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Quality evaluation of cookies produced from blends of orange-fleshed sweet potato, Mushroom, and date palm fruit flour

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Abstract

The Quality characteristics of cookies produced from blends of orange-fleshed sweet potato (*Ipomoea batatas L.*), mushroom (Pleurotus ostreatus) and date palm (*Phoenix dactylifera L.*) flours were investigated. Five formulations were prepared: 100% orange-fleshed sweet potato flour (A), 85:5:10 (B), 80:10:10 (C), 75:15:10 (D) and 70:20:10 (E) for Orange-fleshed sweet potato, mushroom and date palm flours respectively. The cookies were evaluated for proximate composition, functional properties, physical characteristics and sensory attributes. Increasing mushroom inclusion resulted in a reduction in fat and carbohydrate contents from 4.22% to 2.61% and 79.14% to 60.53%, respectively, while moisture, protein, ash and fibre contents increased from 9.68% to 10.61%, 2.75% to 24.98%, 3.79% to 5.43% and 1.05% to 3.85%, respectively. A decline in swelling index, emulsification capacity and water absorption capacity were observed as the proportion of orange-fleshed sweet potato flour decreased. Sensory evaluation indicated no significant differences among the cookie samples. The study demonstrates that nutritionally enhanced cookies can be produced using blends of orange-fleshed sweet potato, mushroom and date palm flours without adversely affecting consumer acceptability.

Keywords: Cookies, Orange-fleshed, sweet Potato, Mushroom, Date Palm Fruit, blends Flour

Introduction

In recent years, consumers have become increasingly aware of the relationship between diet and health, resulting in a growing demand for innovative, functional, and health-promoting foods. The rising incidence of diet-related diseases has further strengthened the need for nutritious, safe, and wholesome food products capable of supporting immune function and improving overall well-being. In response to this demand and in line with efforts to enhance food and nutrition security, attention has shifted toward the utilization of locally available and under-utilized crops with high nutritional value in the development of commonly consumed products such as cookies. Alongside this is the increasing preference for convenient foods enriched with functional and health-enhancing ingredients (Oladunjoye *et al.*, 2021) [43].

Cookies are widely consumed bakery products because they are affordable, convenient, and shelf-stable, and they provide appreciable amounts of nutrients such as iron, calcium, protein, calories, fibre, and B-vitamins (Ikuomola *et al.*, 2017) [28]. Food industries are therefore continually exploring the incorporation of functional ingredients into cookies to improve their nutritional quality, particularly for populations vulnerable to protein-energy malnutrition and micronutrient deficiencies (Olugbuyi *et al.*, 2022; Malomo *et al.*, 2018) [38, 47]. Although wheat flour remains the primary raw material for cookie production, research has demonstrated the potential of composite flours to enhance the nutritional and functional properties of cookies beyond those produced solely from wheat (Udeh *et al.*, 2023).

Orange-fleshed sweet potato (*Ipomoea batatas*) has gained prominence as a biofortified crop due to its high β-carotene content, a precursor of vitamin A, making it a valuable dietary component in regions affected by vitamin A deficiency. Increased consumption of orange-fleshed sweet potato offers an affordable dietary strategy for vulnerable populations with limited access to animal-based vitamin A sources, while also supplying energy-yielding macronutrients (Abewoy *et al.*, 2024) [1].

Mushrooms, particularly (*Pleurotus ostreatus*), are recognized for their nutritional, medicinal, and functional properties. They provide high-quality protein, vitamins such as riboflavin, niacin, and vitamin D, minerals, fibre, and bioactive compounds with health-promoting effects including cholesterol-lowering and immunomodulatory properties (Martínez-Ibarra *et al.*, 2019; Miah *et al.*, 2017) [39, 40]. Mushrooms have therefore been recommended as a valuable dietary supplement, particularly in regions where protein intake remains inadequate (Ferdousi *et al.*, 2020) [24].

Date palm fruit *(Phoenix dactylifera L.*) is another nutrient-dense ingredient, rich in natural sugars (70-80%), fibre, minerals such as potassium, calcium, magnesium, phosphorus, and selenium, as well as phenolic compounds and antioxidants. These components contribute to energy provision, growth, bone health, and potential antimicrobial activity, which may enhance the storage stability of formulated foods (Alu'datt *et al.*, 2025) [8]. Despite their nutritional potential, locally available crops such as orange-fleshed sweet potato, mushroom, and date palm fruit remain under-utilized in the development of enriched bakery products such as cookies. Additionally, the high moisture content of fresh crops predisposes them to rapid spoilage and post-harvest losses, sometimes exceeding 40-50% (Enyiukwu *et al.*, 2020) [20]. Processing these crops into shelf-stable flours for use in composite products represents a viable strategy for value addition and nutrient enhancement.

Therefore, this study aims to evaluate the quality attributes of cookies formulated from blends of orange-fleshed sweet potato, mushroom, and date palm fruit flours, with the goal of developing a nutritionally enriched, functional baked cookies suitable for widespread consumption.

Materials and methods

1. Preparation of Raw Materials

Orange Fleshed Sweet potato (Ipomea batatas L) and date palm fruits (P. dactylifera) were purchased from the village market section of the Modern Market, Makurdi, Benue State and the fresh Mushroom (Pleurutus ostreatus) was purchased from Adem market, Makurrdi (mobile barrack road), Benue State, and were transported to the laboratory, Department of Food Science and Technology, Joseph Sarwuan Tarka University, Makurdi.

1.1 Preparation of Orange-Fleshed Sweet Potato Flour

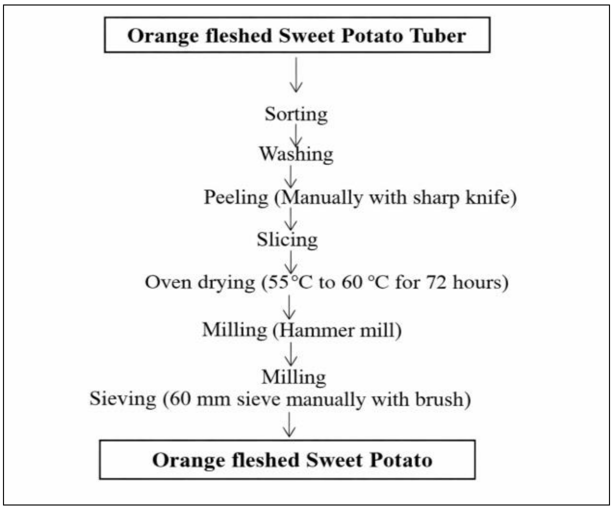
This was done according to the method described by Kolawole *et al*. (2020) [32] with little modification. Briefly, Orange-Fleshed Sweet Potato (OFSP) were sorted, cleaned and peeled, sliced to a 2 mm thickness and dried in an Oven at 55oC to 60oC for 72 h. It was allowed to cool, and then milled using Hammer mill and sieved with 60 mm sieve to obtain OFSP flour.

1.2 Preparation of Mushroom Flour

This was done according to the method described by (Patel and Goyal 2012) [50]. The mushroom (*Pleurotus ostreatus*) fruiting bodies collected were cleaned with distilled water to remove dirt, soils, damaged portions, and other undesirable materials and sliced thinly to a 2 mm size using a kitchen knife, spread on aluminum foiled tray and dried in an oven dryer at 55 ºC to 60 ºC for 72h. The dried mushrooms were coarsed milled using Hammer mill and sifted through a 60mm mesh. Flour obtained was kept in air tight polythene bags at 35 ºC until analysis.

1.3 Preparation of Date Palm Fruit (*Phoenix dactylifera L.*) Flour

Date palm fruit was produced first by removing the seeds of the fruit manually with the aid of knife and weighing the dried palm fruit. The date palm fruit was washed with water to remove adhering dirt. The deseeded fruit was then oven dried at 60 °C for 8 h and subsequently milled.



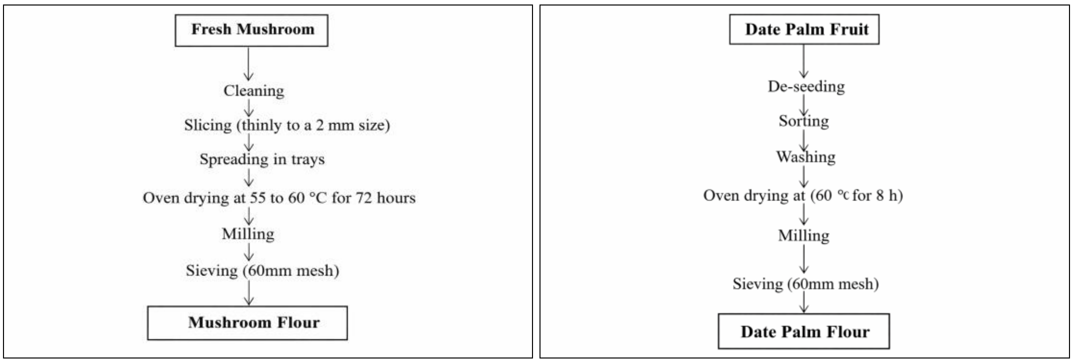


Fig 2: Flow Chart for Mushroom Flour Production.

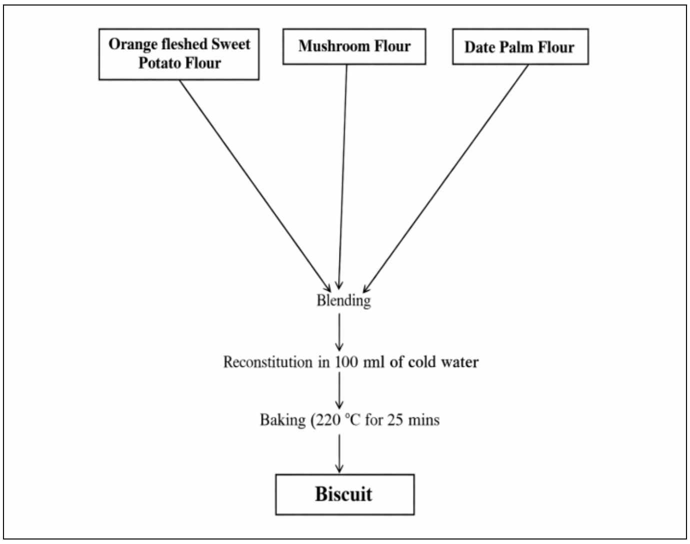


Fig 3: Flow Chart for Date Palm Fruit Flour Production

Table 1: Blend formulation

Sample (%)	Orange Fleshed Sweet potato (%)	Mushroom (%)	Date Palm (%)
$OFSP_{100}$ MR_0 DP_0	100	-	-
$OFSP_{85}$ MR_5 DP_{10}	85	5	10
$OFSP_{80}$ MR_{10} DP_{10}	80	10	10
$OFSP_{75}$ MR_{15} DP_{10}	75	15	10
$OFSP_{70}$ MR_{20} DP_{10}	70	20	10

KEY: OFSP=Orange fleshed sweet potato flour, MR=Mushroom flour, DP=date palm fruit flour

Table 2: Recipe used for the preparation of cookies

Ingredient	Composition (g)
Composite flour	100
Fat	37
Salt	0.8
Egg	1
Baking powder	1.5

2 Methods

2.1 Determination of proximate composition

The moisture, ash, fat, protein and crude fibre content of the cookies were determined using AOAC (2015) [52] methods. Carbohydrate content was obtained by difference.

3 Determination of Functional Properties

3.1 Swelling Index

One gram (1.0g) of the sample was weighed into a conical flask. It was hydrated with 15 ml distilled water, shook for 5 min with mechanical shaker at low speed. Heating was done for 40 min at 80-85oC with constant stirring in a water bath. The content was transferred into a clean, dried and pre-weighed centrifuge tube. 7.5 mil of distil water was added and centrifuged at 2200 rpm for 20 min. The supernatant was decanted into a pre-weighed can and dried at 100oC to a constant weight. The sediment was weighed in the centrifuge. Swelling power and solubility was calculated *viz*: (AOAC2015)

3.2 Emulsification capacity

Two gram (2.0g) of sample was blended with 25 ml distilled water for 30 sec in a blender at 1600 rpm. After complete dispersion, refine corn oil was added from a burette and blended until there was a separation into two layers of water and fat. Emulsifying capacity will be expressed as ml of oil emulsified by 1 g of flour.

3.3 Water absorption capacity

Fifteen mills (15ml) of distilled water were added to 1 g of the flour in a weighed 25 ml centrifuge tube. The tube was agitated on a vertex 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 the reweighed. Water absorption capacity is expressed as the weight of water bound by 100 g dried flour.

3.4 Oil absorption capacity

Ten mills (10 ml) refined corn oil was added to 1 g of the flour in a weighed 25-80 ml centrifuge tube. The tube was agitated on a vertex mixer for 2 min. It was centrifuged at 4000 rpm for 20 min. The volume of free oil was recorded and decanted. Fat absorption capacity is expressed as mil of oil bound by 100 g dried flour.

3.5 Foaming capacity

Two-gram (2.0g) flour sample and 50 ml distilled water were mixed in a blended at room temperature. The suspension was stirred for 5 min at 1000 rpm. The total volume after 30 sec was recorded. It was allowed to stand at room temperature for 30 min and the volume of foam recorded. The percentage increase in volume after 30 sec is expressed as foaming capacity.

3.6 Bulk density

Ten-gram (10.0g) flour sample was put into a 50 ml measuring cylinder. The cylinder was tapped several times on a laboratory bench to a constant volume. The volume of sample was recorded.

$$\text{Bulk density (g/cm)} = \frac{weight\ of\ samplenx}{volume\ of\ sample\ after\ tapping}$$

4. Evaluation of Physical Characteristics of Biscuits

The method of AACC (2018) was used to determine biscuits diameter, thickness volume, weight/density and spread factor.

4.1 Spread ratio

The spread ratio was determined by using this formula.

$$\text{Spread ratio} = \frac{diameter\,(mm)}{thickness\,(mm)}$$

4.2 Thickness

The thickness was measured in mm by screw gauge.

4.3 Volume

Volume of biscuit is defined as the area of the biscuit multiplied by thickness.

$$\text{Volume } (cm^3) = \frac{d^2\,\pi T}{4}$$

t=Average thickness of biscuit (mm)
d=Diameter of biscuit (mm)

4.4 Diameter

The diameter was measured in mm by Vernier caliper.

4.5 Density /weight

After calculating volume, density/weight was obtained by ratio of weight of volume. Density

$$\left(\frac{G}{CM3}\right) = \frac{mass\ of\ sample\ (g)}{volume\ of\ sample\ (cm3)}$$

5. Determination of Sensory Attributes

The biscuits were evaluated by a panel of fifteen semi-trained judges drawn from the department of food science and technology, Joseph Tarka University Makurdi. Biscuit samples were evaluated and scored for appearance, flavor, taste, mouthfeel, and general acceptability using a 9-point hedonic scale, where "9" represented "like extremely" and "1" represented "dislike extremely". The scoring scale was: 1 (Dislike extremely), 2 (Dislike very much), 3 (Dislike moderately), 4 (Dislike slightly), 5 (Neither dislike nor acceptable), 6 (Slightly acceptable, 7 (Moderately acceptable), 8 (Highly acceptable) and 9 (Extremely acceptable). (Olaniran *et al*., 2024) [46].

6. Statistical Analysis

Analysis of variance (ANOVA) was used in all the analysis for detection of significant differences (p<0.05) among samples. All measurements were performed in triplicate for each sample. Data was analyzed using statistical software (SPSS for Windows Version 20.0).

Results

1. Proximate Composition of Cookies Produce from Orange Fleshed Sweet Potato Mushroom and Date Palm Fruit Flour Blends

The results of proximate composition of cookies produced from the blends of Orange Fleshed Sweet Potato, Mushroom and Date Palm fruit flour is presented in Table 3, the moisture content ranged from 8.75-9.63 %, with sample 100:0:0 having the highest and 70:20:10 having the lowest. Addition of mushroom led to a significant variation in the protein content, increasing from 3.6712% (100:0:0) to 24.05% (70:20:10). The fat content ranged from 3.92% (CTRL) to 1.62% (70:20:10), while the highest ash content was recorded in 70:20:10 (5.02%) and lowest in 100:0:0 (2.29%). The fibre content ranged from 1.35% (CTRL) to 2.09% (60:35:5). The carbohydrates content was highest in 100:0:0 (79.78%) and lowest in 70:20:10 (58.52%). A progressive reduction in moisture content was observed as mushroom and date palm fruit flours were incorporated into the blends. This reduction may be attributed to the ability of the composite flours to bind and entrap water within their matrix, thereby limiting free moisture. Moisture content is a critical determinant of shelf-life stability, as lower moisture levels reduce susceptibility to microbial spoilage and enzymatic deterioration (Ayougu *et al*., 2016). The moisture values obtained in this study are consistent with the 7.9-10.0% range reported by Sengev *et al*. (2015) [52] for cookies produced from sweet potato-mango mesocarp flour blends, but lower than the 12.04-15.33% reported for cookies enriched with edible mushroom sclerotium by Kolawole *et al*. (2020) [32]. Moisture levels below 10% are considered desirable for extended storage stability of baked products (Lancelot *et al*., 2021) [35].

A significant (p < 0.05) increase in crude protein content was recorded with increasing inclusion of mushroom and date palm fruit flours. Protein content rose markedly from 3.67% in the 100:0:0 sample to 24.05% in the 70:20:10 blend. This trend reflects the relatively high protein content of edible mushrooms compared with OFSP. Similar observations have been reported by Nwankwegu *et al*. (2025) [41] for cookies produced from OFSP, soybean, and date palm fruit flour blends, and the values obtained in this study were higher than the 5.66-11.02% reported by Kolawole *et al*. (2020) [32]. The results clearly indicate that enrichment of OFSP flour with mushroom and date palm fruit flour substantially improves the protein quality of the cookies, making them suitable for the development of nutrient-dense bakery products (Kolawole *et al*., 2020) [32].

The fat content of the cookies decreased progressively with increasing substitution levels of mushroom and date palm fruit flour, ranging from 1.62% in the control sample to 3.92% in the 70:20:10 blend. These values are lower than those reported by Kolawole *et al*. (2020) and Sengev *et al*. (2015) [32, 52], which may be attributed to differences in formulation ratios and raw material composition. Although fat is an important source of energy and essential fatty acids required for growth and development, particularly in infants (Wong, 2016) [55], lower fat content in baked products is advantageous as it reduces susceptibility to oxidative rancidity, thereby enhancing storage stability (Tenagashaw *et al*., 2015) [53].

Crude fibre content increased significantly (p < 0.05) with the incorporation of mushroom and date palm fruit flours, ranging from 1.35% in the control to 2.09% in the 60:35:5 formulation. Dietary fibre, which consists mainly of indigestible carbohydrates such as cellulose, hemicellulose, pectin, and lignin, plays a crucial role in moderating glucose release, improving bowel function, and reducing the risk of colon-related diseases (Awuchi, 2019) [12]. The fibre values obtained are comparable to those reported by Kolawole *et al*. (2020) [32] for OFSP-based cookies enriched with edible mushroom sclerotium. The observed increase suggests that the composite cookies could serve as a functional food with potential gastrointestinal health benefits.

Ash content, an indicator of total mineral content, increased significantly (p < 0.05) with the inclusion of mushroom and date palm fruit flours. The highest ash value (5.02%) was recorded in the 70:20:10 blend, while the lowest (2.29%) was observed in the control sample. Although the ash values were lower than those reported by Kolawole *et al*. (2020) [32], they were slightly higher than those documented by Ihuoma (2021) [27] for cookies produced from sorghum, OFSP, and date palm fruit flour blends. The increase in ash content suggests an improvement in the mineral profile of the cookies, as minerals are essential micronutrients involved in numerous metabolic processes and structural functions, including the formation of biomolecules such as DNA, ATP, and hemoglobin (Adelekan *et al*., 2019; Arif *et al*., 2024) [5, 11].

A significant (p < 0.05) reduction in carbohydrate content was observed with increasing levels of mushroom and date palm fruit flours, with the highest carbohydrate value recorded in the 100:0:0 formulation and the lowest (60.53%) in the 70:20:10 blend. This decrease reflects the dilution effect of higher protein, fibre, and mineral contents contributed by mushroom and date palm fruit flours. A similar trend was reported by Kolawole *et al*. (2020) [32] for OFSP-based composite cookies.

2. The functional properties of cookies from the blends of orange fleshed sweet potato, mushroom and date palm fruit flours blends

The functional properties of cookies from the blends of orange fleshed sweet potato, mushroom and date palm fruit flours blends presented in Table 4 The inclusion of mushroom and date palm fruit in orange fleshed sweet potato flour had a significant (p<0.05) effect on all the functional properties of the flour blends. the parameters for Swelling index SI, Emulsification capacity and Water absorption capacity WAC decreased significantly with an increase, except for Oil absorption capacity OAC, Foaming capacity FC and Bulk density BD increased significantly across the samples. The variation in the functional properties was as follows; 12.12-6.73%, 12.73-9.34% 1.89-2.88 mL/g, 1.10-2.40 mL/g, 2.20-3.96% and 5.28-6.96g/mL. The swelling index of the composite flour blends decreased across samples. Swelling index reflects the ability of starch granules to absorb water and swell upon heating, which is largely influenced by starch content, granule integrity, and the presence of non-starch components such as fibre and protein (Majzoobi & Farahnaky 2021) [37]. The observed decrease may be attributed to the progressive inclusion of mushroom and date palm fruit flours, which are relatively higher in dietary fibre and lower in starch compared to orange-fleshed sweet potato flour. Dietary fibre restricts starch granule expansion by competing for water and physically limiting swelling. Similar reductions in swelling capacity have been reported in composite flours containing fibre-rich ingredients, where starch dilution and increased non-starch polysaccharides reduced granule hydration and swelling (Adebowale *et al*., 2017; Abioye & Aka, 2015) [2, 4].

The emulsification capacity also decreased this indicate ability of the flour blends to stabilize oil-water interfaces. Emulsification is primarily influenced by protein quantity, protein solubility, and surface activity. Mushroom flour contributes protein; present may have lower emulsifying efficiency compared to those in cereal or legume flours (Hisham *et al*., 2025) [26]. In addition, increased fibre content from date palm fruit flour may interfere with protein alignment at the oil water interface, which may reduce emulsification. This trend aligns with findings by Chandra *et al*. (2016) [17] and Adebayo-Oyetoro *et al*. (2019) [3], who observed decreased emulsifying properties in composite flours with increasing levels of fibre-rich plant materials.

A similar decreasing pattern was observed for water absorption capacity (WAC), which declined from 2.88 to 1.89. Water absorption capacity reflects the ability of flour constituents particularly starch and hydrophilic proteins to bind water (Awuchi *et al*., 2019) [12]. The reduction in WAC suggests a dilution of starch content and possible structural modifications in starch due to blending. though fibre can enhance water retention, insoluble fibre from date palm fruit may not bind water as effectively as starch, leading to an overall reduction in WAC. Comparable results were reported by Oyeyinka *et al*. (2018) [49], who noted reduced WAC in composite flours as starch content decreased and non-starch components increased.

In contrast, oil absorption capacity (OAC) increased this indicate enhanced ability of the flour blends to bind oil. This increase can be attributed to the higher proportion of hydrophobic amino acid side chains from mushroom proteins and the porous structure of fibre in date palm fruit flour, which physically entraps oil. High oil absorption is desirable in bakery and snack products because it improves mouthfeel and flavour retention. Similar increases in OAC have been reported in composite flours containing mushroom or fruit pomace due to increased protein lipid interactions and fibre-oil binding (Olagunju *et al*., 2020; Okafor *et al*., 2019) [42, 45].

The foaming capacity of the flour blends increased this suggest improved air incorporation ability. Foaming capacity is closely related to protein content, protein flexibility, and the ability of proteins to form stable films around air bubbles (Li *et al*., 2022). The observed increase may be due to the contribution of mushroom proteins, which are known to enhance foaming properties when present in moderate amounts. Increased foaming capacity has also been associated with reduced starch interference, for proteins to more effectively migrate to the air water interface. This trend is consistent with reports by Kaur *et al*. (2017) and Fasasi *et al*. (2021) [22, 31] on protein enriched composite flours.

The bulk density of the composite flours increased indicating heavier and more compact flour particles. Bulk density of 0.4-0.80gcm3 are considered acceptable for effective packaging of dry food product, as they promote efficient space utilization, ease of handling and packaging stability (Fellows, 2009; Brennan *et al*., 2012; FAO, 2011) [16, 21, 23]. The incorporation of date palm fruit flour, which is dense and fibrous, likely contributed to the increased bulk density. This increase has implications for packaging, transportation, and formulation, as higher bulk density flours require less storage space but may affect reconstitution properties. Similar increases in bulk density have been observed in composite flours formulated with fruit or vegetable powders (Iwe *et al*., 2016; Adeola & Ohizua, 2018) [6, 29].

3. Physical properties of the cookies of orange fleshed sweet potato, mushroom and date palm fruit flour blends

The physical characteristics of the cookies are presented in Table 5. There were significant differences ($p < 0.05$) observed in the thickness, density, and volume of sample A, where orange-fleshed sweet potato (OFSP) flour was used at 100%. However, a gradual increase in cookie thickness was recorded as the level of composite flour incorporation increased. This increase in thickness can be attributed to the higher water absorption capacity and dietary fibre content of OFSP, mushroom, and date palm fruit flours. These components tend to restrict dough spread during baking, thereby promoting vertical expansion rather than lateral flow. Similar observations have been reported by Giri and Sakhale (2021) [25], who noted that the inclusion of OFSP and soybean flours significantly increased cookie thickness compared with control samples. Other studies have also associated increased cookie thickness with improved moisture retention and reduced gluten extensibility in composite flour systems.

A reduction in cookie volume was observed with increasing substitution of OFSP flour by mushroom and date palm fruit flours. This reduction is largely linked to gluten dilution and the elevated dietary fibre content of the composite ingredients, particularly the edible mushroom. High fibre levels interfere with gluten network development, thereby limiting the dough's ability to retain carbon dioxide during baking and resulting in cookies with lower volume (Rumler *et al*., 2023) [51]. The increase in cookie diameter observed with mushroom and date palm fruit flour inclusion may be related to changes in dough rheology caused by increased fibre and carbohydrate fractions, as well as the water-binding properties of OFSP and date palm fruit flours is consistent with this trend, Rumler *et al*. (2023) [51] reported that decreasing the proportion of sweet potato flour led to a linear reduction in cookie diameter, volume, and density.

Furthermore, an overall decrease in cookie density was noted as the proportion of mushroom flour increased. Cookies produced from 100% OFSP flour exhibited the highest mean density, followed by samples containing 20% mushroom flour. The diameter values obtained in this study are comparable to the range of 6.5-7.4 cm reported by Jemziya and Mahendran (2017) [30] for similar cookie formulations. The observed reduction in density (37.26 to 30.37) with increasing levels of composite flours can be explained by the weakening of the gluten matrix, higher fibre-induced water absorption, and increased air incorporation during baking. These factors collectively contribute to the formation of a lighter cookie structure with a higher void fraction, as also reported by Korese *et al.* (2021) [34].

Table 3: Proximate composition of cookies produced from Orange Fleshed Sweet Potato, Mushroom and Date palm Fruit flour blends (%)

Samples	Moisture	Protein	Fat	Ash	Fibre	Carbohydrate
$OFSP_{100}$ MR_0 DP_0	$9.63^a \pm 0.07$	$3.67^d \pm 0.48$	$3.92^a \pm 0.15$	$2.29^d \pm 0.09$	$1.35^e \pm 0.52$	$79.14^a \pm 0.27$
$OFSP_{85}$ MR_5 DP_{10}	$9.56^b \pm 0.11$	$18.22^d \pm 0.36$	$1.92^b \pm 0.27$	$2.36^c \pm 0.06$	$1.46^d \pm 0.57$	$66.48^b \pm 0.21$
$OFSP_{80}$ MR_{10} DP_{10}	$9.48^c \pm 0.05$	$19.42^c \pm 0.06$	$1.89^c \pm 0.03$	$2.31^d \pm 0.06$	$1.65^c \pm 0.40$	$65.25^d \pm 1.02$
$OFSP_{75}$ MR_{15} DP_{10}	$8.75^e \pm 0.19$	$19.96^b \pm 0.99$	$1.62^d \pm 0.07$	$2.50^b b \pm 0.05$	$1.86^b \pm 0.17$	$65.31^c \pm 1.38$
$OFSP_{70}$ MR_{20} DP_{10}	$8.98^d \pm 0.06$	$24.05^a \pm 0.45$	$1.64^d \pm 0.16$	$2.71^a \pm 0.14$	$2.09^a \pm 0.16$	$60.53^e \pm 0.38$

Values are Mean ± Standard deviation of duplicate determination
Values with same superscript along the column are not statistically significant $P < 0.05$ different
KEY: OFSP=Orange fleshed sweet potato flour, MR=Mushroom flour, DP=date palm fruit flour

Table 4: Functional properties of of orange fleshed sweet potato, mushroom and date palm fruit flours blends

Samples	SI	EC (%)	WAC (g/g)	OAC (g/g)	FC (%)	BD (g/cm3)
$OFSP_{100}$ MR_0 DP_0	$12.12^a \pm 0.47$	$12.74^a \pm 0.41$	$2.88^a \pm 0.79$	$1.10^d \pm 0.32$	$2.20^e \pm 0.03$	$5.28^d \pm 0.06$
$OFSP_{85}$ MR_5 DP_{10}	$8.34^b \pm 074$	$10.16^b \pm 0.43$	$2.38^b \pm 0.88$	$1.82^c b \pm 0.29$	$2.32^d \pm 0.01$	$6.22^c \pm 0.47$
$OFSP_{80}$ MR_{10} DP_{10}	$6.73^e \pm 0.27$	$9.46b^c \pm 0.32$	$2.17^c \pm 0.98$	$1.81^c b \pm 0.45$	$2.99^c \pm 0.30$	$6.57^b \pm 0.18$
$OFSP_{75}$ MR_{15} DP_{10}	$6.96^d \pm 009$	$9.34b^d \pm 0.44$	$1.94^d \pm 0.86$	$2.13^b \pm 0.14$	$3.36^b \pm 0.35$	$6.56^b b \pm 0.08$
$OFSP_{70}$ MR_{20} DP_{10}	$7.11^c \pm 0.06$	$8.69^e \pm 0.38$	$1.89^e \pm 0.68$	$2.40^a \pm 0.03$	$3.96^a \pm 0.15$	$6.96^a \pm 0.91$

Values are Mean ± Standard deviation of duplicate determination
Values with same superscript along the column are not statistically significant $p < 0.05$ different
KEY: OFSP=Orange fleshed sweet potato flour, MR=Mushroom flour, DP=date palm fruit flour

4. Sensory evaluation of the cookies produced from the blends of Orange Fleshed Sweet Potato, Mushroom and Date palm Fruit flours.

The sensory attributes of the cookies samples produced is presented in Table 6 presents the results of consumer acceptability of the organoleptic attributes of cookies produced from blends of orange-fleshed sweet potato (OFSP), mushroom and date palm fruit flours. Sensory evaluation is an essential tool for assessing consumer perception and determining the acceptability of baked products formulated with composite flours. In this study, the cookies were assessed using a 9-point hedonic scale for taste, flavour, appearance, texture and overall acceptability. The results revealed both increasing and decreasing trends across the sensory attributes with varying levels of composite flour incorporation, indicating that formulation significantly influenced sensory quality.

The taste scores of the cookies ranged narrowly from 6.06 to 6.26, suggesting that all samples were generally acceptable in terms of taste, despite a slight decline at higher substitution levels. This relatively stable acceptability may be attributed to the natural sweetness contributed by OFSP and date palm fruit flours, which helped maintain palatability. However, increased inclusion of mushroom flour may have introduced subtle earthy notes that slightly reduced taste preference at higher levels of substitution. Similar observations have been reported by Adeola and Ohizua (2018), who noted that while composite flours containing naturally sweet ingredients can enhance taste, higher substitution levels may negatively affect palatability due to unfamiliar flavour profiles. Oluwamukomi *et al.* (2019) also reported slight reductions in taste scores in OFSP-based cookies at elevated substitution ratios, linked to changes in sweetness balance and flavour perception.

Flavour scores varied between 5.86 and 7.13, showing both increasing and decreasing trends among the samples. The initial improvement in flavour may be associated with the pleasant aroma and caramel-like notes of date palm fruit flour, combined with the characteristic aroma of OFSP. However, a decline in flavour scores at higher substitution levels may be due to the intensified flavour of mushroom flour, which may not align with conventional cookie flavour expectations. This trend agrees with the findings of Chinma *et al.* (2014), who reported that moderate inclusion of non-wheat flours can enhance flavour complexity, whereas excessive inclusion may introduce undesirable flavour notes. Ajibola *et al.* (2021) similarly observed fluctuations in flavour acceptability of composite cookies depending on the proportions of fruit and vegetable flours used.

The appearance scores showed a clear decreasing trend, declining from 7.46 to 6.06. Cookies with lower levels of composite flour incorporation were rated higher in appearance, likely because of their lighter colour and smoother surface, which more closely resemble conventional wheat-based cookies. Increasing the proportion of OFSP, mushroom and date palm fruit flours resulted in darker and less uniform cookies, possibly due to higher sugar content and enhanced Maillard browning reactions during baking. The presence of natural pigments such as carotenoids in OFSP and darker compounds in date palm fruit flour may have further contributed to colour changes. These findings are consistent with reports by Adebayo-Oyetoro *et al.* (2017) and Yusufu *et al.* (2020), who observed reduced appearance scores in composite cookies as substitution levels increased.

In contrast, texture scores increased from 6.04 to 6.93, indicating improved textural acceptability in some composite formulations. This improvement may be attributed to the higher dietary fibre content of OFSP and date palm fruit flours, which can enhance water absorption and contribute to a desirable balance between softness and crispness. Mushroom flour may also have influenced dough rheology, resulting in a more tender crumb structure. Similar improvements in cookie texture with fibre-rich composite flours have been reported by Olagunju *et al.* (2018), while Ugwuona and Suwaba (2019) noted enhanced mouthfeel and reduced hardness in cookies containing root and tuber-based flours.

The overall acceptability scores decreased from 7.20 to 5.86, reflecting the combined effects of changes in taste, flavour and appearance. Cookies with lower levels of composite flour incorporation were generally well accepted, whereas higher substitution levels resulted in reduced overall liking. Although the products remained moderately acceptable. This trend aligns with the findings of Bolarinwa *et al.* (2016) [15] and Odeyemi *et al.* (2020), who reported that overall acceptability of composite cookies often declines at higher substitution levels despite improvements in nutritional quality.

Table 5: Physical properties of the cookies of orange fleshed sweet potato, mushroom and date palm fruit flour blends

Samples	Thickness (cm)	Volume (cm^3)	Diameter (cm)	Density (g/ml)
$OFSP_{100}$ MR_0 DP_0	6.35^e±0.79	9.65^a±0.06	9.19^c±0.23	37.26^a±1.35
$OFSP_{85}$ MR_5 DP_{10}	6.65^d±0.45	9.41^b±0.04	10.00^b±0.15	34.73^b±1.37
$OFSP_{80}$ MR_{10} DP_{10}	6.99^c±0.16	9.07^c±0.23	10.05^b±0.16	30.62^d±1.14
$OFSP_{75}$ MR_{15} DP_{10}	7.13^b±0.13	8.26^e±0.10	10.03^b±0.06	31.08^c±0.65
$OFSP_{70}$ MR_{20} DP_{10}	7.27^a±0.06	8.35^d±0.12	10.12^a±0.02	30.37^e±0.06

Values are Mean ± Standard deviation of duplicate determination
Values with same superscript along the column are not statistically significant P < 0.05 different
KEY: OFSP=Orange fleshed sweet potato flour, MR=Mushroom flour, DP=date palm fruit flour

Table 6: Sensory scores of cookies produced from Orange Fleshed Sweet Potato, Mushroom and Date palm Fruit flour blends

Samples	Taste	Flavor	Appearance	Texture	General acceptability
$OFSP_{100}$ MR_0 DP_0	6.20^b±0.38	5.86^e±1.29	7.46^a±1.66	6.06^d±1.42	7.20^a±0.44
$OFSP_{85}$ MR_5 DP_{10}	6.13^c±0.65	6.60^d±1.41	6.53^b±1.31	6.26^c±0.25	6.40^b±0.34
$OFSP_{80}$ MR_{10} DP_{10}	6.06^d±0.61	7.00^b±1.69	6.46^c±1.30	6.73^b±1.37	6.06^c±0.62
$OFSP_{75}$ MR_{15} DP_{10}	6.20^b±0.59	7.13^a±1.70	6.20^d±1.63	6.93^a±1.55	5.86^e±0.81
$OFSP_{70}$ MR_{20} DP_{10}	6.26^a±0.58	6.93^c±1.42	6.06^e±1.63	6.73^b±0.13	5.93^d±0.53

Values are Mean ± Standard deviation of duplicate determination
Values with same superscript along the column are not statistically significant P < 0.05 different
KEY: OFSP=Orange fleshed sweet potato flour, MR=Mushroom flour, DP=date palm fruit flour

Conclusion

The result demonstrate that blends of orange-fleshed sweet potato, mushroom, and date palm fruit flours can be successfully utilized to produce nutritionally enriched cookies suitable for household use and commercial application the composite cookies improve protein, fibre, and ash contents, with reduced moisture and fat and carbohydrate levels that may support better shelf stability and potential health benefits. Changes observed in functional and physical properties reflect interactions among starch, protein, and fibre components, and can lead to modified cookie structure. Sensory assessment further revealed that addition of mushroom and date palm fruit flours improved all the sensory attributes. The acceptability decreased with increase in the percentage mushroom and date palm fruit flour, all the cookies were acceptable, which indicates that acceptable cookies could be produced from blends of up to 20% substitution of mushroom flour.

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