



Food Science and Applied Biotechnology

e-ISSN: 2603-3380

Journal home page: www.ijfsab.com
<https://doi.org/10.30721/fsab2024.v7.i1>



Research Article

Effect of substitution of whole wheat flour with sweet potato (*Ipomoea batatas*) and *Mucuna utilis* flours on the nutritional, physical and sensory qualities of cookies

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Abstract

Composite flours were made from blends of whole wheat (WWF), sweet potato (SPF), and *Mucuna utilis* (MUF) flours, the 100% WWF served as control. These flours were used to bake cookies. The flours and the cookies were analyzed for functional and proximate composition while in addition to these, physical and sensory tests were conducted on the cookies. Results of the study showed that the protein and fat contents of the flours and cookies increased as the quantity of MUF increased but decreased with an increase in SPF. In the flours, the ash content of the control (2.38%) decreased to 1.76-2.14% in the composite flours. Ash content decreased with the addition of MUF but increased with the addition of SPF. The carbohydrate content of the composite flour cookies ranged 48.57-62.26% while the energy value ranged 376.91-392.11 kcal.100 g⁻¹. Except for the cookie baked with 50% WWF and 50% SPF, whose mouth-feel did not differ significantly ($p < 0.05$) from that of the control, the remaining cookies scored higher than that of the control. Cookie baked with 60% WWF, 10% SPF, and 30% MUF had optimum protein (21.84%), diameter (5.30 cm), spread ratio (6.90), and sensory qualities that were comparable to that of the control.

Keywords

ash, composite flour, mouth feel, protein, spread ratio, water absorption capacity

Abbreviations

ANOVA – analysis of variance; DO – density of oil; DW – density of water; FO – free oil; FW – free water; LGC – least gelation concentration; LSD – least significant difference; MUF – *Mucuna utilis* flour; OAC – oil absorption capacity; SPF – sweet potato flour; WWF – whole wheat flour; TOA – total oil absorbed; TWA – total water absorbed; WAC – water absorption capacity

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Article history:

Received 22 December 2023

Reviewed 15 January 2024

Accepted 26 February 2024

Available on-line 19 March 2024

<https://doi.org/10.30721/fsab2024.v7.i1.347>

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Introduction

Cookies are made predominantly from refined wheat flour because of its unique gluten content (Ikuomola et al. 2017). However, refined wheat flour is high in starch but low in other important nutrients such as proteins and fiber, which were destroyed to a greater amount during the refining process (Ishiwu et al. 2020). Furthermore, wheat flour is expensive in tropical countries such as Nigeria since it is not cultivated in sufficient amounts due to climatic reasons. Therefore, researchers have investigated the use of flour from tubers, legumes, and other cereals to replace wheat flour. Composite flours have a higher nutritional value than flours made from refined wheat and other staple grains (Igbabul et al. 2018). The inclusion of leguminous flour to replace part of wheat is also reported to complement lysine, which is the limiting amino acid in wheat flour (Igbabul et al. 2018).

Sweet potato is a tuber crop noted for its short period of maturity and high yield even at low soil fertility but it has the problem of a short shelf-life (Truong et al. 2018). It is a source of carbohydrates, dietary fiber, beta-carotene, and some minerals like calcium, phosphorus, potassium, and iron (Saeed et al. 2012; Ogundipe et al. 2023).

Mucuna utilis is a little-known protein-rich legume that is predominantly used as a soup thickener in Southeast Nigeria (Saeed et al. 2012). The nutritional composition of *Mucuna* bean flour has been reported in several studies. For example, a report by Baby et al. (2022), found that 100 g of *Mucuna* bean flour contains 16.64-17.17 kJ.g⁻¹ of energy, 24.50-29.79% of protein, 59.20-64.88% of carbohydrate, 39.22-41.17% of starch, 4.72-7.28% of fat, and 3.65-4.43% of crude fiber.

Previous studies were conducted on cookies made from wheat-sweet potato composite flour (Okpala and Ofoedu. 2018; Igbabul et al. 2018; Singh et al. 2019; Korese et al. 2021). In the present study, whole wheat, sweet potato, and *Mucuna utilis* flours were mixed at different ratios and used to bake the cookies, and the physical, nutritional, and sensory qualities were compared to those of whole wheat flour. This study aimed to increase the fiber and protein contents of the cookies and to increase the utilization of sweet potato and *Mucuna utilis*. This will encourage farmers to cultivate these plants to earn more income.

Materials and Methods

Materials. Whole wheat grains (*Triticum aestivum*), sweet potato (*Ipomoea batatas*), Velvet bean (*Mucuna utilis*), and the baking ingredients were bought from Ogige market, Nsukka, Enugu State, Nigeria.

Preparation and formulation of composite flour.

For the preparation of composite flour, *Mucuna utilis* seeds (2000 g) were sorted, cleaned, and steeped for 12 h in water at room temperature (29±2°C) afterward the water was drained and the seeds boiled for 20 min, oven-dried (50°C, 48 h), milled to pass through 0.15 mm mesh sieve. Furthermore, sweet potatoes were sorted, peeled into water containing NaCl solution (1%), washed, and cut into thin slices manually. They were dried (50°C, 48 h) and milled to pass through a 0.15 mm mesh sieve. Also, whole wheat grains were sorted, washed, oven-dried (50°C, 48 h), and milled to pass through a 0.15 mm mesh sieve. A randomized method was used to mix these flours in different ratios and obtained seven samples as shown in Table 1.

Determination of Functional Properties of the Flours

Water absorption capacity. The AOAC (2015) method was used to determine the water absorption capacity. One gram of the sample was weighed into a graduated conical flask and 10 mL of distilled water was added. This was followed by whirling for 30 s to mix. The sample was allowed to stand at room temperature (29±2°C) for 30 min after which it was centrifuged at 5000 rpm for 30 min. The mixed sample was finally poured into a 10 mL measuring cylinder to determine the volume of the free water. The water absorption capacity was calculated using Equation 1.

$$WAC = (TWA - FW) \times DW \quad (1)$$

Where

WAC = water absorption capacity;

TWA = Total water absorbed;

FW = Free water (supernatant);

DW = Density of water

Table 1. Blending ratios of the composite flours

Samples	Whole wheat flour, % (W)	Sweet potato flour, % (S)	<i>Mucuna utilis</i> flour, % (M)
W ₁₀₀	100	0	0
W ₅₀ S ₅₀	50	50	0
W ₅₀ M ₅₀	50	0	50
W ₆₀ S ₃₀ M ₁₀	60	30	10
W ₆₀ S ₁₀ M ₃₀	60	10	30
W ₅₀ S ₃₀ M ₂₀	50	30	20
W ₅₀ S ₂₀ M ₃₀	50	20	30

Oil absorption capacity. The AOAC (2015) method was used to determine the oil absorption capacity. One gram of the sample was weighed into a graduated conical flask and 10 mL of soya bean oil was added. This was followed by whirling for 30 s to mix. The sample was allowed to stand at room temperature (29±2°C) for 30 min after which it was centrifuged at 5000 min⁻¹ for 30 min. The mixed sample was finally poured into a 10 mL measuring cylinder to determine the volume of the free oil. The oil absorption capacity was expressed as grams of oil absorbed per gram of sample. The oil absorption capacity was calculated using Equation 2.

$$OAC = (TOA - FO) \times DO \quad (2)$$

Where

OAC = Oil absorption capacity;

TOA = Total oil absorbed;

FO = Free oil (supernatant);

DO = Density of oil

Swelling index. The method of Hussein et al. (2011) was used to determine the swelling index. The sample (3.0 g) was weighed into a clean 50 mL graduated cylinder and the volume was noted. Distilled water (30 mL) was mixed with the samples followed by swirling after which the mixture was left to stand for 60 min during this time the volume change (swelling) was recorded at 15, 30, 45, and 60 min intervals. The swelling index was calculated as the multiple of the original volume.

Least gelation concentration. The least gelation concentration was evaluated using the method of Chandra et al. (2015). The flour dispersions of 2, 4, 6, 8, 10, 12, 14, 16, 18, 20,

22, and 30 g (w/v) respectively were dispersed in 5 mL of distilled water and heated at 90°C for 1 h in a water bath. The contents were cooled under tap water and kept for 2 h at 10°C. When the sample did not slip from the inverted tube, that concentration was considered the least gelation concentration.

Production of the cookies. The creamy method was used to produce the cookies. The recipe included the composite flour (140.1 g), margarine (56.1 g), sugar (35.1 g), eggs (43.8 g), skimmed milk powder (21 g), sodium bicarbonate (1.5 g), sodium chloride (1.5 g), nutmeg (0.9 g) and vanilla flavor (0.9 g). Baking was done in an oven (Gulfex Scientific DHG 9202, England) at 180°C for 20 min, after which they were left to cool at ambient temperature (29±2°C), packaged in high-density polyethylene, labelled, and stored at ambient temperature for analyses.

Proximate composition and energy value. The proximate composition of the composite flours and the baked cookies was determined. In addition to this, the gross energy value of the cookies was determined. Moisture, crude protein, crude fat, ash, and crude fiber were determined using the methods described in AOAC (2015). For the calculation of the digestible carbohydrate content, the algebraic sum of the percentage composition of protein, fat, fiber, moisture, and ash was subtracted from 100%. The energy value was calculated using the At Water formula. The content of protein, carbohydrate, and fat was multiplied by the factors of 4.0, 4.0, and 9.0 kcal respectively, and summing them up to get the energy value in kcal.100 g⁻¹.

Physical Properties of Cookies

Breaking strength. The breaking strength was determined according to the method described by Ikuomola et al. (2017). Cookies were placed centrally between two parallel metal bars and weights were applied until the cookies snapped. The least weight that caused the breaking of the cookies was regarded as the breaking strength of the cookies.

Diameter. The diameter of the cookies was determined according to a method described by Bala et al. (2015). Four cookies were placed edge to edge and the total diameter was measured in cm with the help of a Vernier caliper. The cookies were rotated at an angle of 90° for duplicate readings. This process was repeated three times to get an average value and results were reported in cm.

Thickness. The thickness of cookies was determined according to a method described by Bala et al. (2015). Four cookies were stacked and the total thickness was measured in cm with the help of a Vernier calipers. This process was repeated three times to get an average value and results were reported in cm.

Spread ratio. The spread ratio of the cookies was determined using the method of Bala et al. (2015). The diameter of the cookies was divided by their thickness to determine the spread ratio.

Sensory evaluation. A panel of 30 judges was used to evaluate the appearance, flavor, texture, mouth – feel, crispness of the cookies on a-9 point hedonic scale.

Statistical analysis. Data were analyzed using two-way ANOVA followed by the Least Significant Difference test to separate significantly different means at $p < 0.05$ using the Statistical Package for Social Science (SPSS) version 17. Means and standard deviations were computed.

Results and Discussion

Functional properties. Table 2 shows the results of the functional properties of the flours. The LGC was 18 g in the control and the range of 10 to 16 g in the composite flours. The WAC was 2.94 in the control and the range of 2.47 to 3.86 in the composite flours. The WAC increased as the quantity of *M. utilis*

increased in the composite flour, the highest ($p < 0.05$) was found in the composite flour containing 50% whole wheat and 50% *M. utilis* flours. The swelling index was 0.47 in the control and the range of 0.27 to 0.67 in the composite flours. The oil absorption capacity of the flour ranged 1.50 to 1.85 with samples made up of 50% wheat and 50% *M. utilis* having the highest value while sample that contained 50% wheat and 50% sweet potato flours had the lowest (1.50). The swelling index ranged 0.27 to 0.67; samples that were made up of 50% whole wheat and 50% *M. utilis* flours had the least value.

The LGC indicates the gelation ability of the flour and the lower the LGC the better the gelling ability of the flour (Hussein 2011). The increase in WAC with an increase in the addition of *M. utilis* flour could be due to the increased protein content contributed by *M. utilis* flour since the WAC has been reported to increase with the increase in protein content (Iwe et al. 2016). It was concluded from this study that flours with high WAC can be used for preparing products such as cookies, bread, and cakes that require hydration. The result also revealed that the OAC of the flours increased with the increased inclusion level of *M. utilis* flour. This could be due to the high level of protein recorded in *M. utilis* since nonpolar amino acid side chains can form hydrophobic interaction with hydrocarbon chains of lipids (Jitngarmkusol 2008). This result agrees with the findings of Attaugwu et al. (2022) who reported good oil absorption capacity in boiled Mucuna flour used for soup. This high oil absorption capacity of flour is essential in baked products for improved flavor retention and mouthfeel (Anyadioha et al. 2022). This suggested that 30% and above Mucuna inclusion into composite flour will have a good flavor due to its high OAC. The swelling index was used to determine the hydration capacity of starches and it was used to determine the amount of associative absorption forces within the starch granules (Jitngarmkusol 2008). In this study, the swelling index was high when the amount of sweet potato flour in the composite flour was high and this could be attributed to the increase in starch content contributed by the sweet potato flour.

Table 2. Functional properties of the composite flour

Samples	LGC, g	WAC	OAC	SI
W ₁₀₀	18.00 ^a ±0.27	2.94 ^c ±0.00	1.70 ^b ±0.00	0.47 ^c ±0.01
W ₅₀ S ₅₀	15.00 ^b ±0.24	2.47 ^d ±0.05	1.48 ^d ±0.01	0.67 ^a ±0.01
W ₅₀ M ₅₀	16.00 ^{ab} ±0.24	3.86 ^a ±0.02	1.85 ^a ±0.00	0.27 ^d ±0.03
W ₆₀ S ₃₀ M ₁₀	15.00 ^b ±0.19	3.08 ^c ±0.01	1.48 ^d ±0.01	0.50 ^b ±0.02
W ₆₀ S ₁₀ M ₃₀	10.00 ^c ±0.18	3.53 ^b ±0.03	1.60 ^c ±0.02	0.66 ^a ±0.01
W ₅₀ S ₃₀ M ₂₀	10.00 ^c ±0.20	3.46 ^b ±0.02	1.61 ^c ±0.00	0.56 ^b ±0.04
W ₅₀ S ₂₀ M ₃₀	10.00 ^c ±0.15	3.52 ^b ±0.11	1.67 ^b ±0.11	0.60 ^{ab} ±0.01

Values are means ± standard deviation of triplicates. Values with different superscripts along the same column are significantly different ($p < 0.05$). Where LGC – Least Gelation Concentration; WAC – Water Absorption Capacity; OAC – Oil Absorption Capacity; SI – Swelling Index; W – Whole wheat flour; M – Mucuna flour; S – Sweet potato flour. Subscripts 10, 20, 30, 50, 60, and 100 are percent inclusion of the flour

Proximate composition of the composite flour.

Table 3 shows the results of the proximate composition of the composite flour blends. The protein content was 14.21% in the control but was in the range of 12.59 to 23.25% in the composite flour blends. The protein content increased significantly ($p < 0.05$) as the quantity of *M. utilis* increased in the formulation but decreased with an increase in sweet potato flour. Ash content indicates the mineral composition of food (Ukpong et al. 2023). It was 2.38% in whole wheat flour and decreased to the range of 1.76 to 2.14% in the

composite flours. The ash content decreased as the *M. utilis* flour increased in the composite flour and this could be due to the loss of the minerals as a result of the removal of the hull during the processing of *M. utilis* flour (Idowu et al. 2020). The fat content ranged 3.40 to 6.83%. Fat content increased with the addition of *M. utilis* flour but decreased with the increase of sweet potato flour. High fat contents of the flour may enhance the mouth-feel and palatability of the product but may also encourage rancidity (Anyadioha et al. 2022).

Table 3. Proximate composition of the flours

Samples	Protein, %	Ash, %	Fat, %	MC, %	Fiber, %	CHO, %
W ₁₀₀	14.21 ^f ±0.06	2.38 ^a ±0.01	3.96 ^d ±0.06	10.22 ^b ±0.02	3.77 ^a ±0.02	65.46 ^b ±0.06
W ₅₀ S ₅₀	12.59 ^g ±0.04	2.14 ^b ±0.01	3.40 ^e ±0.01	10.49 ^{ab} ±0.02	3.46 ^{ab} ±0.07	67.92 ^a ±0.09
W ₅₀ M ₅₀	23.25 ^a ±0.06	1.76 ^c ±0.02	6.83 ^a ±0.05	9.96 ^b ±0.02	1.52 ^d ±0.04	56.68 ^e ±0.02
W ₆₀ S ₃₀ M ₁₀	16.15 ^e ±0.04	2.11 ^b ±0.04	5.45 ^c ±0.02	7.79 ^d ±0.04	3.48 ^{ab} ±0.09	65.02 ^b ±0.08
W ₆₀ S ₁₀ M ₃₀	20.83 ^b ±0.04	1.98 ^{bc} ±0.02	6.03 ^b ±0.06	10.83 ^a ±0.33	2.85 ^c ±0.04	57.48 ^e ±0.02
W ₅₀ S ₃₀ M ₂₀	17.61 ^d ±0.01	2.10 ^b ±0.04	5.77 ^{bc} ±0.04	10.17 ^{bc} ±0.04	3.20 ^b ±0.04	61.15 ^d ±0.09
W ₅₀ S ₂₀ M ₃₀	19.13 ^c ±0.02	2.02 ^b ±0.04	4.00 ^d ±0.08	9.79 ^c ±0.02	1.96 ^d ±0.03	63.10 ^c ±1.69

Values are means ± standard deviation of triplicates. Values with different superscripts along the same column are significantly different ($p < 0.05$). MC – Moisture content; CHO – Carbohydrate; W – Whole wheat flour; M – Mucuna flour; S – Sweet potato flour. Subscripts 10, 20, 30, 50, 60, and 100 are percent inclusion of the flour

The fiber content was 3.77% in the control but decrease to the range of 1.52 to 3.48% in the composite flour. The fiber content decreased in the composite flour as the quantity of *M. utilis* flour increased in the formulation. The observed decrease in fiber with an increase in *M. utilis* flour was not advantageous since it has been reported that fiber acts as prebiotics and an increase in its consumption

could decrease the risks of obesity, type 2 diabetes, constipation, coronary heart diseases, and some cancers (Bala et al. 2015; Ukpong et al. 2021). Moisture ranged 7.79 to 10.83% while carbohydrates ranged 56.68 to 67.92%. The moisture content was low and this is advantageous since it will discourage microbial growth. The carbohydrate content of the composite flour

increased when the quantity of sweet potato flour was increased but decreased as the quantity of *M. utilis* flour was increased.

Proximate composition and energy value of the cookies. Table 4 shows the proximate composition and Energy value of the cookies. The protein content was 15.17% in the control and in the range of 13.15 to 23.92% in cookies baked with the

composite flours. The protein content of the cookies baked with the composite flour increased significantly ($p < 0.05$) as the quantity of *M. utilis* increased in the formulation but decreased with an increase in sweet potato flour. This was in accord with the objective of the study, which aimed at enhancing the protein composition of the cookies via *Mucuna utilis* supplementation.

Table 4. Proximate composition and energy value of the cookies

Samples	Protein, %	Ash, %	Fat, %	Mc, %	Fiber, %	CHO, %	Energy, kcal.100 g ⁻¹
W ₁₀₀	15.17 ^e ±0.05	2.86 ^a ±0.02	9.81 ^b ±0.02	11.43 ^a ±0.04	3.18 ^a ±0.03	57.55 ^b ±0.18	379.17 ^b ±3.81
W ₅₀ S ₅₀	13.15 ^f ±0.02	2.63 ^{ab} ±0.01	8.58 ^c ±0.02	10.53 ^b ±0.02	2.85 ^b ±0.03	62.26 ^a ±0.07	378.86 ^b ±5.03
W ₅₀ M ₅₀	23.92 ^a ±0.05	2.39 ^c ±0.02	11.35 ^a ±0.07	11.54 ^a ±0.02	2.23 ^e ±0.24	48.57 ^e ±0.17	392.11 ^a ±2.24
W ₆₀ S ₃₀ M ₁₀	17.45 ^d ±0.07	2.85 ^a ±0.02	8.71 ^c ±0.05	10.93 ^{ab} ±0.03	2.88 ^b ±0.04	57.18 ^b ±0.16	376.91 ^b ±3.12
W ₆₀ S ₁₀ M ₃₀	21.84 ^b ±0.04	2.63 ^{ab} ±0.06	9.21 ^b ±0.02	11.17 ^a ±0.05	2.36 ^d ±0.06	52.79 ^d ±0.04	381.41 ^b ±3.18
W ₅₀ S ₃₀ M ₂₀	19.30 ^c ±0.04	2.54 ^b ±0.03	9.09 ^{bc} ±0.06	10.53 ^b ±0.02	2.69 ^b ±0.08	55.85 ^{bc} ±0.04	382.41 ^b ±2.01
W ₅₀ S ₂₀ M ₃₀	20.84 ^{bc} ±0.04	2.50 ^b ±0.02	9.19 ^b ±0.02	10.78 ^b ±0.03	2.58 ^c ±0.08	54.11 ^c ±0.01	382.51 ^b ±2.42

Values are means ± standard deviation of triplicates. Values with different superscripts along the same column are significantly different ($p < 0.05$). Where MC – Moisture content: CHO – Carbohydrate: W – Whole wheat flour: M – *Mucuna* flour: S – Sweet potato flour. Subscripts 10, 20, 30, 50, 60, and 100 are percent inclusion of the flour.

Ash was 2.86% in the control and in the range of 2.39 to 2.85% in the cookies baked with the composite flours. The ash contents increased with the addition of sweet potato flour but decreased with the addition of *M. utilis* flour. Fat was 9.81% in the control and in the range of 8.58 to 11.35% in cookies baked with the composite flours. Fats increased as the quantity of *M. utilis* flour in the formulation increased but decreased with the increase in sweet potato flour. Fiber was 3.18% in control and reduced to the range of 2.23 to 2.88% in cookies baked with composite flours. Moisture was 11.43 % in the control and in the range of 10.53 to 11.54% in cookies baked with composite flours, carbohydrate was 57.55% in the control and in the range of 48.57 to 62.26% in cookies baked with composite flours while energy value was 379.17 kcal.100 g⁻¹ in control and in the range of 376.91 to 392.11 kcal.100 g⁻¹ in cookies baked with the composite flours.

Like the composite flours, the protein contents of the cookies also increased with a higher inclusion level of *M. utilis* flour. The protein contents of cookies of the present work are higher than the ranges of 10.10 to 11.32% recorded for cookies

made with sweet potato-wheat-brewers spent grain flour (Korese et al. 2021) as well as the ranges of 12.83 to 17.02% recorded for cookies made with wheat-orange flesh potato-cashew nut composite flours (Bala et al. 2015) and this could be due to inclusion of *M. utilis* flour. According to the FAO/WHO, crude fiber content of cookies should not exceed 5% (Ishiwu et al. 2020). Interestingly, that the fiber of this work was below 5%. The fiber contents of the cookies were comparable to previous studies (Okpala and Ofoedu 2018; Korese et al. 2021). Carbohydrates increased with the increase in the quantity of sweet potato flour but decreased with the increase in the *M. utilis* flour. The highest energy value ($p < 0.05$) was found in the cookie baked with 50% wheat and 50% *M. utilis* composite flour and this could be due to its higher fat content of *M. utilis* as fat contributes more than twice the energy value than protein and carbohydrate.

The physical properties of the cookies. Table 5 shows the physical properties of the cookies. The thickness of the cookies ranged 0.75 to 1.00 cm and there was no significant differences ($p < 0.05$) between the control and the other composite flour samples. The diameter was 5.25 cm in the control

and in the range of 4.95 to 5.30 cm in cookies baked with the composite flours. The spread ratio was 5.83 in the control and in the range of 4.29 to 6.90 in cookies baked with the composite flours.

The breaking strength was 85.00 g in the control and in the range of 39.90 to 93.90 g in samples baked with the composite flours.

Table 5. Physical properties of cookies

Samples	Thickness, cm	Diameter, cm	Spread ratio	Breaking strength, g
W ₁₀₀	0.90 ^a ±0.00	5.25 ^a ±0.07	5.83 ^c ±0.07	85.00 ^b ±0.00
W ₅₀ S ₅₀	0.80 ^b ±0.00	4.95 ^b ±0.07	4.29 ^e ±0.21	75.10 ^c ±0.41
W ₅₀ M ₅₀	0.90 ^a ±0.14	5.10 ^{ab} ±0.00	5.74 ^c ±0.90	93.90 ^a ±1.50
W ₆₀ S ₃₀ M ₁₀	0.90 ^a ±0.03	4.95 ^b ±0.07	5.30 ^d ±0.28	64.90 ^d ±1.41
W ₆₀ S ₁₀ M ₃₀	0.75 ^{ab} ±0.07	5.30 ^a ±0.28	6.90 ^a ±0.74	81.50 ^b ±0.70
W ₅₀ S ₃₀ M ₂₀	0.90 ^a ±0.00	4.95 ^b ±0.07	5.84 ^c ±0.40	39.90 ^e ±0.70
W ₅₀ S ₂₀ M ₃₀	1.00 ^a ±0.00	5.15 ^{ab} ±0.07	6.19 ^b ±0.08	85.00 ^b ±0.00

Values are means ± standard deviation of triplicates. Values with different superscripts along the same column are significantly different ($p > 0.05$). Where: W – Whole wheat flour; M – Mucuna flour; S – Sweet potato flour. Subscripts 10, 20, 30, 50, 60, and 100 are percent inclusion of the flour

The diameter and spread ratio indicates the quality of the flour used in the baking and the ability of the dough to rise (Ishiwu et al. 2020). These parameters decreased as the quantity of sweet potato increased in the composite flour. An increase in spread ratio could be caused by an increase in the WAC of the flour, which also depends on the increase in both the quantity of protein and its hydrophilic sites (Ishiwu et al. 2020). A high spread ratio is desirable in cookies and cookie baked with 60% wheat, 10% sweet potato and 30% *M. utilis* composite flour had the highest spread ratio. Generally, the spread ratio of the cookies in this research was higher than the range of 3.18 to 4.12 reported for wheat-sorghum-tiger nut composite flour cookies (Ishiwu et al. 2020) as well as the range of 3.30 to 3.83 reported for wheat and fermented Afzelia Africana flour (Igbabul et al. 2018) and these disparity could be due to differences in the formulation. Breaking strength represents the smallest amount of force required to break the cookies and from the result of this study, much more force could be required to break cookie baked with 50% whole wheat and 50% *M. utilis* composite flour compared to those of the other samples. In this study, breaking strength increased as the quantity of *M. utilis* flour increased in the formulation and the reason could be due to increased protein content, which could lead to increase in protein-starch interaction (Ishiwu et al. 2020).

Sensory evaluation of the cookies. Table 6 shows the sensory evaluation of the cookies. It is interesting that the judges like the appearance, flavor, texture and mouth feel of all the samples as they were scored above 6 point. Cookie containing 60% wheat flour, 30% sweet potato flour, and 10% *M. utilis* composite flour had the lowest score for appearance while the remaining cookies did not differ significantly ($p < 0.05$) from that of the 100% whole wheat flour. Appearance and taste are important sensory attributes that affect the acceptability of food products. The flavor of cookies produced from the composite flours did not differ significantly from the control. The texture of all types of cookies was comparable to that of the control except that containing 50% wheat and 50% sweet potato composite flour which was significantly lower ($p < 0.05$). With the exception of cookie baked with 50% whole wheat and 50% sweet potato composite flours whose mouth-feel did not differ significantly ($p < 0.05$) from that of 100% whole wheat flour, the remaining cookies got scores that were higher than that of the control. The scores for the crispness of the cookies made with composite flours were also comparable to that of the control.

Table 6. Results of sensory evaluation

Samples	Appearance	Flavor	Texture	Mouth Feel	Crispness
W ₁₀₀	7.34 ^a ±0.07	7.69 ^a ±0.03	7.62 ^a ±0.21	6.90 ^b ±0.46	5.36 ^{ab} ±0.88
W ₅₀ S ₅₀	6.76 ^a ±0.59	7.82 ^a ±0.31	6.41 ^b ±0.79	6.92 ^b ±0.30	5.29 ^a ±1.03
W ₅₀ M ₅₀	7.63 ^a ±0.54	7.47 ^a ±1.32	7.54 ^a ±0.28	7.04 ^{ab} ±1.00	5.38 ^a ±0.55
W ₆₀ S ₃₀ M ₁₀	6.18 ^b ±1.50	7.05 ^a ±0.3	7.47 ^a ±0.54	7.30 ^a ±0.51	5.40 ^a ±0.70
W ₆₀ S ₁₀ M ₃₀	7.17 ^a ±2.51	6.99 ^a ±0.24	7.10 ^{ab} ±0.19	7.20 ^a ±0.12	5.63 ^a ±2.22
W ₅₀ S ₃₀ M ₂₀	7.88 ^a ±0.38	8.16 ^a ±0.27	7.47 ^a ±0.46	7.54 ^a ±0.30	4.49 ^b ±1.32
W ₅₀ S ₂₀ M ₃₀	7.98 ^a ±0.21	7.96 ^a ±1.49	7.26 ^a ±0.30	8.06 ^a ±1.14	4.93 ^b ±0.69

Values are means ± standard deviation of triplicates. Values with different superscript along the same column are significantly different ($p < 0.05$). Where: W – Whole wheat flour; M – Mucuna flour; S – Sweet potato flour. Subscripts 10, 20, 30, 50, 60, and 100 are percent inclusion of the flour

Conclusions

This research revealed that the water absorption capacity, oil absorption capacity and protein content of the composite flour decreased as the quantity of the sweet potato flour increased but increased as the quantity of *Mucuna utilis* flour increased. Substitution of 50% *M. utilis* flour for wheat flour increased these parameters by 92.0, 15.0 and 90.4%, respectively. This research also revealed that cookies with enhanced physical, nutritional, and sensory qualities could be produced from whole wheat-sweet potato-*Mucuna utilis* composite flours. The composite flour which comprised 60% whole wheat flour, 10% sweet potato flour, and 30% *M. utilis* flour produced cookies with optimum protein (21.84 %), diameter (5.30 cm), spread ratio (6.90), and sensory qualities that were comparable to that of 100% whole wheat flour.

Acknowledgment

The authors wish to acknowledge the invaluable technical support of the Dean of the Faculty of Engineering and Technology and the Head of the Department of Food Science and Technology for allowing us to use the laboratory. Our gratitude goes to the management of Madonna University Nigeria, Akpugo Campus.

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