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ORIGINAL RESEARCH PAPER

POTENTIAL OF AVOCADO PUREE AND ORANGE FLESHED SWEET POTATO FOR WHEAT-BASED CAKE PRODUCTION

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Abstract

Avocado puree is rich in unsaturated healthy fats, being a better alternative to the saturated bakery fats usually used in cake production. Hence, the potential of avocado puree as a fat replacer and the use of composite flours made from wheat and orange fleshed sweet potato (OFSP) for cake production were investigated. Various ratios of substitution of the OFSP flours and avocado puree were used. The proximate composition of the flour blends, physical properties, colour and sensory acceptability of the cake were evaluated. Moisture content (6.17-9.17%) was low, such as to support stability during storage. The 100% OFSP flour had the highest content of ash, crude fat, and carbohydrate (1.50, 4.17, and 82.76%, respectively). The 100% wheat flour showed the highest protein content (15.42%) and fibre content (1.01%), whereas 100% OFSP had the lowest contents (4.53 and 0.21%, respectively). Significant variation of the cake height and weight were noticed among different formulations considered in this experiment. The cake produced with 90% wheat and 10% OFSP was the most preferred, with the highest overall acceptability (8.40). Therefore, wheat flour supplemented with 10% OFSP produces a batter which possesses the potential to create a health-beneficial cake and provide economic advantages to the nation by reducing wheat importation.

Keywords: avocado puree, composite flour, orange fleshed sweet potato, functional cake

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Introduction

Fat plays an important role in food systems. It contributes to physicochemical, sensory and physiological characteristics such as flavour, mouth feel, taste, and texture. In bakery products such as muffins, cakes, and bread, fat (in the form of shortening) traps air during mixing to incorporate air bubbles into the batter or dough, which helps produce a porous crumb texture (Dwyer and Gallagher, 2001; Nurul Ain *et al.*, 2016) and leaven the final products (Matsakidou *et al.*, 2010). Butter and margarine, which are conventionally used in bakery products, are high in trans-fatty acids (TFAs) and saturated fatty acids (SFAs), and should be avoided or reduced for a healthier lifestyle. A high intake of TFAs and SFAs leads to hypercholesterolemia and coronary heart disease. Also, FAs increase the risk of coronary heart disease, due to an increase in low-density lipoprotein (LDL) and reduced high-density lipoprotein (HDL) (Nurul Ain *et al.*, 2016). Thus, there is a need to find healthier fat replacers or substitutes for these conventional fats in baking. Also, as the public demand remains high for reduced-fat food products, without compromising the good taste, many studies have been conducted on using natural ingredients as fat replacers, to make acceptable low-fat food products. These include the mung bean paste (Adair and Knight, 2001), pawpaw fruit puree (Wiese and Duffin, 2003), cocoa fibre (Martinez-Cevera *et al.*, 2011) and apple sauce (Hayek and Ibrahim, 2013).

Avocado (*Persea americana*) is a tropical fruit that originated in Mexico. Other countries such as Chile, the Dominican Republic, and Indonesia produce a high yield of avocados annually. Besides being consumed as fresh fruit, avocado is suitable for fruit salad, sandwich spread, and guacamole (Yahia and Woolf, 2011). In contrast to typical sweet and acidic fruits, avocado has a buttery and smooth texture that makes it suitable as a potential fat replacer in bakery products. Moreover, it contains a high level (66.67%) of monounsaturated fatty acid (MUFA) and 12.24% of polyunsaturated fatty acid (PUFA) with a relatively low level (14.29%) of saturated fatty acid (SFA) (Gillingham *et al.*, 2011). In addition, avocado is also known as a medium nutrient-dense fruit, given that approximately 80% of the edible part of avocado consists of 72% water, which indicates the perishability of the fruit, and 6.8% dietary fibre (Dreher and Davenport, 2013; Nurul Ain *et al.*, 2016). Thus, using avocado fat in baking will be an added value to improve the utilisation and ultimately reduce postharvest losses of the crop.

Composite flour is a mixture of flour, starches, and other ingredients intended to replace wheat flour totally or partially in bakery and pastry products (Manisha *et al.*, 2021). Also, in agreement with this, Antankar *et al.* (2019) described composite flours as either binary or ternary mixtures of flours from some other crops, with or without wheat flour. Composite flour is considered advantageous in developing countries as it reduces the importation of wheat flour and encourages the utilisation of locally grown crops in its place (Hasmadi *et al.*, 2014; Peter-Ikechukwu *et al.*, 2019). Consequently, local raw materials' substitution for wheat flour is increasing due to the growing market for confectioneries (Yanova *et al.*, 2019). Thus, several developing countries have encouraged the initiation of programmes to evaluate the feasibility of alternative locally available flours as a substitute for wheat flour (Abdelghafor *et al.*, 2011). Noorfarahzilah *et al.* (2014) and Xu *et al.* (2020) reported that the bakery products produced using composite flour had good quality, with some characteristics similar to wheat flour bread, though the texture and some other properties of the composite flour bakery products were different from those made from 100% wheat flour. However, they possessed an increased nutritional value and better appearance. Apart from being a good source of calories and other nutrients, wheat is considered nutritionally poor, because its proteins are deficient in essential amino acids, such as lysine and threonine (Sibian *et al.*, 2017; Chowdhury *et al.*, 2020). Therefore, supplementing wheat flour with inexpensive staples such as sweet potato, other cereals, and pulses helps improve the nutritional quality of the products (Akajiaku *et al.*, 2017).

Sweet potato (Ipomea batatas) is a perennial crop that serves as one of the major sources of food for humans. It is widely cultivated in the tropics, subtropics, and even in some temperate areas of the developing world (Ahn *et al.*, 2010). There are various cultivars of sweet potatoes available for commercial production in Nigeria, which include: an orange/copper skin with cream colour flesh, purple-fleshed sweet potato, red/purple skin with cream/white flesh and orange-fleshed sweet potato (OFSP), fortified with vitamin A to address the problem of vitamin A deficiency (Mardi, 2010). However, regardless of the cultivar, raw sweet potatoes have limited uses because of their slightly perishable nature. Thus, processing sweet potatoes into flour increases their shelf-life when stored for a long period (Ahmed *et al.*, 2010), and is easier to handle during transportation and application in other food products preparation, such as cake.

The cake is a delicate, tender, highly sweetened baked product (Etudaiye *et al.*, 2015). Cake has become a constant food in our diet for a long time, and its continued popularity has encouraged the development of a newer and more attractive product in the market today (Eke *et al.*, 2009). Cake can be served alone, packed in a lunch, taken on a picnic, or regarded as a traditional favourite for guests (Etudaiye *et al.*, 2015).

Although much work has been done on the use of orange-fleshed sweet potato in food or bakery products, documentation in conjunction with a natural and healthier fat as shortening is scarce in the literature. Therefore, the objectives of this study are to formulate and develop nutritive cakes from composite flours, consisting of wheat and OFSP flours, and to test the partial replacement of butter/margarine fat with natural avocado puree. The products' baking properties, nutritional, and sensory qualities were evaluated.

Materials and methods

Materials

The OFSP was purchased from a local farm in Osogbo, Osun State, Nigeria. Avocado fruits, refined white granulated sugar, bakery margarine (80% fat), baking powder, full milk powder, fresh eggs, flavouring, salt and wheat flour were purchased from Ikole market, Ekiti State, Nigeria. All chemicals used for analysis were of analytical grade.

Production of avocado puree

The method described by Nurul-Ain *et al.* (2016) was adopted for producing avocado puree. Fully matured and ripe avocado fruits (slightly yellow and soft when touched) were selected based on the texture and were appropriately handled to maintain the quality of the raw material. The fruits were cut in halves to remove the seeds. Avocado flesh was scooped out of the skin using a clean spoon, blended to a smooth paste, and divided into a few portions according to the formulations.

Processing of orange-fleshed sweet potato flour

The method described by Etudaiye *et al.* (2008), with little modification was employed in producing orange-fleshed potato flour. The fresh potato roots were washed, peeled and directly sliced to a thickness of ≤ 2 mm using a manual slicer to obtain sweet potato chips. The chips were dipped in sodium metabisulphite solution with a concentration of 2000 ppm to prevent browning and dried in an air oven (PBs 118SF Genlab Widnes, England) at 60 °C for 24 h, until the chips became well dried and of constant weight. Dried chips were dry-milled using a local disc attrition mill (VIKNG Exclusive JONCOD, TYPE YL112M-4, Lagos, Nigeria), then sieved through a 100 mm mesh sieve to obtain the fine flour of uniform particle size, which was packaged in self-sealing polyethylene plastic. The formulations used for cake production are presented in Table 1.

Table 1. The formulation for composite blends of wheat: OFSP flours and fat: avocado puree

Ingredient (%)	TNA	TNB	TNC	TND	TNE	TNF	TNG
Wheat flour	100	90	80	70	60	100	0
OFSP flour	0	10	20	30	40	0	100

OFSP= Orange-fleshed sweet potato; TNA= Control flour (100% wheat); TNB= Flour blend (90% wheat flour: 10% OFSP); TNC= Flour blend (80% wheat flour: 20% OFSP); TND= Flour blend (70% wheat flour: 30% OFSP); TNE= Flour blend (60% wheat flour: 40% OFSP); TNF = 100% wheat flour; TNG = 100% OFSP flour = (TNA)

Determination of the proximate composition of the flour blends

The proximate analysis of the flour blends was determined through the method of AOAC (2010) for percentage moisture (925.10), ash (942.05), crude protein (968.08), crude fiber (978.10), and crude fat (922.06) contents. The carbohydrate content was calculated by the difference i.e: % Carbohydrates = [100 - (%moisture + %ash + %crude protein + %crude fibre + %crude fat)].

Production of cake

The margarine and avocado puree blend was creamed together with the granulated sugar in a bowl until smooth, fluffy and creamy. The eggs were beaten and added to the cream, followed by mixing with an electric mixer (Kitchen Aid, model 5K45SS, Antwerp, Belgium). The flour blends consisting of different amounts of OFSP and wheat flour were mixed thoroughly with other dry ingredients (salt, baking powder, milk). The batter was poured into the pre-greased (using margarine) baking pans (L-10 cm, H-10.16 cm) and baked in a preheated oven (PBs 118SF Genlab Widnes, England) at 180 °C for 20 min. After baking, the cakes were allowed to cool and released from the pans before packaging to avoid moisture re-absorption (Sanful *et al.*, 2010). In the above production method, seven batches were produced using different formulations and recipes as shown in Table 2.

Table 2. Blend formulation and recipe for cake production

Ingredient	RNA	RNB	RNC	RND	RNE	RNF	RNG
Wheat flour (g)	250	225	200	175	150	250	0
OFSP flour (g)	0	25	50	75	100	0	250
Fat (g)	250	225	200	175	150	0	250
Avocado puree (g)	0	25	50	75	100	250	0
Sugar (g)	150	150	150	150	150	150	150
Egg (No.)	8	8	8	8	8	8	8
Baking powder (g)	3	3	3	3	3	3	3
Milk (g)	10	10	10	10	10	10	10
Flavoring (g)	2	2	2	2	2	2	2

OFSP = Orange-fleshed sweet potato; RNA = Cake made from 100% wheat flour and 100% fat (control); RNB = Recipe for ratio 90:10 flour blend (90% wheat flour: 10% OFSP & 90% fat: 10% avocado puree); RNC = Recipe for ratio 80:20 flour blend (80% wheat flour: 20% OFSP & 80% fat: 20% avocado puree); RND = Recipe for ratio 70:30 flour blend (70% wheat flour: 30% OFSP & 70% fat: 30% avocado puree); RNE = Recipe for ratio 60:40 flour blend (60% wheat flour: 40% OFSP & 60% fat: 40% avocado puree); RNF = Recipe for 100% wheat flour & 100% avocado puree; RNG = Recipe for 100% OFSP & 100% fat

Determination of the pH of the cake batter

The pH of the batter was determined by direct immersion of a pH electrode in the batter at room temperature (~25°C) using a Digital pH meter (Jenway, Model 3020, Dunmow, Essex, UK).

Measurement of the cake weight and height

The batter of the cake before baking was weighed and the weight of the baked cake was also measured after removal from the pan. The height (cm) was measured at the center and highest point of the cake.

Evaluation of colour

The crust and crumb colour of cakes were determined using a Lovibond Tintometer (The Tintometer LTD., Salisbury, England). The readings were further converted into CIE units using visual density graphs and the instruction manual supplied with the apparatus.

Sensory evaluation

The cake products were evaluated for sensory quality using the method of Iwe (2002) with 9 points Hedonic scale where; 9 = like extremely, 5 = neither like nor dislike, and 1 = dislike extremely. Thirty (30) untrained panelists, comprising of males and females, were selected among the staff, as well as students of the Department of Food Science and Technology, from Federal University Oye Ekiti, Ekiti State, Nigeria, who are familiar with the quality of cake. Those, who were not familiar with cake were excluded to avoid prejudice in the assessments of sensory attributes of colour (for crust and crumb), aroma, taste, grain quality, texture, and general acceptability of the cake products. A cake made from 100% wheat flour and 100% fat was used as the control.

Statistical analysis

The results are given as means ± standard deviation of triplicate determinations. One-way analysis of variance (ANOVA) was used to analyze the data, and the means were separated where differences existed using Duncan's multiple range test. All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS), Version 21, and significance was observed to be at $p<0.05$.

Results and discussion

Proximate composition of the flour blends

The result of the proximate composition of flour blends is shown in Table 3. A significant difference ($p \leq 0.05$) exists between the moisture, protein, and fat contents of the flour blends. However, an increase in carbohydrate, fat and ash, along with a decrease in fiber and protein contents, was detected as the level of substituting wheat flour with orange-fleshed sweet potato flour increased. The TNF flour was a replica of TNA flour (100% wheat flour), only different in the type of fat mixture and, as such, excluded in this analysis. The composite flour made from the ratio of 80% wheat: 20% OFSP flours (TNC) recorded the highest value of moisture (9.17%), while the lowest moisture content (6.17%) was recorded in composite blends flour made with (90% wheat: 10% OFSP). Khaliduzzaman *et al.* (2010) also reported an increase in moisture content when supplementing the wheat flour with 20% potato flour in making biscuits. However, the moisture content (6.17-9.17%) in the entire flour blends of the present work was low enough to support stability during storage. The ash content ranged between 0.67 to 1.50% with samples TNB and TNC having the least and same ash value (0.67%), and sample TNG having the highest (1.50%) value. Thus, presenting the ash content of a food material could be used as a guide for predicting the mineral constituents of the food, since ash is the inorganic residue remaining after the water and organic matter have been removed through heating in the presence of an oxidizing agent (Igbua *et al.*, 2019).

Table 3. Proximate composition (%) of the flour

Sample	Moisture	Ash	Crude protein	Crude fibre	Crude fat	Carbohydrates
TNA	$7.33{\pm}0.76^{c}$	$1.00{\pm}\ 0.50^{ab}$	$15.42{\pm}\ 0.42^{a}$	$1.01{\pm}0.38^{a}$	$1.10{\pm}0.10^{e}$	$74.14{\pm}0.66^{d}$
TNB	$6.17{\pm}0.65^{df}$	$0.67{\pm}0.29^{c}$	$12.52{\pm}0.50^{b}$	$0.82{\pm}0.40^{b}$	$1.43{\pm}0.51^{d}$	$78.39{\pm}0.19^{bc}$
TNC	$9.17{\pm}0.89^{a}$	$0.67{\pm}0.29^{c}$	$10.13{\pm}0.02^{c}$	$0.67{\pm}0.02^{c}$	$2.67{\pm}0.58^{c}$	$76.70{\pm}0.47^{c}$
TND	$8.17{\pm}0.44^{b}$	$0.83{\pm}0.58^{b}$	$9.13{\pm}0.03^{d}$	$0.60{\pm}0.02^{c}$	$3.00{\pm}0.25^{b}$	$78.27{\pm}0.78^{bc}$
TNE	$6.33{\pm}0.26^{df}$	$1.00{\pm}0.70^{ab}$	$7.71{\pm}0.01^{e}$	$0.51{\pm}0.25^{c}$	$3.67{\pm}0.58^{b}$	$80.79{\pm}0.49^{b}$
TNG	$6.50{\pm}0.56^{d}$	$1.50{\pm}0.00^{a}$	$4.53{\pm}0.10^{f}$	$0.21{\pm}0.26^{d}$	$4.17{\pm}0.29^{a}$	$82.76{\pm}0.81^{a}$

Values are the mean of triplicate determinations ± SD. Mean with different superscripts in the same column are significantly different ($p \leq 0.05$)

OFSP= Orange-fleshed sweet potato; TNA= Control flour (100% wheat); TNB= Flour blend (90% wheat flour: 10% OFSP); TNC= Flour blend (80% wheat flour: 20% OFSP); TND= Flour blend (70% wheat flour: 30% OFSP); TNE= Flour blend (60% wheat flour: 40% OFSP); TNF = 100% wheat flour; TNG= 100% OFSP flour = (TNA)

The protein content ranged from 4.53% in sample TNG (100% OFSP flour) to 15.42% in sample TNA (100% wheat flour). The result revealed that flour blends exhibited decreasing amounts of protein with increasing the quantity of potato flour substitution. This suggested that raw wheat contains more protein than raw potato which should be expected as OFSP lacks gluten (wheat protein). This result agrees with the work of Khaliduzzaman *et al.* (2010); and Onabanjo and Igbere (2014). The crude fibre (0.21-1.01%) reduces as more potato flour is added to wheat flour blends. The highest crude fibre (1.01) was seen in the flour sample with 100% wheat flour (TNA) and the least (0.21%) in 100% OFSP flour (TNG). This suggests that wheat flour has more crude fibre than potato flour as observed in the present work. However, this observation is contrary to what was reported by Sanni *et al.* (2008) where the addition of OFSP flour increases the fibre content of the flour blends.

The amount of fat in the flour blends ranged between 1.10 and 4.17, with the highest value (4.17) observed in the flour blend of 100%OFSP (TNG). This showed that fat content increases as the quantity of potato flour inclusion increases. This result showed a good comparison with the fat content of wheat flour in the report of the USDA-ARS (2014) database where a fat content of 1.01 and 2.47 was reported for different varieties of wheat. The carbohydrates ranged between 74.14 and 82.76% with sample TNA (100% wheat) having the lowest carbohydrate composition of 74.14% which is comparable with the range of values reported for wheat flour (71.13-75.90%) by USDA-ARS (2014). Sample TNG (100% OFSP) had the highest (82.76%) carbohydrate content. It could also be inferred from the result obtained in the present work that the substitution of wheat flour with OFSP increased the carbohydrate content of the flour blends.

Physical properties of the batter and cakes

The results of physical properties of the batter and cakes are depicted in Table 4.

The weight of the batter varied significantly ($p \leq 0.05$) with values ranging between 444.04 and 900.25 g. Sample BCNF (100% wheat flour and 100% avocado puree) had the lowest batter weight compared to other formulations. However, the mean weight of the composite flour batters was higher than the control sample (BCNA) but decreased with an increasing level of OFSP flour and avocado puree level. Sample BCNB (90% wheat flour: 10% orange fleshed sweet potato flour and 90% fat: 10% avocado puree) had a higher batter weight (900.25 g) than other formulations. This conforms to the report of Ebuehi and Oyewole (2008), who also observed a reduction in the weight of sweet potatoes and wheat flour composite batters.

The pH of the cake batter varied with little significant difference ($p<0.05$) among the samples since both the control and the composites had a relatively neutral pH of between 7.25 and 7.44. This indicates that the level of substitutions has little to no effect on the pH of the cake batter which is in agreement with the similar work of Linlin and Hyun-Jung (2016) who reported comparable pH values of (7.65-7.75). The height of a cake is usually a function of the volume of air trapped by the gluten structure of wheat flour (Falade *et al.*, 2014). Sample BCNA (100% wheat flour and 100% fat) and BCNB (90% wheat flour: 10% sweet potato flour and 90% fat: 10% avocado puree) had no significant difference in the height of the corresponding cakes (9.41 and 9.40 cm, respectively). This may be due to the relative closeness of the formulation used in the flour blends. The height of the cake could also be correlated to the quantity of fat used in each formulation with a reducing height where a reduced quantity of fat is used (Martínez-Cervera *et al.*, 2011; Rodríguez-García *et al.*, 2014).

Table 4. Physical properties of the batter and cake

Sample	Weight of batter (g)	pH of batter	Height of cake (cm)	Weight of cake (g)
BCNA	834.30±0.01^{f}	7.44 ±0.06^{a}	9.41 ±0.02^{a}	793.60±0.14^{c}
BCNB	900.25 ±0.07^{a}	7.25±0.07^{c}	9.40 ±0.00^{a}	865.69 ±0.03^{a}
BCNC	891.55 ±0.07^{b}	7.40 ±0.00^{a}	8.12±0.03^{b}	829.76 ±0.01^{b}
BCND	850.26 ±0.07^{e}	7.25±0.07^{c}	7.50 ±0.14^{c}	777.50±0.14^{e}
BCNE	870.70 ±0.07^{c}	7.33 ±0.04^{b}	6.70 ±0.14^{d}	787.19 ±0.01^{d}
BCNF	444.04±0.01^{g}	7.30 ±0.00^{b}	3.30±0.14^{f}	348.60 ±0.05^{g}
BCNG	853.94 ±0.01^{d}	7.32±0.03^{bc}	5.60 ±0.00^{e}	759.34 ±0.01^{f}

Values are mean of triplicate determinations ± SD. Mean with different superscripts in the same column were significantly different ($p \leq 0.05$)

BCNA = Batter/cake made from 100% wheat flour and 100% fat (control); BCNB = Batter/Cake made from ratio 90:10 flour blend (90% wheat flour: 10% OFSP & 90%fat: 10%avocado puree); BCNC = Batter/cake made from ratio 80:20 flour blend (80% wheat flour: 20% OFSP & 80%fat: 20%avocado puree) BCND = Batter/cake made from ratio 70:30 flour blend (70% wheat flour: 30% OFSP & 70%fat: 30%avocado puree); BCNE = Batter/cake made from ratio 60:40 flour blend (60% wheat flour: 40% OFSP & 60%fat: 40%avocado puree); BCNF = Batter/cake made from 100% wheat flour & 100% avocado puree; BCNG = Batter/cake made from 100% OFSP & 100% fat

The weight of the cakes was positively correlated with that of the batter. However, a weight reduction was noticed in the final weight of the cake. This weight reduction was attributed to the loss of moisture during baking and the reduction in bulk density of the flour due to the incorporation of air during the mixing of the batter which is in agreement with the report of Denardin *et al.* (2012). A similar observation is also reported by Hu *et al.* (2004) who recorded a loss in weight due to baking. However, Pe'rez and Bertoft (2010) attributed the reduction in the weight of cake to a factor of the composition of the shortening agent, as well as the sublimation of fats during the baking process. Generally, except for BCNF, there were minimal variations ($p \leq 0.05$) in the physical properties of the entire cake products, which corroborates the observation of Nurul-Ain *et al.* (2016) in the physical properties of muffins using avocado puree as a fat replacer.

Colour evaluation of the cakes

The result of the colour evaluation of the cakes as shown in Table 5, is a quality indicator commonly associated with the aroma, taste, and appearance of a baked product as perceived by consumers on their first approach. A significant difference ($p<0.05$) exists between the colour parameters (the L* a* b*, and C*) of the cake samples. The lightness L* values of the cakes decreased with the level of substitution of OFSP flour in the formulations, as evident from samples CNA, CNB, CNC, CND, and also sample CNG, which had the highest level of OFSP and a corresponding lower lightness value (51.03) compared to samples CNE and CNA, both of which contain 100% wheat flour. This effect was also reported by Srichuwong *et al.* (2005), where the crust lightness decreased with a corresponding increase in the substitution of OFSP with wheat flour and avocado fat.

Table 5. Colour characteristics of the cakes

Sample	*L**	*a**	*b**	*C**	*h**
CNA	65.67±0.02[a]	8.66±0.02[e]	21.21±0.67[f]	22.91±0.05[e]	67.79±0.11[b]
CNB	62.17±0.16[b]	8.58±0.04[e]	23.40±0.06[e]	24.92±0.06[d]	69.86±0.05[a]
CNC	60.63±0.08[bc]	14.13±0.01[b]	29.73±0.05[b]	32.91±0.04[b]	64.58±0.03[d]
CND	61.88±0.12[bc]	11.14±0.02[d]	26.89±0.04[c]	29.11±0.03[c]	67.50±0.20[b]
CNE	58.71±0.24[c]	13.94±0.01[c]	32.20±0.02[a]	35.08±0.03[a]	66.60±0.10[bc]
CNF	66.07±0.10[a]	9.49±0.05[f]	21.20±0.10[f]	23.22±0.06[e]	65.89±0.20[c]
CNG	51.03± 0.10[d]	15.23±0.02[a]	25.21±0.04[d]	29.45±0.03[c]	58.83±0.14[e]

Values are mean of triplicate determinations ± SD. Mean with different superscripts in the same column were significantly different ($p \leq 0.05$)

CNA = Cake made from 100% wheat flour and 100% fat (control); CNB = Cake made from ratio 90:10 flour blend (90% wheat flour: 10% OFSP & 90%fat: 10%avocado puree); CNC = Cake made from ratio 80:20 flour blend (80% wheat flour: 20% OFSP & 80%fat: 20%avocado puree); CND = Cake made from ratio 70:30 flour blend (70% wheat flour: 30% OFSP & 70%fat: 30%avocado puree); CNE = Cake made from ratio 60:40 flour blend (60% wheat flour: 40% OFSP & 60%fat: 40%avocado puree); CNF = Cake made from 100% wheat flour & 100% avocado puree; CNG = Cake made from 100% OFSP & 100% fat

*L** -is lightness or whiteness; *a** -is degree of the red – green colour with a positive 'a' value indicating a redder shade and a negative value indicating green; *b**-value indicates the degree of the yellow – blue colour, with a positive b* value indicating more yellow and a higher negative b indicating blue; *C** (Chroma) - is the vividness or dullness of a colour; h* value- is hue angle

The a* parameter indicates redness with a negative value pointing toward the green shade. Cake samples were significantly different with a* values ranging between 8.58 and 15.23. Thus, sample CNA, CNB and CNF with a* values of 8.66, 8.58 and 9.49 respectively, had a less red shade when compared with sample CNG with the highest a* value (15.23). This increasing shade of red can be attributed to increasing levels of OFSP and avocado puree in the cakes as evident in sample CNF. The b* colour parameter is an indicator of the degree of yellowness. It ranged between 21.20 and 32.20 and sample CNE had the highest yellow shade with a b* value of 32.20, and CNF had the lesser shade of yellow (21.20) together with sample CNA with a b* value of (21.21). The increased b* value of sample CNE is directly associated with the high level of OFSP and avocado puree in the sample.

The Chroma (C*) indicates the colourfulness of an area and is judged as a proportion of brightness of a similarly illuminated area, the value ranges from 22.91 to 35.08. This, in turn, indicates that sample CNE has the darkest colour among the samples, since it has the highest Chroma, and sample CNA has the lightest colour, since it has the lowest Chroma (C*). The increased a*, b*, and C* values of these samples, in general, may be attributed to the caramelisation of the sugar, as well as Maillard reactions of wheat protein occurring during baking (Madhu, 2018; White, 2021). This was also reported to be associated with the high β-carotene and other pigments of OFSP flour and avocado puree by Hoover and Sosulski (1985) and Srichuwong *et al.* (2005). The reduction in L* may be linked to colour degradation (darkening) in line with the report of Hoover *et al.* (2010).

Sensory evaluation of the cakes

The sensory evaluation results of the cakes, showing significant differences ($p \leq 0.05$) across the attributes of the samples, are presented in Table 6. The crust likeness scores of the cakes ranged between 6.2 and 7.97 (liked slightly to like very much) based on a 9-point hedonic scale. The cake sample with 100% wheat flour and fat (CNA) had the highest crust likeness (7.97) compared to the samples with OFSP and avocado purees. While the crumb of baked foods influences eating quality and consumer acceptability, crumb mean scores varied greatly from 5.93 to 8.00 (like slightly to like very much). The mean score of the cake crumbs decreased as the fat was gradually substituted with avocado and wheat flour with orange fleshed sweet potato; reaching a minimum when fat was completely replaced with avocado puree (CNF) with a mean average score of 5.93.

Table 6. Sensory properties of cakes

Sample	Crust	Crumb	Taste	Texture	Overall acceptability
CNA	7.97^{a}	8.00^{a}	7.97^{ab}	8.00^{a}	8.10^{ab}
CNB	7.70^{b}	8.00^{a}	8.13^{a}	8.20^{a}	8.40^{a}
CNC	6.80^{cd}	6.77^{b}	6.87^{c}	7.00^{b}	6.83^{de}
CND	7.30^{abc}	7.17^{b}	7.43^{bc}	7.23^{b}	7.53^{bc}
CNE	6.57^{cd}	6.73^{b}	6.93^{c}	6.80^{b}	6.53^{e}
CNF	6.20^{d}	5.93^{c}	5.00^{d}	5.90^{c}	5.47^{f}
CNG	7.07^{bc}	7.20^{b}	7.06^{c}	7.17^{b}	7.40^{cd}

Mean with different superscripts in the same column were significantly different ($p \leq 0.05$)

CNA = Cake made from 100% wheat flour and 100% fat (control); CNB = Cake made from a ratio 90:10 flour blend (90% wheat flour: 10% OFSP & 90%fat: 10%avocado puree); CNC = Cake made from a ratio of 80:20 flour blend (80% wheat flour: 20% OFSP & 80%fat: 20%avocado puree); CND = Cake made from a ratio 70:30 flour blend (70% wheat flour: 30% OFSP & 70%fat: 30%avocado puree); CNE = Cake made from a ratio of 60:40 flour blend (60% wheat flour: 40% OFSP & 60%fat: 40%avocado puree); CNF = Cake made from 100% wheat flour & 100% avocado puree; CNG = Cake made from 100% OFSP & 100% fat

In terms of taste likeness, the average score ranged between 5.00 and 8.13. Generally, the cakes' taste scores were reduced, starting with the substitution of 20% wheat flour and fat with OFSP and avocado puree, respectively, with the highest reduction at a 40% substitution level (CNE). However, at a substitution level of 10% (CNB), the average mean score for taste (8.13) of the cake was significantly ($p \leq 0.05$) higher than that of other cakes, including the control sample (TCNA), which had the taste value of (7.97).

The texture of a food product is used to describe the chewiness, hardness, and gumminess of the product. The wheat flour substituted with 10% sweet potato flour (CNB) had the highest texture preference with a mean average score of (8.20), compared to (8.00) in sample CNA (100% wheat flour and fat). However, the subsequent increase in the substitution of wheat flour and fat led to a decrease in texture likeness such that the lowest score was recorded when fat was completely replaced with avocado puree, having a mean average score of (5.90). It can, therefore, be inferred that the reduced likeness of the texture of the cakes may be a result of the increased replacement of fat with avocado puree, in comparison with the cases when only fat or a high percentage of fat is used, since fat also impacts the texture of baked food products. This result correlates with the crumb results where increased substitution of fat with avocado puree reduced the average mean score of the cakes' crumbs.

The results of the overall acceptability during sensory evaluation revealed that cake produced from a ratio of 90:10 wheat-OFSP composite, 90:10 fat, and avocado puree (CNB) was the most preferred of the cake samples, with a significantly higher score (8.40) than even the control sample. However, the control sample had a higher mean score (8.10) compared to other cake samples, with more than 10% OFSP flour and avocado. The results from this sensory evaluation are similar to the work of Lee-Hoon *et al.* (2017) in the substitution of wheat flour at a 20% level for sponge cake production. According to Noor-Aziah *et al.* (2011), overall acceptability is one of the most important attributes of product preference, because it is associated with the textural and sensorial properties of the food. Thus, the present results suggest that wheat flour could be supplemented with OFSP flour and avocado puree in the production of cakes and possibly other baked products, and still produce the desirable organoleptic properties when incorporated into formulation blends.

Conclusions

The study revealed that substituting wheat and fat with orange-fleshed sweet potato (OFSP) and avocado puree, respectively, resulted in the production of cakes with a nutritional quality and consumer acceptance comparable to that of conventional cakes. The CNB (cake made from 90% wheat flour: 10% orange-fleshed sweet potato flour; and 90% fat: 10% avocado puree) had the superior mean score average in colour evaluation, physical properties, and preferential acceptability compared to the control sample (CNA). Thus, sample TNB formulation is the preferred choice for the production of quality cakes with potential health benefits. This will add value to avocado fruits and orange-fleshed sweet potatoes; the total dependence on the importation of wheat could also be reduced to improve the nation's economy by the act of compositing wheat flour with orange-fleshed sweet potato (OFSP) flour. However, the suitability of OFSP and avocado puree should be further studied in the production of other baked products to maximise the derived benefits from their utilisation.

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