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FUNCTIONAL AND NUTRITIONAL CHARACTERIZATION OF CUPCAKES PRODUCED FROM BLENDS OF MUSHROOM, ORANGE-FLESHED SWEET POTATO AND WHEAT FLOUR

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Abstract

The increased awareness of healthy eating has necessitated the need for producing healthy and functional foods. This study aimed at producing a healthy nutritious snack containing essential nutrients that are lacking in most conventional cupcakes. This research investigated the quality of cupcakes produced from wheat, orange-fleshed sweet potato (OFSP) and mushroom flourin the ratio 90:5:5; 80:10:10, and 70:15:15, respectively.

The control sample was a cupcake produced from 100% wheat flour. The proximate composition, total phenolic, vitamin A content, and sensory properties of the cupcakes, as well as some functional properties of the flour blend, were determined. The protein, ash and crude fibre of cupcakes increased as levels of mushroom and OFSP flours in the cupcake increased. Phenolic content of the cupcakes ranged from 0.13 to 0.16 mg/g and vitamin A content ranged from 0.64 to 1.06 mg/100 g. Functional properties of the flour sample ranged from 72.00–94.67%, 6.97–8.19% and 0.70–0.67 g/ml for water absorption capacity, swelling capacity and bulk density, respectively. The developed cupcakes had improved nutritional composition.

Introduction

A cupcake is a delicious snack baked in a thin paper cup purposely to serve only one person. The basic ingredients include flour, fat, sugar, raising agents and eggs.The production of cupcakes originated in the United States in the 19th century because it saves time and ingredients during preparation than the larger cakes. It was opined that the name ‘cupcake’

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was adopted because cakes were originally cooked in cups and two, the recipes used in making cupcakes were measured out by the cup (DARNELL 2015). It is a good source of nutrients such as macronutrients; carbohydrates, proteins, and fats. Cupcakes also consist of vitamins and mineral compounds (RAHUT et al. 2012). Cupcakes are taken as desserts and used to mark special occasions. There is increased awareness of the importance of composite flour to prepare more nutritious food with an effort to reduce the calorie load which as a result will reduce the product's glycemic index, and increase the fibre and protein levels through the incorporation of protein-rich foods such as mushroom.

Over 2000 species of mushroom (*Pleurotus plumonarius)* exist in nature: despite that, less than 25 species are broadly accepted as important in food (LINDEQUIST et al. 2005, LILIAN et al. 2007). Historically, mushroom has both medicinal and culinary functions in many countries (IBRAHIM and HEGAZY 2014) which include lowering blood pressure and strengthening the immune system against disease (REGULA and SIWULSKI 2007). Besides, mushroom provides the body with important nutrients such as potassium, selenium, riboflavin, niacin, fibreand proteins. Mushrooms are consumed for their special aroma and flavour (VALVERDE et al. 2015).

Orange-fleshed sweet potato (OFSP) belongs to the group of tubers that has an excellent amount of beta carotene which is highly bioavailable (JAARSVELD et al. 2005). The high percentage of beta carotene in OFSP may help to reduce the incidence of vitamin A deficiency since beta carotene is a provitamin A (POBEE et al. 2017). Orange-fleshed sweet potato is rich in vitamin A, C, E, thiamin, riboflavin, and niacin (PADMAJA 2009). The crop can be used in nutrition intervention programs, especially in areas where vitamin A deficiency is prevalent (IBRAHIM and HEGAZY 2014). It can also contribute to the nutritional content of the developed product, lower gluten levels, and consequently, reduce the risk of celiac disease in people with gluten intolerance (TILMA et al. 2003). Additionally, orange-fleshed sweet potato flour enhances the sensory attributes by adding natural sweetness, colour, flavour and dietary fibre to the processed products (YADAV et al. 2006).

Wheat is one of the most cultivated crops produced in temperate regions, and one of the most important food crops consumed all over the world (SHIFERAW et al. 2013).Wheat grain and flour contain mainly carbohydrates and a considerable amount of proteins, mineral compounds and vitamins (SHEWRY and Hey 2015).

Several efforts have been made to increase the potential of underutilized crops by using them as composite flours in the production of baked products and other confectioneries. Composite flours are blends of flours from tubers such as cassava, yam, and potato, protein-rich flours and other major or minor cereals which in some cases may include wheat flour (Bugusu et al. 2001). Schmelter et al. (2021) advocated for the replacement of a substantial amount of wheat flour with flour from pulses which can increase the protein content of biscuits or cookies. In this study, however, partial replacement of wheat flour with a blend of orange-fleshed sweet potato and dried mushroom flour has the potential to improve the fibre, protein and vitamin contents of cupcake. This can benefit the body by reducing food cravings whilst offering required energy not just for children but serving as healthy snacks for adults who are health conscious. This study aimed at partially replacing wheat flour with a mixture of orange-fleshed sweet potato and mushroom flour to produce more nutritious and healthy snacks (cupcakes).

Materials and Methods

Samples procurement

The orange-fleshed sweet potatoes (OFSP) and mushrooms (*Pleurotus ostreatus*) were procured from a farmer in Osogbo and Ladoke Akintola University of Technology (LAUTECH) Research Farm, Nigeria, respectively. The cupcakes were processed in the Food Processing Laboratory, LAUTECH, Ogbomosho, Nigeria.

Production of high-quality dried orange-fleshed sweet potato flour

High-quality-OFSP flour was produced as described by Saeed et al. (2012). The tuber was weighed, peeled, washed, weighed and sliced manually into 2 mm thickness. It was dried in a solar drier at 45±2ºC. OFSP was cooled, milled into flour using a Model SK-24-MS attrition mill (USA) and sieved using a 250 μm screen to obtain fine particles. The resulted (1.55 kg, 8% moisture content) flour was packed in an air-tight container for further use and stored at ambient conditions (26±2ºC).

Preparation of mushroom flour

The procured mushrooms were sorted, cleaned, shredded and dried at 50ºC in a cabinet drier for 48 h, milled into flour using a laboratory micro mill (Landersand CIA, USA). The flour (1.60 kg, 10% moisture content dry basis) was sieved into fine flour of 150 µm particle size to obtain a finer mushroom flour, packaged in a transparent polyethene bag and stored in a desiccator as described by Ojo et al. (2017).

Formulation of wheat, mushroom and orange-fleshed sweet potato flours

Four different flour samples were formulated for cupcake production. The first batch was the control which was made up of 100% wheat flour (8.40% moisture content, Golden penny confectionery soft flour, Flour Mills of Nigeria); batch 2 which was tagged S1 comprised 90% wheat flour, 5% mushroom, and 5% orange-fleshed sweet potato flours (8.80% moisture content); batch 3 which was tagged S2 comprised 80% wheat flour, 10% mushroom and 10% orange-fleshed sweet potato flours (9.00% moisture content) and batch 4 which was tagged S3 comprised 70% wheat flour, 15% of mushroom, and 15% orange-fleshed sweet potato (9.50% moisture content) flours.

Functional properties of flours from wheat, mushroom and orange-fleshed sweet potato mixes

Functional properties such as bulk density, water absorption capacity and swelling capacity were analyzed according to methods described by Sosulski et al. (1976). The bulk density of the varying levels of wheat flour, mushroom and orange-fleshed sweet potato flour blends was determined by weighing 50 g of the sample into the 100 ml graduated cylinder, then, the bottom was trapped gently several times on a laboratory bench, until no further diminution of the sample level. After this, the final volume was expressed as g/ml. The swelling capacity of the varying levels of wheat flour, mushroom and orange-fleshed sweet potato flours was determined by filling 100 ml graduated cylinder up to 10 ml mark. Distilled water was added to make it up to 50 ml. The graduated cylinder was covered and inverted to ensure rigorous mixing of both flour and water. The mixture was mixed again after 2 min then left to stand for another 8 min. The volume was taken and swelling capacity determined). Water absorption was estimated as per cent water-bound per gram of flour. The method of Chandra (2015) was used for estimating oil absorption capacity.

Production of cupcakes

The cupcakes were prepared by replacing wheat flour with different levels of composite flour (Table 1) according to the method of Rahut et al. (2012). The production of cake is presented in Figure 1. The wheat flour, orange-fleshed sweet potato, mushroom, and other ingredients for each cupcake were measured accurately after which sugar and shortening (Golden Penny Margarine, Flour Mills of Nigeria) were mixed in a bowl using a mixer (Kenwood, A901) till the mixture become fluffy and creamy.

Table 1
Ingredients formulation of cupcakes from blends of wheat, orange-fleshed sweet potato (OFSP) and mushroom flour

Ingredient	Composition [g]			
Wheat flour	100	90	80	70
Orange-fleshed sweet potato	0.00	5	10	15
Mushroom	0.00	5	10	15
Sugar	84	84	84	84
Shortening	84	84	84	84
Baking powder	3.6	3.6	3.6	3.6
Whole eggs	2	2	2	2

Source: own study based on RAHUT et al. (2012).

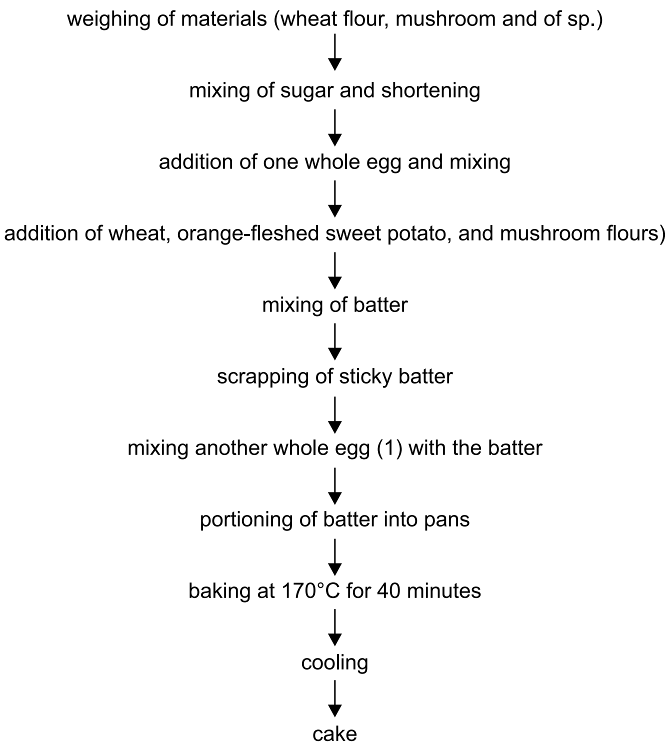

Fig. 1. Flow chart for production of cupcakes

In the later stage, one whole egg and other ingredients were added to the mixture and mixed using a Kenwood mixer (A901) at a low speed of 145 rpm for 10 minutes to ensure homogeneity. After scraping the batter at the edge of the bowl, it was mixed for another two minutes at medium speed 250 rpm, then another whole egg was added and the batter was mixed. The batter was scooped into pre-greased cake cups and baked in a Thermocool oven (MY DIVA 604G OG-6840 INX) for 40 minutes at 170°C. The cupcakes were removed from the oven and cooled. The cupcakes were baked in three series.

Proximate composition of cupcake samples

The proximate composition of each sample was determined using the method of AOAC (2005). The moisture content was estimated by air-oven (Model DHG 9101. Changzhou, China) drying to a constant weight at 103 ± 2°C; ash content was obtained by incinerating the sample in a muffle furnace (STXMF115, STERICOX) at 550°C for 3–4 hours after partial oxidation of organic matter. The crude fat content was determined using the Soxhlet extraction method using petroleum ether while fibre was obtained by dilute acid and alkali hydrolysis. Crude protein content was estimated by the Kjeldahl method and % protein was obtained by multiplying nitrogen with a conversion factor of 6.25.

Vitamin A determination

Vitamin A in the cupcake was determined spectrophotometrically using a modified standard method of AOAC (2005). The cake sample (0.5 g) was homogenized and saponified with 2.5 ml of 12% alcoholic KOH in a water bath at 60°C for 30 min. The saponified extract was separated in a separating funnel containing 10–15 ml of petroleum ether. The lower aqueous layer was dispensed in a separating funnel and the upper petroleum ether layer containing the carotenoids was collected. The extraction was repeated until the aqueous layer became colourless. One ml of anhydrous sodium sulphate was mixed with the ether extract to remove excess moisture. The final volume of the petroleum ether extract was noted. The absorbance of the yellow colour was read in a visible Spectrophotometer (Beckman Instrument DK-2A) at 450 nm using petroleum ether as a blank.

Total phenolic content determination

The total phenolic content (TPC) of the cupcake sample was analyzed using Folin-Ciocalteu (FC) reagent. At first, 250 µl sample solution was mixed with 1 ml diluted (1:9) FC reagent. It was incubated for 5 min after which 750 µl 1% Na_2CO_3 solution was added. The sample was gently mixed and incubated for 2 h at 30°C. The absorbance of the solvent extract was later measured at 760 nm on a Spectronic 21DUV spectrophotometer using the modified method of AYUSMAN et al. (2020).The TPC was measured as equivalents of gallic acid (mg GAE/g crude extract).

Sensory evaluation of cupcakes

The sensory evaluation of cupcakes sobtained from wheat, mushroom, orange-fleshed sweet potato flour mixtures at different levels, and control (100% wheat cupcake) was performed by 50 semi-trained panellists representing the staff and students (both) of Ladoke Akintola University of Technology Ogbomosho, Nigeria. The samples were scored for the appearance, flavour, texture, and overall acceptability using a nine-point hedonic scale where 9 indicated like extremely, 5 indicated like nor disliked, and 1 indicated dislike extremely as described by BABARINDE et al. (2020).

Statistical analysis

All data obtained were replicated three times ($n=3$) while the sensory attributes were carried out by fifty ($n=50$) panellists. Data obtained were subjected to a one-way analysis of variance and means were separated using the new Duncan multiple-range test (SPSS version 20).

Results and Discussion

Functional properties of flour samples of wheat, orange-fleshed sweet potato and mushroom mixes

The functional property of food determines the application and the use of food materials for various food products (ADELEKE and ODEDEJI 2010). The results of water absorption capacity, oil capacity, swelling capacity, and bulk density results are presented in Table 2.

The bulk density values were 0.69 g/ml, 0.70 g/ml, 0.70 g/ml and 0.68 g/ml for flour samples containing 100% of wheat, 90% wheat, 5% OFSP and 5% mushroom; 80% wheat, 10% OFSP and 10% mushroom and 70% wheat, 15% OFSP and 15% mushroom, respectively. The bulk density of composite flour ranged from 0.69 to 0.70. The lower densities observed in composite flour may be attributed to the difference in the particle size or total partial gelatinization of the flour during drying (FALADE and OLUGBIYI 2010). However, flour sample S1 and control flour had the same bulk density value (0.70) as control flour (0.70). This can be due to the low levels of OFSP and mushroom flour in the sample.

Table 2

Functional properties of flour samples

Samples	Water absorption capacity [%]	Oil absorption capacity [%]	Swelling capacity [%]	Bulk density [g/ml]
Control	57.67±5.13^{a}	69.00±3.61^{a}	6.90±0.22^{a}	0.70±0.03^{b}
S1	72.00±9.54^{b}	71.00±1.00^{ab}	6.97±0.24^{a}	0.70±0.03^{b}
S2	78.67±1.53^{b}	72.67±1.16^{ab}	7.00±0.31^{a}	0.68±0.03^{a}
S3	94.67±1.53^{c}	74.67±3.06^{b}	8.19±0.26^{b}	069±0.02^{a}

Values represent means of triplicate reading. Means within the same column with different alphabets are significantly different (p < 0.05)
S1 – 90% wheat, 5% mushroom, 5% OFSP flours
S2 – 80% wheat, 10% mushroom, 10% OFSP flours
S3 – 70% wheat, 15% mushroom, 15% OFSP flours
Control – 100% wheat flour

The water absorption capacity (WAC) of the samples increased with an increase in the inclusion of OFSP and mushroom, the WAC value of composite value ranged from 72 to 94%, while the control sample had the least WAC value being 57.67%. This confirmed the report of SAEED et al. (2012) who reported that the water absorption capacity of composite flours is higher than wheat flour. Water absorption is an attribute that has implications for viscosity. It aids bulking and ensures consistency in some products during baking (NIBA et al. 2001). A very low water absorption capacity can negatively influence the quality of the food products by reducing the volume of the product and increasing staling activity in baked foods (AWUCHI et al. 2019).

There was an increase in oil absorption capacity (OAC) of the flour samples with increased levels of OFSP flour and mushroom powder. The higher OAC observed in the flour samples may be attributed to the higher protein content of the flour sample containing mushroom and OFSP mixes. This has been reported to contribute to the oil retaining properties of food materials. The OAC of flour plays a major role in the storage stability of food products (FALADE and KOLAWOLE 2011). The oil absorption capacity is an important attribute that enhances flavour and mouth feel in food preparation. A flour with moderately high OAC is desirable and used as a functional ingredient in some baked products, especially cakes and desserts (SURESH and SAMSHER 2013).

The swelling capacity of the flours ranged from 6.90–8.19% for samples S1, S2 and S3. The higher swelling capacity observed in S1, S2 and S3 may be attributed to a higher level of orange-fleshed sweet potato and mushroom. This confirmed the report of AWUCHI et al. (2019) who similarly observed that the swelling capacity is often related to their protein and starch content. The amylopectin is primarily responsible for granule swelling, the higher the amylopectin content in composite flour with a higher level of potato flour would increase the swelling power of composite flour (TESTER and MORISSON 1990).

Proximate composition of cupcakes

The results of the proximate composition of cupcakes produced from the blend of wheat, mushroom, and orange-fleshed sweet potato (OFSP) flours are presented in Table 3. The protein content of cupcake samples increased from 7.76 % in the control sample to 17.75% in samples containing 15% OFSP and 15% mushroom flour. Protein content increased with an increased level of mushroom substitution. VALVERDE et al. (2015) confirmed that mushrooms are high in important nutrients such as proteins, selenium, riboflavin, and fibre. Mushrooms can be incorporated into foods to enrich their protein contents and reduce the risk of protein energy malnutrition (IBRAHIM and HEGAZY 2014).

Table 3

Proximate composition of cupcake samples

Sample	Protein [%]	Moisture [%]	Fat [%]	Ash [%]	Crude fibre [%]	Carbohydrate [%]
Control	7.76±0.25^{a}	12.19±0.32^{a}	18.56±0.51^{b}	0.67±0.15	0.44±0.10^{a}	59.87±0.31^{ab}
S1	9.30±0.25^{b}	13.00±0.67^{a}	16.89±1.02^{b}	1.17±29a^{b}	0.78±0.19^{ab}	59.13±0.91^{a}
S2	13.42±0.07^{c}	17.26±0.23^{b}	13.67±0.58^{a}	1.43±0.51^{b}	0.96±0.34^{b}	58.27±1.35^{ab}
S3	17.75±0.44^{e}	17.67±0.58^{b}	12.00±1.33^{a}	1.47±0.06^{b}	0.98±0.01^{b}	50.13±0.35^{b}

Values represent means of triplicate reading. Means within the same column with different alphabets are significantly different ($p < 0.05$)
S1 – 90% wheat, 5% mushroom, 5% OFSP flours
S2 – 80% wheat, 10% mushroom, 10% OFSP flours
S3 – 70% wheat, 15% mushroom, 15% OFSP flours
Control – 100% wheat flour

The incorporation of mushrooms into diets may reduce protein deficiency in developing countries, especially in areas where quality proteins from animal sources are either expensive or unacceptable due to ethnic bias or religious beliefs (DUNKWAL et al. 2007). Usually, roots and tubers arepoor sources of protein as observed in OFSP. NEELA and FANTA (2019) observed that the protein content of OFSP is similar to that of potatoes (2%). Orange fleshed sweet potato can be partially replaced with wheat flour because of its protein content and the significantly little visco-elastic property in the preparation of various bakery products (IBRAHIM and HEGAZY 2014).

An increase in ash and crude fibre contents was also observed in the cupcake samples. The values obtained were in the ranges of 0.67–1.47% and 0.44– 0.98% (Table 3). The increase in ash and fibre could be due to the incorporation of OFSP and mushroom flours. VALVERDE et al. (2015) reported that mushroom provides the body with important nutrients including fibre and ash. Ash and fibre contents of cake samples with different levels of mushroom flour were higher than that of control cakes.The ash content of OFSP as reported by MOHAMMAD et al. (2016) ranged from 1.17 to 4.33%. TOLERA and ABERA (2017) reported that oven-dried mushrooms contained 11.6% ash content. The values obtained in the cupcake samples were lower than the values reported by TOLERA and ABERA (2017) for mushrooms. The difference in the fibre could be due to varietal differences.

Crude fibre provides faecal bulkiness and plays a vital role in cholesterol reduction. It aids the entrapment of dangerous substances like cancer-causing agents and the growth of natural beneficial microbial floral in the gut (DHINGRA et al. 2012). ENDRIAS et al. (2016) reported that the dietary fibre of OFSP varieties ranged from 0.35 to 3.6%.

The moisture content of cupcake samples increased with an increase in mushroom and OFSP. The moisture content of cupcake samples containing various levels of OFSP and mushroom flours ranged from 13.00 to 17.67%. The sample containing 15% OFSP and 15% mushroom had the highest value as compared to the control sample. The increase in moisture could be related to the high water absorption capacity of the composite flour. Moisture is the major component in OFSP, which accounts for about 75% of the entire tuber (ENDRIAS et al. 2016).

The fat content of cupcake samples decreased with an increase in mushroom and OFSP flours. The sample containing 15% OFSP and 15% mushroom had the lowest fat content 12.00% while the control sample (100% wheat flour) had the highest fat content (18.56%). RODRIGUES et al. (2016) reported that OFSP is low in fat (< 1%), which is the usual trend for roots and tubers. The fat concentration of the OFSP is even lesser than other roots and tubers such as potato (0.09%), cassava (0.28%) and other staple tuber crops that contain less fat (0.15–1.00%) and this is a positive nutritional aspect of the OFSP (NEELA and FANTA 2019). Significant ($P < 0.05$) differences were noted among the values obtained for fat contents of cake samples.

The carbohydrate content of cupcake samples decreased with the inclusion of OFSP and increased in mushroom flour (Table 2). SHEIKH et al. (2010) reported that the carbohydrate content of the control cake was higher than other samples containing varying levels of OFSP and mushroom flour. MOHANRAJ and SIVASANKAR (2014) reported that the carbohydrate from OFSP does not result in a blood sugar spike. The World Health Food Organization also acknowledged OFSP as the root crop with anti--diabetic activity (ANBUSELVI et al. 2012).

Total phenolic content and vitamin A

The results of the phenolic compound and vitamin A are shown in Table 4. The vitamin A content of cake samples containing various levels of OFSP and mushroom powder ranged from 0.62 mg/100 g to 1.06 mg/100 g. Sample containing the highest levels of OFSP and mushroom had the highest value (0.16 mg GAE/g) of total phenols that was significant at $p < 0.05$. Vitamin A and total phenol contents increased with an increase in mushroom and OFSP flour. The total phenolic contents of the cake samples were higher than the values 0.06–0.23 mg GAE/g fresh weight reported by TEOW et al. (2007) for various sweet potato cultivars. OFSP and mushrooms could have contributed to the higher values of total phenols since they are rich sources of total phenols (ELMASTAS et al. 2007) which contribute to their antioxidative and anti-tumour (ADEBAYO et al. 2014; LINDEQUIST et al. 2005) activities. Phenolic compounds are the major antioxidants in mushroom and which play a protective role in human health due to their ability to scavenge and inhibit free radicals (GĄSECKA et al. 2016).

Table 4

Total phenol and vitamin A contents of cupcakes

Samples	Total phenol [mg GAE/g]	Vitamin A [mg/100 g]
Control	0.13 ± 0.00^a	0.62 ± 0.05^a
S1	0.13 ± 0.00^a	0.64 ± 0.03^a
S2	0.15 ± 0.02^b	0.94 ± 0.05^b
S3	0.16 ± 0.01^b	1.06 ± 0.09^c

Values represent means of triplicate reading. Means within the same column with different alphabets are significantly different ($p < 0.05$)
S1 – cupcake baked from 90% wheat, 5% mushroom, 5% OFSP flours
S2 – cupcake baked 80% wheat, 10% mushroom, 10% OFSP flours
S3 – cupcake baked 70% wheat, 15% mushroom, 15% OFSP flours
Control – cupcake baked 100% wheat flour

On vitamin A content of the cake samples, KURABACHEW et al. (2015) reported that OFSP has a high potential to address vitamin A deficiency (due to the high concentrations of beta-carotene) using food-based intervention programs in areas where vitamin A deficiency is prevalent.

Sensory evaluation of cupcake samples

The cupcake samples produced from S1, S2 and S3 were subjected to sensory evaluation by a panel of 50 tasters. The mean scores for colour, aroma, texture, and overall acceptability of the cupcake are presented in Table 5. The cupcake samples showed varying degrees of acceptability of the analysed indices.

Cupcakes produced from 15% mushroom, 15% OFSP, and 70% of wheat flour had the highest rating for taste, appearance and colour, and overall acceptability, while S1 (90% wheat, 5% OFSP, 5% mushroom) had the highest rating of aroma. This indicates that both mushroom and OFSP flour had a strong impact on the taste, aroma, appearance and texture. This confirmed the report of SHEIKH et al. (2010) who reported that the increasing percentage of mushroom flour gave the highest score for colour, flavour and texture. Additionally, orange-fleshed sweet potato flour enhanced the sensory attributes by adding natural sweetness, colour, flavour and dietary fibre to the processed products (YADAV et al. 2006). Wheat flour had a higher rating in taste appearance and aroma. As shown in Table 5, the sensory scores revealed that cake containing 15% mushroom powder and 15% of OFSP was the most preferred in terms of colour than other cake samples containing various levels of mushroom powder and OFSP.

Table 5

Sensory evaluation of cupcake samples

Samples	Taste	Appearance	Texture	Aroma	Colour	Overall acceptability
Control	8.03 ± 0.72^{b}	7.80 ± 0.76^{bc}	8.07 ± 0.69^{b}	8.40 ± 14.30^{c}	7.40 ± 0.77^{b}	7.87 ± 0.73^{b}
S1	7.67 ± 0.93^{ab}	7.27 ± 1.02^{ab}	7.17 ± 1.18^{a}	7.73 ± 0.94^{b}	7.07 ± 14.56^{b}	7.83 ± 0.79^{b}
S2	7.13 ± 1.17^{a}	6.83 ± 1.26^{a}	6.63 ± 1.56^{a}	7.13 ± 1.43^{a}	6.47 ± 1.46^{a}	6.90 ± 1.32^{a}
S3	8.30 ± 1.06^{b}	8.03 ± 0.81^{c}	8.17 ± 0.91^{b}	7.90 ± 1.06^{b}	8.00 ± 0.87^{c}	8.30 ± 0.92^{b}

Values represent means of triplicate reading. Means within the same column with different alphabets are significantly different ($p < 0.05$)
S1 – 90% wheat, 5% mushroom, 5% OFSP flours
S2 – 80% wheat, 10% mushroom, 10% OFSP flours
S3 – 70% wheat, 15% mushroom, 15% OFSP flours
Control – 100% wheat flour

Conclusions

The protein, crude fibre and ash contents of the formulated cupcakes (S1, S2, S3) were higher than the control. The swelling capacities of the formulated S1, S2 and S3 flours showed higher values than 100% wheat (control). Cupcakes produced from S3 (samples with 15% mushroom and 15% OFSP flour) revealed the highest total phenolic and vitamin A contents. The overall sensory quality of cupcakes formulated from S3 was higher than those prepared from S1, S2 and control. The result of this study suggests that mushroom and OFSP flours should be used for the production of nutritious and acceptable quality cupcakes. Our findings could be adopted in the development of novel and health-beneficial cupcakes with improved nutritional and antioxidant properties.

Conflict of interest. The authors declare no known competing interests that could influence the work reported in this paper.

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