. The roots were cut, peeled, and dried for 48 h at 60 °C in a cabinet dryer (Genlab™ DC500, Mainz, Germany). Before being stored in Ziploc®® bags for later use, the dried chips were ground into flour and sieved (250 μm).

2.2. Preparation of Okara Flour

Okara flour was made from soybeans via the method outlined by [26]. After sorting, the soybeans were cleaned and rinsed with portable water. After being cleaned, the beans were blanched for 5 min at 100 °C in hot water before being dehulled. The cotyledons were dehulled and then wet-milled at a 1:5 (*w*/*v*) ratio. To separate the milk (filtrate) from the residue (okara), the resulting slurry was stirred, and sieved using a muslin cloth after milling. The damp okara were then spread on trays and allowed to dry in a cabinet dryer (Mitchell Dryers Ltd., Carlisle, UK) for 12 h at 60 °C. The dried okara was pulverised into flour, sieved (250 µm), and then stored in Ziploc®® bags until needed.

2.3. Experimental Design

The different blend ratios of the two flour components (orange-flesh sweet potato and okara flour) for biscuit production were obtained via a simplex lattice mixture design in Design Expert 13 (Stat-Ease Inc., Minneapolis, MN, USA) software. The independent variables considered are orange-flesh sweet potato flour (X1) and okara flour (X2). The range of the orange-fleshed sweet potato and okara flours was 80–90% OFSP and 10–20% okara on the basis of preliminary trials, which resulted in eight (8) experimental runs with three (3) replicates, as shown in Table 1, where each run was a composite.

Table 1. Experimental runs for orange-flesh sweet potato and okara composite flours and biscuits.

Experimental Runs	Orange-Flesh Sweet Potato X_1 (80–90%)	Okara X_2 (10–20%)	Sample Codes
1	82.50	17.50	$OFSP_{82.50}$ $OKF_{17.50}$
2	85	15	$OFSP_{85}$ OKF_{15}
3	90	10	$OFSP_{90}$ OKF_{10}
4	87.50	12.50	$OFSP_{87.50}$ $OKF_{12.50}$
5	80	20	$OFSP_{80}$ OKF_{20}
6	85	15	$OFSP_{85}$ OKF_{15}
7	80	20	$OFSP_{80}$ OKF_{20}
8	90	10	$OFSP_{90}$ OKF_{10}

2.4. Preparation of Composite Flours

Using the different blend ratios shown in the matrix of the mixture design (Table 1), orange-flesh sweet potato and okara flours were combined to create a composite flour. To obtain uniform blends that were subsequently utilised for biscuit production, the portions of OFSP and okara flours were thoroughly mixed in a high-speed hand mixer (silver crest mixer SHMSB 300 A2, Lidl Stiftung & Co. KG, Neckarsulm, Germany).

2.5. Production of Biscuits from Orange-Flesh Sweet Potato and Okara Composite Flour

The biscuits were processed following the procedure outlined by [27] with slight adjustments to the baking temperature. The flour blends with other ingredients, as shown in Table 2, were weighed accurately in a bowl. The fat was creamed with sugar until it was fluffy via a hand mixer (Silver crest mixer SHMSB 300 A2, Lidl Stiftung & Co. KG, Neckarsulm, Germany) before a uniform mixture of dried ingredients was added. Smooth dough was created, moulded, kneaded, and flattened out using a rolling pin to achieve the desired width. The dough batter was cut into a round shape via a biscuit cutter and transferred to a lightly greased baking tray. The biscuits were baked at 130 °C for 30 min in a preheated oven (Emel electric oven, Model EOV-9L, Emel group, Shanghai, China). After 30 min, the mixture was allowed to cool completely for approximately 30 min, after which it was packaged in Ziploc® bags until further use.

Table 2. Formulation table for the production of biscuits from orange-flesh sweet potato and okara composite flour.

Ingredients	Samples (g)							
	A	B	C	D	E	F	G	H
Orange-flesh sweet potato flour	82.50	85	90	87.50	80	85	80	90
Okara flour	17.50	15	10	12.50	20	15	20	10
Granulated sugar	25	25	25	25	25	25	25	25
Baking fat	40	40	40	40	40	40	40	40
Baking powder	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Salt	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Egg	50	50	50	50	50	50	50	50

2.6. Proximate Composition of Orange-Flesh Sweet Potato and Okara Flours and Biscuits

2.6.1. Determination of Moisture Content

Moisture content was determined using the air oven method, AOAC method no. 950.46 [28]. 14 petri-dishes were washed and dried in an air oven (U-clear Model: DHG-9030, Guangzhou Jiangbin Trade Co., Ltd., Guangzhou, China) at 105 °C. Thereafter, the petri-dishes were transferred into the desiccator to cool. The weights of the petri-dishes were recorded. 3 g of each sample was weighed into each petri-dish and was transferred into the air oven, maintaining a temperature of $105\ °C$ for 6 h. Each petri-dish was weighed, returned to the oven until a constant weight was obtained. Each petri-dish with its content was then removed from the oven and placed in the desiccator to cool. After cooling, the weight was recorded. The percentage of moisture was calculated using the following equation:

$$\text{Moisture (\%)} = \frac{\text{Original sample weight} - \text{Dried sample weight} \times 100}{\text{Original sample weight}}$$

2.6.2. Determination of Crude Fat

The crude fat was determined using soxhlet method, AOAC method no 920.39 [28]. 3 g of each sample was extracted with analytical grade hexane in a ground joint Soxhlet apparatus (Thermo scientific EME3100/CEB, Waltham, MA, USA). Extraction was allowed to continue by heating in the electric heater at the temperature of $70\ °C$ until clear solvent (without oil) was seen in siphon, which took about 3 h. Then the round bottom flask of the apparatus was separated and the extract was transferred to a pre-weighed beaker and left for evaporation of hexane. After hexane evaporation, only the fat was left in the beaker, which was calculated in percentage.

$$\text{\% Crude fat} = \frac{\text{Weight of beaker with lipid} - \text{Weight of empty beaker} \times 100}{\text{Weight of sample}}$$

2.6.3. Determination of Crude Fibre

Crude fibre was determined using weende method, AOAC method 978.10 [28]. 2 g of each sample was taken into a filter crucible and was inserted into the hot extraction unit. To the reagent heating system, a sufficient amount of pre-heated 0.128 M H_2SO_4 was added. The mixture was digested for 30 min. Thereafter, the mixture was filtered and washed with boiling water to remove the acid. The required amount of 0.223 M KOH was added to the residue in the flask, the mixture was boiled for 30 min, and then filtered. After that, there was subsequent washing in boiling water and acetone. The residual content was then dried in an oven at $105\ °C$ for a few hours and then ignited in a muffle furnace at $550\ °C$ for 3 h. The loss of weight indicates the crude fibre. The percent crude fibre was calculated by the following formula:

$$\text{Crude fibre (\%)} = \frac{\text{Oven dried weight of sample} - \text{Ashweight of sample} \times 100}{\text{Weight of sample}}$$

2.6.4. Determination of Ash Content

Ash was determined using AOAC method 942.05 [28]. Clean crucibles were ignited at $350\ °C$ in a muffle furnace (Carbolite, ELF11/14B, Carbolite Gero Ltd., Hope Valley, UK) for 15 min, cooled in a desiccator, and then weighed. One gram of each well mixed sample was transferred into each of the appropriately labeled crucibles and then reweighed. Thereafter, the crucibles with their contents were transferred into the muffle furnace at $550\ °C$ for 5 h for ashing. After ashing was completed, the crucibles were transferred to a desiccator to cool, and their weights after ashing were recorded. The percentage of ash was then determined using the following equation.

$$\text{Ash content (\%)} = \frac{\text{Weight of crucible with ash (g)} - \text{Weight of empty crucible (g)} \times 100}{\text{Weight of sample (g)}}$$

2.6.5. Determination of Crude Protein

Crude protein of the samples was determined using Kjeldahl method AOAC method no. 984.13 [28]. 0.5 g of each sample and a blank were estimated in the digestion tube. For digestion at high temperature, 10 mL of concentrated H_2SO_4 and 1.1 g of the digestion mixture were introduced into the tube. Thereafter, the digestion tubes were placed in the digestion chamber fixed at $420\ °C$ for 45 min, ensuring easier gas outlets, water supply, etc. After digestion, the tubes were allowed to cool and 5 mL of sodium thio-sulphate ($Na_2S_2O_3$, 33%) and 30 mL of sodium hydroxide (NaOH) solution were added to each tube. Then the distilled extraction was collected with 25 mL of Boric acid (4%) and titrated with standard hydrochloric acid (0.2N). The nitrogen values obtained were converted into a percentage of crude protein by multiplying by a factor of 6.25.

$$\text{Nitrogen (\%)} = \frac{\text{Milliequivalent of nitrogen (0.014)} \times \text{titrant value (ml)} \times \text{HCl strength} \times 100}{\text{Sample weight (g)}}$$

$$\%\ \text{Crude protein} = \%\text{Nitrogen} \times 6.25$$

2.6.6. Determination of Carbohydrates

Carbohydrate content of the samples was calculated by the difference method [29].

$$\text{Carbohydrates (\%)} = 100 - (\%\text{moisture} + \%\text{crude protein} + \%\text{crude fat} + \%\text{ash} + \%\text{crude fibre})$$

2.7. Physical Properties of Orange-Flesh Sweet Potato and Okara Biscuits

Physical properties such as weight, thickness, diameter, and spread ratio were measured using the method outlined by [30]. 2 biscuit samples from each formulations were weighed using an analytical balance, while in terms of the thickness and diameter of the biscuits, one sample of biscuits from each formulation were measured at two and four different places respectively using a vernier caliper and the average value was tabulated. The spread ratio was calculated from the ratio of thickness to diameter.

2.8. Sensory Analysis

2.8.1. Consumer Acceptability Test

The consumer acceptability of the biscuit samples was determined using 100 untrained panelists (comprising 27 males and 73 females) drawn from the Federal University of Agriculture, Abeokuta, Nigeria. The biscuit samples were assigned a unique code, and the panelists scored their degree of likeness for each attribute of the biscuit samples (aroma, taste, appearance, overall acceptability) using a nine-point hedonic scale ranging from 1(dislike extremely) to 9 (like extremely), with 5 indicating neither dislike nor like.

2.8.2. Statistical Analysis

All chemical analyses were conducted in duplicate. The results obtained are expressed as the means ± standard deviations. Statistical analysis was carried out on the data obtained using one way analysis of variance (ANOVA), and the difference between the mean values was separated using Duncan's multiple range test in IBM SPSS version 21.0 at 5% significance level.

3. Results and Discussion

3.1. Proximate Composition of Orange-Flesh Sweet Potato and Okara Flours

Table 3 shows the proximate compositions of the orange-flesh sweet potato and okara flours. Before the OFSP flour and okara flour were used to make biscuits, their compositions were ascertained. The proximate composition of the OFSP flour was comparable to the findings of [31]. Compared with okara flour, OFSP flour presented notably lower amounts of crude protein (5.44%), fat (1.29%), ash (2.34%), and crude fibre (2.51%) than okara flour but presented significantly higher carbohydrate contents (81.20%) than okara flour. The proximate values of okara flour were comparable to the findings of [32]. Compared with OFSP flour, okara flour had noticeably greater amounts of crude protein (39.73%), fat (12.82%), ash (3.61%), and crude fibre (30.74%). The high fibre content found in okara is due to it being the insoluble residue of the soybean cell walls left over after the water soluble component has been extracted to make soymilk and tofu [11]. It is reported that fibre can reduce blood fat and blood pressure, prevent the occurrence of constipation and colon cancer [15]. These findings highlight the nutritional and health advantages of okara flour.

Table 3. Proximate composition of orange flesh sweet potato and okara flours.

Individual Flours	Moisture (%)	Crude Protein (%)	Crude Fat (%)	Ash (%)	Crude Fibre (%)	Total Carbohydrates (%)
OFSP	7.21 ± 0.19 ^{b}	5.44 ± 0.33 ^{a}	1.29 ± 0.41 ^{a}	2.34 ± 0.16 ^{a}	2.51 ± 0.04 ^{a}	81.20 ± 0.32 ^{b}
OKR	4.22 ± 1.59 ^{a}	39.73 ± 0.24 ^{b}	12.82 ± 0.39 ^{b}	3.61 ± 0.08 ^{b}	30.74 ± 0.24 ^{b}	8.87 ± 0.65 ^{a}

The values are mean ± SD (n = 2). Mean values with different superscripts within the same column are significantly different at 5% level. OFSP = Orange-flesh sweet potato flour, OKR = Okara flour.

3.2. Proximate Composition of Biscuits from Orange Flesh Sweet Potato and Okara Composite Flour

Table 4 displays the proximate compositions of biscuits made from blends of orange-flesh sweet potato (OFSP) and okara (OKR) flour. Significant differences ($p < 0.05$) were observed in the crude fibre, crude protein, and total carbohydrate contents among the biscuit samples, whereas the moisture, crude ash, and crude fat contents were not significantly different ($p > 0.05$). As the proportion of okara flour increased from 10% to 20%, the crude protein, fat, crude fibre, and ash contents increased progressively in the biscuit samples, whereas the moisture and carbohydrate contents decreased simultaneously. The moisture content is a critical quality parameter that significantly impacts the physical, sensory, and microbial characteristics of any product [33]. Ref [34] noted that baked foods such as biscuits typically have low moisture levels, and biscuits with moisture content less than 13% are less susceptible to moisture-induced degradation and are less susceptible to microbial growth [35]. OFSP-OKR biscuits have high potential for stability against moisture induced deterioration and microbial growth because their moisture content of 6.21 to 6.52% is less than 13% which is lower than the range of values (6.99–10.96%) of moisture stated by [36] for biscuits produced from wheat, OFSP and haricot bean composite flour, indicating a reduced risk of spoilage and extended shelf stability for biscuits.

Table 4. Proximate composition of biscuits made from orange-flesh sweet potato and okara composite flour.

Composite Flour Ratio (g)	Moisture (%)	Crude Protein (%)	Crude Fat (%)	Crude Ash (%)	Crude Fibre (%)	Total Carbohydrates (%)
$OFSP_{85}$ OKR_{15}	6.35 ± 0.42 ^{a}	15.79 ± 0.25 ^{c}	7.24 ± 0.17 ^{a}	2.74 ± 0.11 ^{a}	7.24 ± 0.00 ^{c}	60.64 ± 0.95 ^{b,c}
$OFSP_{90}$ OKR_{10}	6.49 ± 0.37 ^{a}	14.07 ± 0.28 ^{a}	7.00 ± 0.66 ^{a}	2.67 ± 0.14 ^{a}	5.83 ± 0.02 ^{a}	63.93 ± 1.46 ^{d}
$OFSP_{90}$ OKR_{10}	6.52 ± 0.29 ^{a}	13.99 ± 0.35 ^{a}	6.96 ± 0.60 ^{a}	2.65 ± 0.14 ^{a}	5.86 ± 0.03 ^{a}	64.02 ± 1.40 ^{d}
$OFSP_{80}$ OKR_{20}	6.21 ± 0.48 ^{a}	17.50 ± 0.22 ^{e}	7.62 ± 0.01 ^{a}	2.80 ± 0.09 ^{a}	8.65 ± 0.01 ^{e}	57.22 ± 0.76 ^{a}
$OFSP_{80}$ OKR_{20}	6.22 ± 0.43 ^{a}	17.49 ± 0.24 ^{e}	7.59 ± 0.00 ^{a}	2.82 ± 0.07 ^{a}	8.67 ± 0.03 ^{e}	57.21 ± 0.71^{a}
$OFSP_{82.50}$ $OKR_{17.50}$	6.29 ± 0.44 ^{a}	16.64 ± 0.23 ^{d}	7.43 ± 0.03 ^{a}	2.77 ± 0.11 ^{a}	7.95 ± 0.00 ^{d}	58.93 ± 0.80 ^{a,b}
$OFSP_{85}$ OKR_{15}	6.36 ± 0.37 ^{a}	15.72 ± 0.32 ^{c}	7.20 ± 0.19 ^{a}	2.73 ± 0.14 ^{a}	7.25 ± 0.03 ^{c}	60.74 ± 1.00 ^{b,c}
$OFSP_{87.50}$ $OKR_{12.50}$	6.42 ± 0.36 ^{a}	14.93 ± 0.26 ^{b}	7.05 ± 0.31 ^{a}	2.70 ± 0.12 ^{a}	6.56 ± 0.01 ^{b}	62.34 ± 1.06 ^{c,d}

The values are mean ± SD (n = 2). Mean values with different superscripts within the same column are significantly different at 5% level. OFSP = Orange-flesh sweet potato flour, OKR = Okara flour.

Proteins are essential nutrients that perform a wide range of critical functions in the human body, including providing the necessary building blocks for various biomolecules and supplying essential amino acids that drive metabolic processes [37]. The protein content of OFSP-OKR biscuits, ranging from 13.99–17.50% falls within the range of protein content (9.61–20.81%) reported by [38] in gluten free biscuits from okara and jackfruit seed composite flour. However, the levels of protein noted in OFSP-OKR biscuits may be due to the incorporation of okara flour, which significantly increases protein levels, making OFSP-OKR biscuits a notable source of protein. This is particularly important given that okara flour contains a substantial amount of protein (24.5–37.5%) [14], indicating that these biscuits can make significant contributions to meeting the requirements for protein to facilitate bodily growth, development, and overall nutrition in which the recommended dietary allowance for protein is 0.8g/kg of body weight for adults but it varies by age, sex and life stage [39].

Fat plays crucial roles in the body, including supporting brain function, facilitating joint mobility, energy production, and the assimilation of fat-soluble vitamins, which are crucial for sustaining overall health and well-being [40]. However, consuming excessive amounts of fat has been associated with numerous cardiovascular illnesses. The fat content of the OFSP-OKR biscuits ranged from 6.96–7.62% which is relatively low compared with the fat values (13.35–21.50%) reported by [41] in gluten free biscuits from African pear and OFSP composite flour. However, the fat content of the OFSP-OKR biscuits is likely attributed to the inherently low fat content of the OFSP [42]. Hence, the consumption of OFSP-OKR biscuits provides a sufficient amount of fat required by the body without exacerbating health risks.

Crude ash is an indicator of the amount of mineral residue present in any food material, which directly reflects the mineral content [37]. The OFSP-OKR biscuits had a higher ash content (2.65–2.82%) than the ash content (1.50–1.68%) reported by [43] for cookies made from rice and okara composite flour. The high ash content is likely due to okara flour, which is rich in macronutrient minerals such as calcium, phosphorus, and potassium, which enhance the nutritional quality of the biscuits [13].

Fibre composition refers to the proportion of various types of indigestible carbohydrates such as cellulose, pentosans, lignins, and other nonstarch polysaccharides. The presence of fibre in food plays a vital role in preventing various diseases, including diabetes, colon cancer, obesity, and cardiovascular diseases, lowers blood cholesterol, promotes proper digestion, and supports healthy bowel movements. The fibre content of the OFSP-OKR biscuits was greater (5.83–8.67%) than the fibre content (1.91–5.28%) reported by [44] in biscuits from maize and okara composite flour. The crude fibre content of OFSP-OKR biscuits may be due to the appreciable quantity of fibre in soybean, and the resulting residue (okara) remaining after soy milk processing is composed mainly of rough materials (fibres) [44]. The increased fibre content in OFSP-OKR biscuits offers various health benefits, particularly supporting digestion [45], making them a relatively safe and healthy option for consumers.

Carbohydrates are vital energy sources for the body's cells, including muscles and the brain. It is one of the three macronutrients that the body requires in significant amounts. The carbohydrate content of OFSP-OKR biscuits, ranging from 57.21 to 64.02% was similar to the values (57.45–67.60%) reported by [46] in cookies from wheat, acha, and OFSP composite flour, thus OFSP-OKR biscuits would supply a good amount of energy to the body when consumed, possibly due to the high carbohydrate content in OFSP [47].

3.3. Physical Properties of Biscuits from Orange-Flesh Sweet Potato and Okara Composite Flour

The physical properties of biscuits made from orange flesh sweet potato (OFSP) and okara (OKR) composite flour are presented in Table 5. There was no significant ($p > 0.05$) difference in the physical properties of the biscuits. Increasing the proportion of okara flour with concurrent reduction in orange-flesh sweet potato flour resulted in increased diameter, spread ratio of the biscuit samples, while thickness and weight of the biscuit samples decreased concurrently. The physical properties of biscuits are commonly used for monitoring the physical quality of biscuits or biscuit like products [48]. The diameter of the biscuit is called the width of the biscuit. The diameter of the OFSP-OKR biscuits was higher (4.15 to 4.45 cm) than the diameter (3.64–3.98 cm) reported by [38] in biscuits from jack seed fruit and okara composite flour. However, the high diameter of the OFSP-OKR biscuits could be due to the resulting high flow rate of the dough [44].

Table 5. Physical properties of biscuits from orange-flesh sweet potato and okara composite flour.

Composite Flour Ratio (g)	Diameter (cm)	Thickness (cm)	Spread Ratio (D/T)	Weight (g)
$OFSP_{85}$ OKR_{15}	4.33 ± 0.21 ^{a}	0.39 ± 0.01 ^{a}	11.10 ± 0.14 ^{a}	6.25 ± 1.77 ^{a}
$OFSP_{90}$ OKR_{10}	4.25 ± 0.07 ^{a}	0.45 ± 0.07 ^{a}	9.58 ± 1.66 ^{a}	7.25 ± 0.35 ^{a}
$OFSP_{90}$ OKR_{10}	4.15 ± 0.21 ^{a}	0.43 ± 0.10 ^{a}	9.97 ± 2.79 ^{a}	7.00 ± 0.71 ^{a}
$OFSP_{80}$ OKR_{20}	4.45 ± 0.07 ^{a}	0.35 ± 0.07 ^{a}	12.96 ± 2.41 ^{a}	5.25 ± 1.06 ^{a}
$OFSP_{80}$ OKR_{20}	4.40 ± 0.00 ^{a}	0.36 ± 0.04 ^{a}	12.46 ± 1.24 ^{a}	5.50 ± 0.71 ^{a}
$OFSP_{82.50}$ $OKR_{17.50}$	4.38 ± 0.18 ^{a}	0.38 ± 0.00 ^{a}	11.51 ± 0.47 ^{a}	5.75 ± 1.06 ^{a}
$OFSP_{85}$ OKR_{15}	4.35 ± 0.07 ^{a}	0.40 ± 0.00 ^{a}	10.88 ± 0.18 ^{a}	6.00 ± 2.12 ^{a}
$OFSP_{87.50}$ $OKR_{12.50}$	4.30 ± 0.28 ^{a}	0.44 ± 0.09 ^{a}	10.02 ± 2.57 ^{a}	6.50 ± 0.71 ^{a}

The values are Mean ± SD (n = 2). Mean values with different superscripts within the same column are significantly different at 5% level. OFSP = Orange-flesh sweet potato flour, OKR = Okara flour.

The thickness of the biscuit is also known as the height of the biscuit. The thickness of the OFSP-OKR biscuits was lower (0.35 to 0.45 cm) than the thickness (0.79–0.85 cm) reported by [38] in biscuits from jack seed fruit and okara composite flour. However, the low thickness of the OFSP-OKR biscuits could be attributed to the high fibre content of the composite flour, which has high water absorption characteristics that attract water, resulting in a reduced viscosity of biscuit dough and the inability of the dough to maintain its thickness [49].

The spread ratio is the ratio of the diameter to the thickness of the biscuit. The spread ratio of the OFSP-OKR biscuits was greater (9.58 to 12.96) than the spread ratio (4.37–4.68) reported by [38] in biscuits from jack seed fruit and okara composite flour. Generally, biscuits with a high spread ratio are highly desirable by consumers [50]. The spread ratio of the biscuit is linked to two factors—reduced dough viscosity and fat-sugar-interaction. The high spread ratio of the OFSP-OKR biscuits can be due to fat–sugar-interaction, fat contributes to the plasticity of the dough and helps to lubricate the flour matrix by hindering formation of gluten network and starch granules [50,51], it also influences the air incorporation during dough mixing and the amount of air incorporated affects the viscosity of the dough system [52] which affects the biscuit spreading. Sugar, on the other hand, competes with flour protein for water, delaying starch gelatinization and keeping the dough fluid longer. Together they extend the spread window, thus increasing the spread ratio

The weight of the OFSP-OKR biscuits, ranging from 5.25 to 7.25 g, was lower than the weight (15.69–18.18 g) reported by [44] in biscuits from maize and okara composite flour. The reduction in the weight of the OFSP-OKR biscuits could be due to the lower density of okara flour [44].

3.4. Consumer Acceptability of Biscuits from Orange Flesh Sweet Potato and Okara Composite Flour

The hedonic and consumer acceptability scores of biscuit samples from orange-flesh sweet potato and okara composite flour are presented in Table 6. Significant ($p < 0.05$) differences were observed in attributes such as appearance, aroma, taste, crunchiness, and overall acceptability. The sensory analysis of the food products is an important criterion in product development and quality control as it helps to evaluate and describe sensory terms related to products, ascertain differences between products with the same characteristics and determine noticeable differences in products and the attitudes of consumers in terms of the overall acceptability of the products [53].

The OFSP-OKR biscuits received high scores for appearance, aroma, taste, crunchiness, and overall acceptability, indicating a high level of consumer acceptability. The ratio of 80% OFSP and 20% OKR would be required to produce OFSP-OKR biscuits with the highest overall acceptability scores and most preferred by consumers. The acceptability scores for OFSP-OKR biscuits were higher than the scores for biscuits from cassava and okara composite flour [53] and biscuits from maize and okara composite flour [44]. However, sensory scores improved only up to a certain level of okara inclusion (10–20%). Beyond this level (25% and above) ultimately decrease sensory acceptability, due to the high fibre content of okara as excess fiber absorbed too much water, leading to a stiff dough, reduced spread, and a dense gritty texture. This information is based on preliminary trials done before the research. The biscuit samples from OFSP and OKR composite flour is presented in Figure 1.

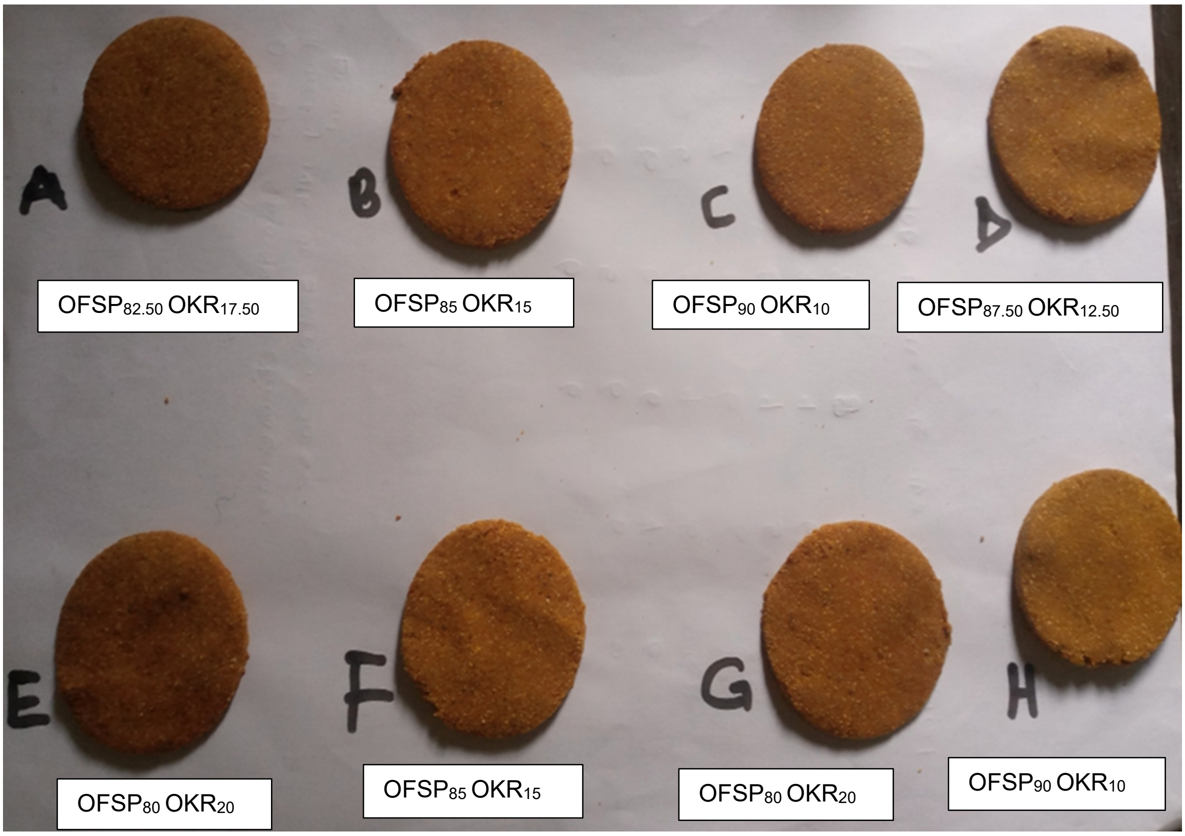

Figure 1. Biscuits from orange-fleshed sweet potato and okara composite flour.

Table 6. Consumer acceptability of biscuits from orange-flesh sweet potato and okara composite flour.

Composite Flour Ratio (g)	Appearance	Aroma	Taste	Crunchiness	Overall Acceptability
$OFSP_{85}$ OKR_{15}	7.19±0.99 ^{a,b}	6.79 ± 1.16 ^{a,b}	6.97 ± 1.21 ^{a,b}	6.84 ± 1.23 ^{c}	7.10 ± 1.09 ^{b}
$OFSP_{90}$ OKR_{10}	7.00 ± 1.17 ^{a}	6.64 ± 1.26 ^{a}	6.75 ± 1.45 ^{a}	6.21 ± 1.57 ^{a}	6.68 ± 1.32 ^{a}
$OFSP_{90}$ OKR_{10}	7.15 ± 1.27 ^{a}	6.75 ± 1.29 ^{a,b}	7.14 ± 1.32 ^{b,c}	6.45 ± 1.38 ^{a,b}	6.87 ± 1.35 ^{a,b}
$OFSP_{80}$ OKR_{20}	7.50 ± 1.10 ^{b}	7.12 ± 1.07 ^{b,c}	7.45 ± 1.05 ^{c}	7.50 ± 0.89 ^{d}	7.54 ± 1.01 ^{c}
$OFSP_{80}$ OKR_{20}	7.52 ± 1.05 ^{b}	7.20 ± 1.06 ^{c}	7.49 ± 1.18 ^{c}	7.52 ± 0.87 ^{d}	7.83 ± 1.03 ^{c}
$OFSP_{82.50}$ $OKR_{17.50}$	7.15 ± 0.97 ^{a}	6.95 ± 1.05 ^{a,b,c}	6.88 ± 1.28 ^{a,b}	6.61 ± 1.36 ^{b,c}	6.96 ± 1.17 ^{a,b}
$OFSP_{85}$ OKR_{15}	7.33 ± 1.04 ^{a,b}	6.83 ± 1.24 ^{a,b}	6.97 ± 1.23 ^{a,b}	6.78 ± 1.13 ^{b,c}	7.15 ± 1.24 ^{b}
$OFSP_{87.50}$ $OKR_{12.50}$	7.20 ± 1.05 ^{a,b}	6.97 ± 1.31 ^{a,b,c}	7.20 ± 1.03 ^{b,c}	6.85 ± 1.36 ^{c}	7.18 ± 1.10 ^{b}

The values are Mean ± SD (n = 100). Mean values with different superscripts within the same column are significantly different at 5% level. OFSP = Orange-flesh sweet potato flour, OKR = Okara flour

4. Conclusions

The study shows that okara flour greatly enhances the nutritional profile of OFSP flour by increasing its crude protein, crude ash, fat, and fiber. The protein, ash, and fibre content of gluten-free biscuits made with orange-fleshed sweet potato and okara composite flour improved, but the physical properties of biscuits showed inconsistent outcomes because of the significant influence of the composition ratio of OFSP and okara. Due to their high sensory acceptance scores, the gluten-free biscuits made with orange-fleshed sweet potato and okara composite flour were judged to be good and acceptable based on positive sensory analysis evaluations. Future studies might concentrate on shelf life studies and microstructure analysis of the biscuits

Author Contributions

O.G.C.: Conceptualization, Methodology, Investigation, Writing—original draft preparation and Writing—review and editing, Data curation; H.F.O.: Supervision, Validation and Writing—review and editing; O.G.O.: Supervision, Data curation, Methodology; O.I.O.: Supervision, Data curation, Visualisation. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Data Availability Statement

Data supporting the findings of this study are available from the corresponding author on a reasonable request.

Acknowledgments

The authors would like to convey their sincere appreciation to the entire staff of the department of Food Science and Technology, Federal University of Agriculture in Abeokuta, Ogun State, Nigeria for their support, assistance at all times in this study.

Conflicts of Interest

The authors declare no conflict of interest.

Use of AI and AI-Assisted Technologies

No AI tools were utilized for this paper.

References

1. Onabanjo, O.O.; Ighere, D.A. Nutritional, functional and sensory properties of biscuit produced from wheat-sweet potato composite. *J. Food Technol. Res.* **2014**, *1*, 111–121.
2. Imam, Y.T.; Irondi, E.A.; Awoyale, W.; et al. Application of legumes in the formulation of gluten-free foods: Functional, nutritional and nutraceutical importance. *Front. Sustain. Food Syst.* **2024**, *8*, 1251760.
3. Irondi, E.A.; Imam, Y.T.; Ajani, E.O.; et al. Natural and modified food hydrocolloids as gluten replacement in baked foods: Functional benefits. *Grain Oil Sci. Technol.* **2023**, *6*, 163–171.
4. Fiori, F.; Parpinel, M.; Morreale, F.; et al. The update of the Italian food composition database of gluten-free products and its application in food based dietary guidelines menus. *Nutrients* **2022**, *14*, 4171.
5. Akriti Thakur, J.; Sontakke, M. Application of gluten free flours in bakery products formulation. *Biol. Forum Int. J.* **2023**, *15*, 1018–1023.
6. Straits Research. Gluten Free Products Market Size and Outlook, 2026–2034. Food and Beverage 2025. Available online: https://straitsresearch.com/report/gluten-free-products-market (accessed on 22 November 2025).
7. Ken Research. Global Gluten Free Food Market Outlook 2030. Food, Beverage and Tobacco. Available online: https://www.kenresearch.com/industry-reports/global-gluten-free-food-market (accessed on 22 November 2025).
8. Azeem, M.; Mu, T.H.; Zhang, M. Influence of particle size distribution of orange fleshed sweet potato on dough rheology and simulated gastrointestinal digestion of sweet potato wheat bread. *LWT* **2020**, *131*, 109690.
9. Endrias, D.; Negussie, R.; Gulelat, D. Comparison of three sweet potato (*Ipomoea batatas* Lam) varieties on nutritional and anti-nutritional factors. *Glob. J. Sci. Front. Res. D Agric. Vet.* **2016**, *16*, 1–11.

10. Oloniyo, R.O.; Omoba, O.S.; Awolu, O.O. Quality characteristics of non-gluten biscuits developed from optimized cream and OFSP flours. *Crop Sci.* **2024**, *64*, 1496–1507.
11. Kamble, D.B.; Singh, R.; Rani, S.; et al. Physicochemical properties, *in vitro* digestibility and structural attributes of okara-enriched functional pasta. *J. Food Process. Preserv.* **2019**, *43*, e14232.
12. Scheved, F.; Hassidov, B. Okara, a natural food ingredient for new product development of food stuffs. *Agro Food Ind. Hi-Tech* **2010**, *21*, 46–48.
13. Santos, D.C.; Oliveira Filho, J.G.; Silva, J.S.; et al. Okara flour: Its physicochemical, microscopical and functional properties. *Nutr. Food Sci.* **2019**, *49*, 1252–1264.
14. Kamble, D.B.; Rani, S. Bioactive components, *in vitro* digestibility, microstructure and application of soyabean residue (okara): A review. *Legume Sci.* **2020**, *2*, e32.
15. Li, S.; Zhu, D.; Li, K.; et al. Soybean curd residue: Composition utilization, and related limiting factors. *ISRN Ind. Eng.* **2013**, *2013*, 423590.
16. Nagata, Y.; Yamasaki, S.; Torisu, N.; et al. Okara, a by-product of tofu manufacturing, modifies triglyceride metabolism at the intestinal and hepatic levels. *J. Nutr. Sci. Vitaminol.* **2016**, *62*, 162–169.
17. Nishibori, N.; Kishibuchi, R.; Morite, K. Suppressive effect on okara on intestinal lipids digestion and absorption in mice ingesting high fat diet. *Int. J. Food Sci. Nutr.* **2018**, *69*, 690–695.
18. Villanueva-Suaez, M.J.; Perez-Cozed, M.L.; Mateos-Aparicio, I.; et al. Potential fat- lowering and prebiotic effects of enzymatically treated okara in high cholesterol-fed wistar rats. *Int. J. Food Sci. Nutr.* **2016**, *67*, 828–833.
19. Asghar, A.; Afzaal, M.; Saeed, F.; et al. Valorization and food applications of okara (soybean residue): A concurrent review. *Food Sci. Nutr.* **2023**, *11*, 3631–3640.
20. Mancebo, C.M.; Rodriguez, P.; Gomez, M. Assessing rice flour starch protein mixtures to produce gluten free sugar snap-cookies. *Food Sci. Technol.* **2016**, *67*, 127–132.
21. Redondo-Cuenca, A.; Villanueva-Suarez, M.J. Mateos-Aparicio, soybean seeds and its by-product okara as sources of dietary fibre. Measurement by AOAC and Englyst methods. *Food Chem.* **2008**, *108*, 1099–1105.
22. Guimaraes, R.M.; Silva, T.E.; Lemes, A.C.; et al. Okara: A soybean by-product as an alternative to enrich vegetable paste. *LWT* **2018**, *92*, 593–599.
23. Salem, M.E.; Elzayet, F.M.; Rayan, A.M.; et al. Physiochemical properties and acceptability of gluten free biscuits affected by some cereals and tubers type. *J. Food Sci.* **2019**, *6*, 1–12.
24. Oloniyo, R.O.; Omoba, O.S.; Awolu, O.O.; et al. Rheological behaviour, physical and sensory properties of orange-fleshed sweet potato and soya concentrate bread. *J. Food Sci. Technol*. **2021**, *59*, 2189–2199.
25. Olatunde, G.O.; Henshaw, F.O.; Idowu, M.A.; et al. Quality attributes of sweet potato flour as influenced by variety pretreatment and drying method. *Food Sci. Nutr.* **2016**, *4*, 623–635.
26. Ibidapo, O.P.; Henshaw, F.O.; Shittu, T.A.; et al. Bioactive components of malted millet *(Pennisetum glaucum),* Soya Residue "okara" and wheat flour and their antioxidant properties. *Int. J. Food Prop.* **2019**, *22*, 1886–1898.
27. Nguyen, V.T.; Nguyen, V.Q.A. Preparation and Improved Quality Production of Flour and the Made Biscuits from Purple Sweet Potato. *J. Food Nutr.* **2018**, *4*, 1–14.
28. AOAC. *Official Methods of Analysis of Association of Official Analytical Chemists*, 18th ed.; AOAC: Washington, DC, USA, 2010.
29. Huber, K.; Bemiller, J. Carbohydrate Analysis. In *Nielsen's Food Analysis*; Springer International Publishing: Cham, Switzerland, 2024, pp. 303–329.
30. Bawa, M.; Dzigbor, A.; Gobe, V.A.D.; et al. Nutritional, sensory, and microbial quality of cookies produced by partial replacement of wheat flour with plantain (*Musa paradisiaca*) and cocoyam (*Colocasia esculenta*) flours. *J. Food Process. Preserv.* **2023**, *2023*, 6762289.
31. Rodrigues, N.R.; Barbosa, J.L.; Barbosa, M.I.M.J. Determination of physico-chemical composition, nutritional facts and technological quality of organic orange and purple-fleshed sweet potatoes and its flours. *Int. Food Res. J.* **2016**, *23*, 2071–2078.
32. Momin, M.A.; Jubayer, M.F.; Begum, A.A.; et al. Substituting wheat flour with okara flour in biscuit production. *Foods Raw Mater.* **2020**, *8*, 422–428.
33. Malavi, D.; Mbogo, D.; Moyo, M.; et al. Effect of Orange-Fleshed Sweet Potato Purée and Wheat Flour Blends on Carotene, Selected Physicochemical and Microbiological Properties of Bread. *Foods* **2022**, *11*, 1051.
34. Ndulaka, J.C.; Obasi, N.E. Effects of Storage on the Proximate and Beta Carotene Contents of Cookie-Like Products Formulated from Blends of Wheat Flour and Garri from Bio-fortified Cassava Varieties. *IOSR J. Environ. Sci. Toxicol. Food Technol.* **2018**, *12*, 2319–2399.
35. Ayo-Omogie, H.N.; Odekunle, O.Y. Substituting Wheat Flour with Banana Flour: Effects on the Quality Attributes of Doughnut and Cookies. *Appl. Trop. Agric.* **2017**, *22*, 134–137.

36. Kindeya, F.; Hailu, W.; Dessalegn, T.; et al. Effect of blending ratio of wheat, orange fleshed sweet potato and haricot bean flour on proximate compositions, β-carotene, physicochemical properties and sensory acceptability of biscuits. *F1000 Res.* **2022**, *10*, 506.
37. Satheesh, N.; Workneh, S.F. Review on nutritional composition of orange-fleshed sweet potato and its role in management of vitamin A deficiency. *Food Sci. Nutr.* **2019**, *7*, 1920–1945.
38. Goh, S.X.; Mamat, H.; Abdul-Aziz, A.H. Valorization of agriculture by product: Development of gluten free biscuit made from blends of okara and jackfruit seed flour. *J. Waste Manag. Bull.* **2024**, *2*, 59–65.
39. World Healh Organisation (WHO). *Dietary Reference Intake for Energy, Carbohydrate, Fibre, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids (Macronutrients)*; World Health Organisation: Geneva, Switzerland, 2007.
40. Ariyo, O.; Adetutu, O.; Keshinro, O. Nutritional composition, microbial load and consumer acceptability of Tigernut (*Cyperus esculentus*), Date (*Phoenix dactylifera* L.) and Ginger (*Zingber officinale Roscoe*) blended beverage. *Agric. Sci.* **2021**, *20*, 72–99.
41. Onwuzuruike, U.A.; Onuoha, N.D.; Uzochukwu, U.C. Nutrient assessment of gluten free biscuit from African pear and orange flesh sweet potato flour blends. *J. Agric. Food Sci. Biotechnol*. **2023**, *1*, 83–94.
42. Mohammad, K.A.; Ziaul, H.R.; Sheikh, N.I. Comparison of the proximate composition, total carotenoids and total polyphenol content of nine orange-fleshed sweet potato varieties grown in Bangladesh. *Foods* **2016**, *5*, 2–10.
43. Net, M.; Kong, S.; Say, M.; et al. Physical Properties, Proximate Analysis, and Sensory Characteristics of Gluten-free Cookies Made from Rice Flour and Okara. *Techno Sci. Res. J.* **2023**, *11*, 9–16.
44. Makinde, F.M.; Tifu, O.D.A. Functionality and chemical composition of maize-okara flour blends on biscuit quality. *Ukr. J. Food Sci.* **2021**, *9*, 88–102.
45. Akmeemana, C.; Wickramasinghe, I.; Wanniarachchi, P.C.; et al. Effect of drying and frying pretreatments on nutrient profile, antioxidant capacity, cooking time and sensory acceptability of easy to cook jack fruit seeds. *Appl. Food Res.* **2022**, *2*, 100234.
46. Ubbor, S.C.; Ekeh, J.I.; Agwo, O.E.; et al. Physicochemical and Sensory Properties of Cookies produced from Composite Flour of Wheat, Acha and Whole Orange Fleshed Sweet Potato. *Niger. Agric. J.* **2022**, *53*, 248–259.
47. Jobling, S. Improving starch for food and industrial applications. *Curr. Opin. Plant Biol.* **2004**, *7*, 210–218.
48. Nashat, S.; Abdullah, M.Z. Quality Evaluation of Bakery Products. In *Computer Vision Technology for Food Quality Evaluation*, 2nd ed.; Sun, D.-W., Ed.; Academic Press: San Diego, CA, USA, 2016; pp. 525–589.
49. Ho, L.H.; Abdul Latif, N.W.B. Nutritional composition, physical properties and sensory evaluation of cookies prepared from wheat flour and pitaya (*Hylocereus undatus*) peel flour blends. *Cogent Food Agric.* **2016**, *2*, 901.
50. Arepally, D.; Reddy, R.S.; Goswami, T.K.; et al. Biscuit baking: A review. *LWT* **2020**, *131*, 109726.
51. Mert, B.; Demirkesen, I. Reducing saturated fat with oleogel/shortening blends in a baked product. *Food Chem.* **2016**, *5*, 809–816.
52. Jacob, J.; Leelavathi, K. Effect of fat-type on cookie dough and cookie quality. *J. Food Eng*. **2007**, *1*, 299–305.
53. Gonzalez-Casado, A.; Jimenez-Carvelo, A.M.; Cuadros-Rodigruez, L. Sensory quality control of dry-cured ham: A comprehensive methodology for sensory panel qualification and method validation. *Meat Sci*. **2019**, *149*, 149.