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Nutritional, Physical and Sensory Quality Evaluation of Sponge Cake Prepared by Substitution of Wheat Flour by Sweet Potato (*Ipomoea* spp.) Flours

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Abstract: This study aimsto determine physicaland chemical properties of VitAto potato flour (VitAto), orange-fleshed sweet potatoflour (OFSP) and purple-fleshed sweet potato flour (PFSP). VitAto, OFSP and PFSPwere substitutedfor wheat flour at 20% level for sponge cake production; VFSC, OSPSC and PSPSC, respectively. Sponge cake without sweet potatoes flour served as control (WSPSC). The physicochemical properties and sensory attributes of prepared sponge cakes were determined. The proximate composition indicates that VitAto contained highest protein (4.59%) while PFSP had the highest ash (1.67%) and crude fiber (2.73%) content. OFSP had higher water activity and pH than VitAto and PFSP. PFSP flour presentedhighest bulk density and lower lightness, red and yellow values than VitAto and OPSP. Composite sponge cakes; VFSC or PSPSC showed higher crude fiber than WSPSC sponge cake. Composite sponge cakes indicated dark crumb colour, low cake volume and high hardness values. Sensory evaluation indicated that the all sponge cakes containing sweet potato flours were acceptable by the consumers.Sweet potatoes have potential to be processed into flour and partially replaced for wheat flour in sponge cakes preparation to improve the nutritional quality.

Key words: VitAto · Orange-fleshed Sweet Potato · Purple-fleshed Sweet Potato · Nutritional Quality · Physicochemical Properties · Sensory Evaluation

INTRODUCTION

Sweet potato (*Ipomoea batatas*) is a perennial crop which serves as one of the major sources of food for human. Sweet potato has a significant contribution as energy supplement and phytochemical source of nutrition. It is widely cultivated in the tropics, subtropics and even in some temperate zones of the developing world [1]. According to Hanim *et al.* [2], sweet potato is one of the major tuber crops which produce over 135 hundred million metric tons of edible food products in the world annually. In developing countries, it ranks third in value of production and fifth in caloric contribution to the human diet [3]. In Malaysia, the production of sweet potato ranks second among the tuber crops next to cassava [2].

Contribution of sweet potato towards health is acknowledged due to high nutrient content and its anti-carcinogenic and cardiovascular disease prevention properties [4]. Sweet potatoes have goodquality nutrient, which are important in meeting human nutritional needs including carbohydrates, vitamins (*i.e.*, A, C, B_2, B_6 and E), trace elements (*i.e.*, iron, potassium, copper and manganese) dietary fibers, protein and low in fat and cholesterol [5, 6].

There are three major cultivars of sweet potatoes available for commercial production in Malaysia, includes: VitAto, an orange/copper skin with cream colour flesh; orange-fleshed sweet potato, an orange/copper skin with orange colour flesh; and purple-fleshed sweet potato, red/purple skin with cream/white flesh [7]. However, raw sweet potatoes have limited uses because it ishighly

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perishable nature.Thus, processing the sweet potato into flour increases its shelf-life and can be stored for a long period of time [8] and easier to be handled during transportation.

According to Kim *et al.* [9], all bakery products made from refined wheat flour is nutritionally poor whereby it lacks of dietary fiber, phytonutrient and natural bioactive compounds. In Malaysia, sweet potatoes are commonly used in traditional dishes and eaten in many ways, either boiled, baked or fried. In order to increase the usage of sweet potatoes, it can be transformed into flour and partially replace for wheat flour in making of other food product (*i.e.* bakery products). The produced flour also can serve as an alternative market outlet for farmers selling the raw sweet potatoes. Sweet potato has natural sweet taste, colour and flavour [10]. Several studies have shown that sweet potato flour can be used to process food products such as noodles, sweets, beverages and healthy bakery products [11-13].

Every cultivar of sweet potatoes and different region of plantation carries different physical properties and nutritional compositions. No research data have been found for sweet potatoes planted on BRIS (Beach Ridges Interspersed with Swales)soil in Besut, Terengganu. Thus, the objectives of undertaking the present study is to evaluate nutritional quality and physicalproperties of different sweet potatoes cultivars (*i.e.* VitAto, orange-fleshedsweet potato and purple-fleshedsweet potatoes) planted in Besut, Terengganu, which the area of plantation are in BRIS area. In addition, the processed sweet potatoes flour was incorporated into wheat flour at 20% level for sponge cakes making. The physicochemical and sensory attributes of sponge cakes containing with or without sweet potatoes flour were also reported in this work.

MATERIALS AND METHODS

Materials

Sweet Potatoes: Three cultivars of sweet potatoes; VitAto, orange-fleshed sweet potato and purple-fleshed sweet potatoes were procured from a local farmer located at Besut, Terengganu to produce VitAto potato flour (VitAto), orange-fleshed sweet potato flour (OFSP) and purple-fleshed sweet potato flour (PFSP). Good quality of sweet potatoes without apparent physical damages such as bruises and holes were used in this study. All chemicals used were of analytical grade.

Methods

Flour Production: The received sweet potatoeswere inspected to remove sweet potato with any apparent physical damage such as flaccid surface or holes. It was then cleaned by rinsing under running tap water. The skin of sweet potatoes was peeled manually using cleaned knife. Then, the sweet potatoes were sliced using semi-automated slicer (Santos, Lyon, France) to produce thin and uniform (thickness ~2.5mm, diameter ~ 5cm) sweet potatoes slices. The slices were immediately rinsed in distilled water for approximately 1 min. to remove loose starch that might be adhering to the surface [14]. The slices were immersed in 0.2% sodium metabisulphite solution for 15 min. to inhibit enzymatic activity. Next, the slices were dried in Laboratory Dryers FDD-720 (Tech-Lab, Selangor, Malaysia) at 50°C for overnight to reduce the moisture content to approximately 10%. The dried sweet potato slices were groundand then strained by using 20-mesh number strainer to produce flour.

Processing of Sponge Cakes: Sponge cakes were prepared according to the egg foaming method. Four types of sponge cakes were made namely, sponge cake made from 100% wheat flour served as a control (WSPSC), three sponge cakes were made from composite flour; a combination of wheat flour and sweet potato flour (VitAto, OFSP and PFSP) by partially replacing of sweet potato flours for wheat flour at 20% level to make VFSC, OSPSC and PSPSC, respectively. The selection of the level of composite flour substitution was based on our preliminary sensory evaluation results. The ingredients used for sponge cakes making were self-rising flour, VitAto or OFSP or PFSP, egg, milk, castor sugar and vanilla essence. The formulation of sponge cakes making is shown in Table 1. The eggs and sugar were whipped to a thick foam batter using a hand mixer (Philips HR1456/70, Toa Payoh, Singapore). The liquid ingredients (*i.e.*, milk and vanilla essence) were then added. The dry ingredients such as pre-sifted flours were then folded gently into the batter for 3 to 4 strokes. The batter was then poured to the round cake pans (8 × 12 inch) and baked in an oven at 180°C for 30 min. The sponge cake was cooled in room temperature for an hr. prior analysis.

Proximate Composition Analyses: The samples were analysed for proximate composition (*i.e.* moisture, ash, crude fat, crude protein and crude fiber by employing A.O.A.C. method [15]. The oven drying method

Table 1: Formulation of sponge cakes preparation

Ingredients	WSPSC[iv]	VFSC[v]	OSPSC[vi]	PSPSC[vii]
Self-rising flour (g)	90	72	72	72
VitAto[i] (g)	-	18	-	-
OFSP[ii] (g)	-	-	18	-
PFSP[iii] (g)	-	-	-	18
Egg (grade A, unit)	3	3	3	3
Milk (mL)	25	25	25	25
Castor Sugar (g)	100	100	100	100
Vanilla Essence (tbsp)	1/2	1/2	1/2	1/2

[i]VitAto represents VitAto flour

[ii]OFSP represents orange-fleshed sweet potato flour

[iii]PFSP represents purple-fleshed sweet potato flour

[iv]WSPSC represents sponge cake without sweet potato flour (control)

[v]VFSC represents VitAto flour containing sponge cake

[vi]OSPSC represents orange sweet potato flour containing sponge cake

[vii]PSPSC represents purple sweet potato flour containing sponge cake

(A.O.A.C. Method 977.11), dry ashing method (A.O.A.C. Method 923.03), Soxhlet method (A.O.A.C. Method 960.39), Kjeldahl's method (A.O.A.C. Method 955.04) and gravimetric method (A.O.A.C. Method 991.43) were referred to quantify moisture, ash, crude fat, crude protein and crude fiber contents, respectively.

Calculation of Carbohydrate: Carbohydrate was calculated by subtracting the sum of the moisture, crude protein, crude fat and ash from 100% [16].

Calculation of Energy: Energy was calculated as the total of multiplied weights (grams) of crude protein, carbohydrate and crude fat with factors of 4, 4 and 9, respectively [17].

Water Activity Determination: The water activity of the sample was determined using a_w meter (Aqualab Water Activity Meter, model 4TE). Approximately 2 g of flour sample was evenly spread into plastic cells and the reading was then recorded when the equilibration was achieved.

pH Determination: The pH of the flour was determined using the method as described by Sanni *et al.* [18] withminor modification. Approximately 10 g of flour sample wasadded to 50 mL of distilled water and allowed to stand for 30 min with constant stirring. The mixture was then filtered for analyses. The pH was determined using pH meter. The electrode was dipped in the pH 7 and pH 4 buffer solutions for calibration purpose prior analysis.

Bulk Density Determination: Bulk density of the flour sample was measured according to the method of Adeleke and Odedeji [19] with minor modification. The flour sample (approximately 5 g) was weighed into a pre-tared 10 mLgraduated cylinder. The bottom of the measuring cylinder was gently tapped on a laboratory bench for several times until there was no further diminution of the sample level. The volume of sample was recorded. The bulk density was expressed as mass of sample (g) per volume of sample (cm^3) (g/cm^3).

Colour Analysis: The colour of the samples were determined using a Chroma Meter CR-400/410 (Konica Minolta, Tokyo, Japan) according to the Commission Internationale de I 'Eclairage (CIE) $L^*a^*b^*$ scale. L^* represents the degree of lightness (100°=white and 0°=black), chroma a^* indicates the green/red value (-value=greenness, +value=redness) and chroma b^* denotes the blue/yellow (-value=blueness, +value=yellowness). The Chromameter was calibrated prior analysis using Konica Minolta white calibration tiles provided with the instrument.

Measurement of Weight, Height, Volume, Specific Volume and Density: The sponge cake was weighed after cooling at room temperature for an hr. using weighing balance and the reading (g) was recorded. The height (cm) of sponge cake was measured using ruler. Three measurements were taken from different sides of sponge cakes. The average of the three points was recorded.

The volume (cm^3) of sponge cake was determined using rapeseed displacement method as described in the AACC method 10-05.01 [20]. The seeds were poured into an empty container to measure its volume. The rapeseeds in the container then measured in a measuring cylinder and marked as A. Subsequently, the sponge cake was placed into a same container and rapeseeds were poured in until the cake was covered. The rapeseeds were again measured in a measuring cylinder and marked as B. The volume of the sponge cake was calculated by subtracting the value of A to B. The specific volume (cm^3/g) of the sponge cake was calculated by dividing the value of sample volume (cm^3) with the value of sample weight (g). The density (g/cm^3) of the sample was calculated by dividing weight (g) of sample with volume (cm^3).

Texture Profile Analysis (TPA): The texture profiles (hardness, gumminess and chewiness) of the sponge cakes were carried out using a texture analyser TA-XT2 (Model TAHDI, Stable Microsystem, Surrey, UK) as described by the standard method of AACC, Method

74-09 [20]. The sponge cake was cut into a cube size 2.5cm × 2.5cm × 2.5cm from the middle of the cake using bread knife. The cut sample was placed centrally beneath the P/36R cylinder probe (36.0mm) to meet with a consistent flat surface at all the time. The compression test was selected in the texture analysis with using 5kg load cell and the sample was compressed to 25% of its original height with duration of 30s of evaluation. The data was analysed using Texture Expert Version 1.05 Software (Stable Micro System Ltd, Surrey, UK.).

Sensory Evaluation: Sensory evaluation was carried out for the sponge cakes. The sensory evaluation of the sponge cake was performed by 30 semi-trained panellists consisting of students and staffs from the Department of Food Industry, Faculty of Bioresources and Food Industry, Universiti Sultan Zainal Abidin, Malaysia. The Sensory was evaluated in a sensory laboratory under fluorescent light and ambient temperature (26±1°C). A 7-point hedonic scale was referred to determine sensory acceptability by panellists [21]. The sponge cakes were cut into cubes of 2.5cm × 2.5cm × 2.5cm using clean bread knife. The coded sponge cakes were then placed on to the paper plate labelled with different 3-digit numerical codes. Each sample was presented to the panellists in the randomized order so that each sponge cake sample appears in a particular position an equal number of times. Each panellist was received a plate of labelled sponge cake samples, a cup of drinking water (300mL) and a sheet of sensory form. The panellists were asked to rate the sponge cakes on the scale for each attribute (colour, aroma, texture, flavour, gumminess and overall acceptability). Where; 1 indicates dislike very much to 7 indicates like very much [22].

Statistical Analysis: Statistical analysis was performed using Statistical Package for the Social Science (SPSS) 20.0 software (SPSS Inc., Chicago, IL, USA). All the results presented in the present study are represented as mean values of three individual replicates±standard deviation (n=3±s.d.). One-way analysis of variance (ANOVA) and Duncan's multiple range test was used to determine the statistical significance at level of $p<0.05$.

RESULTS AND DISCUSSION

Proximate Composition and Chemical Properties of Sweet Potato Flours: Table 2 shows the proximate composition of VitAto potato flour (VitAto), orange-fleshed sweet potato flour (OFSP) and purple-fleshed sweet potato flour (PFSP). The results indicated that there were no significant different ($p>0.05$) between VitAto and OFSP for moisture (9.50% and 9.69%, respectively) and ash content (1.35% and 1.36%, respectively). The PFSP had a significantly ($p<0.05$) lower content of moisture (8.83%) but higher ash content (1.67%) than VitAto and OFSP. The variation of moisture content amongst cultivars might be attributed to the difference in their genetic composition and agro climatic conditions [23]. According to James [24], the standard range of moisture content in flour ranged from 0 to 10%. The high moisture content is an indicator of low dry matter and lower storage quality in tubers. However, the moisture content of all produced sweet potatoes flours in the present study were found to be within the categories of standard range. Therefore, low moisture content of the sweet potatoes flours has a critical influence on the storage stability.

Table 2: Proximate composition and chemical properties of sweet potato flours

Composition (%)	VitAto[i]	OFSP[ii]	PFSP[iii]
Moisture	9.50^{b}±0. 06	9.69^{b}±0.09	8.83^{a}±0.48
Ash	1.35^{a}±0.35	1.36^{a}±0.2	1.67^{b}±0.03
Crude fat	0.78^{b}±0.04	0.82^{c}±0.01	0.62^{a}±0.01
Crude Protein	4.59^{c}±0.16	2.63^{b}±0.01	1.78^{a}±0.12
Crude Fiber	2.20^{a}±0.31	2.40^{a}±0.04	2.73^{b}±0.11
*Carbohydrate	81.58^{a}±0.34	82.95^{b}±0. 36	83.65^{b}±0. 47
*Energy (kcal/100g)	351.70^{a}±0.68	349.70^{a}±0.52	374.30^{b}±1.02
Water activity	0.50^{b}±0.00	0.52^{c}±0.00	0.45^{a}±0.00
pH	6.16^{a}±0.01	6.38^{c}±0.01	5.91^{a}±0.02

[i]VitAto represents VitAto flour

[ii]OFSP represents orange-fleshed sweet potato flour

[iii]PFSP represents purple-fleshed sweet potato flour

Presented data are mean values of three replications±standard deviation.

Mean values in the same row with different superscript letters are significantly different ($p<0.05$).

*Result obtained by calculation

The crude fat content of PFSP was found to be the lowest (0.62%) followed by VitAto (0.78%) and OFSP (0.78%), which indicated that PFSP has less susceptible to quick rancidity. The crude fat content of OFSP showed similar value as reported by Jangchud *et al.* [25] for Thailand orange-fleshed sweet potato flour which has 0.7%. However, the authorsreported that Thailand purple-fleshed sweet potato flour has 4% of crude fat, which shows seven times higher than that of the results obtained from the present study. Yadav*et al.* [26] reported that sweet potatoes from India have more than 1% crude fat content. This can be concluded that the sweet potatoes planted in Malaysia possess low in crude fat content.

Crude protein content of VitAto (4.59%) was higher than OFSP (2.63%) and PFSP (1.78%). The crude protein value of VitAto was also higher than the sweet potato from Thailand (1.9%) and Australia (3.15%) as reported by Jangchud *et al.* [25] and Aprianita *et al.* [27], respectively. The difference in the protein content can be attributed to the climatic conditions. Studies showed that the content of main nutrients in BRIS soil where the studied sweet potatoes were cultivated are low in nitrogen (N), phosphorus (P), potassium (K), magnesium (Mg) and calcium (Ca) [28]. According to Toriman *et al.* [28], low nutrients in BRIS soil is due to the sandy structure of the soil which causes rapid leaching of these nutrients. However, VitAto was able to accumulate slight protein/nitrogen (N) from BRIS soil. High protein content of flour is known as strong flour that can improve the overall structure of baked goods [29]. Thus, VitAto flour can be a suitable optionfor applying in bakery products.

Crude fiber content of PFSP (2.73%) was highest, followed by OFSP (2.40%) and VitAto (2.20%). According to Brennan and Samyue [30], high content of dietary fiber has an impact on food by reducing the rate of glucose breakdown and absorption, hence avoiding an excess of glucose in the human body and facilitating the steady breakdown of carbohydrates and release of glucose. This indicatesthat PFSPhas potential application as a source of fiber incorporated to bakery products to compensate the deficiency in dietary fibre in the daily diet.

The carbohydrate content of VitAto was found significantly ($p<0.05$) lower (81.58%) than that OFSP (82.95%) and PFSP (83.65 g/100g). However, there was no significant difference in energy content between VitAto (351.70 kcal/100g) and OFSP (349.70 kcal/100g), while PFSP had highest energy content (374.30 kcal/100g) among the three samples.

The water activity of PFSP (0.45) was found to be significantly ($p<0.05$) lower than the VitAto (0.50) and OFSP (0.52). Water activity affects microbial growth, shelf-life, texture, aroma and flavour, moisture migration, caking, clumping and colour of foods [31]. Flour generally has a low water activity level and as such keep much longer [32]. Therefore, the water activity results obtained in the present study indicated the growth of microorganisms and development of enzymatic activities in PFSP occurs slower than the VitAto and OFSP. According to Smith and Simpson [33], flour has value of water activity in ranging 0.50 to 0.87 is considered as intermediate water activity flour. Therefore, VitAto, OFSP and PFSP produced in the present study fell into the intermediate water activity flour range.

pH is an important property in starch industrial applications, being used generally to indicate the acidic or alkaline properties of liquid media. The pH values of all flours (VitAto, OFSP and PFSP) produced in the present study was 6.16, 6.38 and 5.91 respectively. The result shows that the pH of the OFSP was less acidic than the other cultivars of sweet potatoes (VitAto and PFSP). The result obtained in this study showed slightly higher pH (5.66-5.93) than the reported study by Hanim *et al.* [2]. This might be due to the geographical factors such as weather and soil condition as well as the difference in genetic of sweet potato cultivars which are affecting the pH value of the plant. According to Ihekeronye and Ngoddy [34], acidic products are more shelf stable that non acidic counterpart. Therefore, based on the results obtained from water activity and pH analyses, it can be concluded that PFSP is more shelf stable than VitAto and OFSP.

Colour Properties of Sweet Potato Flours: Figure (1) shows the colour (L^*, a^* and b^* values) of the VitAto, OFSP and PFSP. The results obtained from colour analysis showed that the PFSP flourwas statistically different from VitAto and OFSP for L^* (65.30, 79.67 and 80.74, respectively) and b^* (6.60, 25.86 and 25.93, respectively) values. The PFSP had a significantly ($p<0.05$) darker and less yellowish colour than the VitAto and OFSP. However, Hathorn *et al.* [35] classified values around 50 as dark, 60 as optimum and 70 as light in colour. Therefore, all the produced sweet potato flours with the exception of PFSP fell into the light colour range. The VitAto produced in the present study was shown to had more redness (a^* = 19.74) which differ significantly ($p<0.05$) with the OFSP (a^* = 17.66) and PFSP (a^* = 12.45). This indicates that VitAto presented a much more intensity of the red colour than the OFSP and PFSP. According to Maskan [36], drying processing resulted to the change of final product to pale yellow colour is due to the non-enzymatic reactions. The results obtained in the present study are in agreement with those reported by Hanim *et al.* [2], who reported that the colour of VitAto to be L^*= 73.3, a^* = 15.0 and b^* = 29.9, while the variety of Okinawan sweet potato flour has L^*= 61.6, a^* = 13.6 and b^* = 12.6.

Bulk density is generally affected by the particle size and density of the flour. It is very important in determining the packaging requirement, material handling and application in wet processing in the food industry [37]. Figure (2) depicts bulk density of VitAto, OFSP and

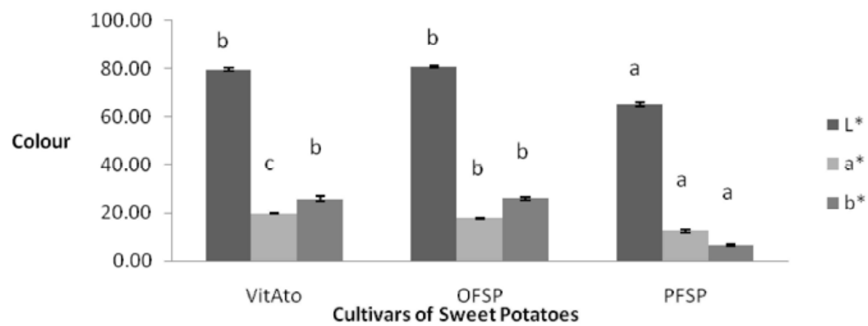

Fig. 1: The colour (L^*, a^*, b^*) reading for sweet potato flours
VitAto represents VitAto flour
OFSP represents orange-fleshed sweet potato flour
PFSP represents purple-fleshed sweet potato flour
Values with different superscripts within same parameter are statistically significant from each other ($p< 0.05$)
Presented data are mean value of three replications±standard deviation (error bars)

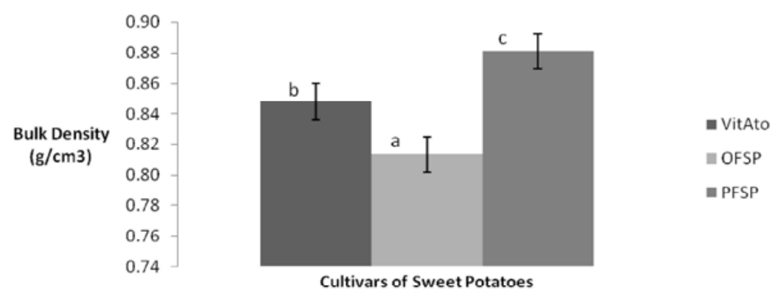

Fig. 2: The bulk density of sweet potato flours
VitAto represents VitAto flour
OFSP represents orange-fleshed sweet potato flour
PFSP represents purple-fleshed sweet potato flour
Values with different superscripts are statistically significant from each other ($p< 0.05$)
Presented data are mean value of three replications±standard deviation (error bars)

PFSP. The bulk density measurement results indicated that PFSP (0.88 g/cm^3) had significantly ($p<0.05$) higher bulk density than VitAto (0.85 g/ cm^3) and OFSP (0.81 g/cm^3).

Proximate Composition of Sponge Cakes: The results of the proximate analyses performed on the sponge cake samples are presented in Table 3. The substitution of 20% OFSP and PFSP for self-rising flour in sponge cake caused a decrease in the moisture content. According to Julianti *et al.* [38], moistness is a favourable sensory attribute in bakery products due to it reflects to soft and tender crumb. However, excess moisture content might accelerate food spoilage due to microbial growth. Therefore, this result indicated that sponge cakes with 20% OFSP (OSPSC) or PFSP (PSPSC) was more shelf stable than sponge cake without composite flour (WSPSC) or sponge cake with 20% VitAto (VFSC). The result of the moisture contained in OSPSC and PSPSC is in agreement with the previous work done by Noor Aziah *et al.* [39] and Lee [40] where sponge cakes incorporated with mango pulp and peel flours at 10% level and pine leaf powder to contain 34.77% and 28.49-36.59% of moisture content, respectively.

The ash and crude fat composition in the OSPSC sponge cakes were shown to be significantly higher than in the WSPSC. The higher fat content in the OSPSC was contributed by the orange-fleshed sweet potato flour where it contains higher ash (1.36%) and crude fat (0.82%) content (Table 2) than wheat flour (0.56% and 0.25%, respectively) [41]. The present study is in accordance with that published by Okorie and Onyeneke [42], who reported that cakes made from sweet potato flour has higher crude fat and ash content than 100% wheat cake.

Table 3: Proximate composition of sponge cakes

Composition (%)	WSPSC[i]	VFSC[ii]	OSPSC[iii]	PSPSC[iv]
Moisture	38.20^{b}±0.28	38.20^{b}±0.61	35.49^{a}±0.71	34.95^{a}±0.14
Ash	1.31^{a}±0.65	1.76^{ab}±0.04	2.03^{b}±0.04	1.80^{ab}±0.03
Crude fat	6.41^{a}±0.17	6.59^{ab}±0.39	6.86^{b}±0.03	6.67^{ab}±0.08
Crude Protein	13.30^{b}±0.15	13.31^{b}±0.47	12.84^{ab}±0.06	12.73^{a}±0.02
Crude Fiber	0.31^{a}±0.01	0.57^{b}±0.05	0.43^{ab}±0.06	0.49^{b}±0.11
*Carbohydrate	40.77^{a}±0.96	40.13^{a}±0.69	42.78^{b}±0.72	43.85^{b}±0.20
*Energy (kcal/100g)	284.05^{a}±2.61	282.62^{a}±5.69	288.37^{ab}±3.14	291.91^{b}±1.37

[i]WSPSC represents sponge cake without sweet potato flour (control)
[ii]VFSC represents VitAto flour containing sponge cake
[iii]OSPSC represents orange-fleshed sweet potato flour containing sponge cake
[iv]PSPSC represents purple-fleshed sweet potato flour containing sponge cake
Presented data are mean values of three replications±standard deviation.
Mean values in the same row with different superscript letters are significantly different (p<0.05).
*Result obtained by calculation

Table 4: Colour properties of sponge cakes

Parameter	WSPSC[i]	VFSC[ii]	OSPSC[iii]	PSPSC[iv]
Crust				
L*	44.57^{b}±0.35	44.40^{b}±1.40	44.69^{b}±0.19	42.10^{a}±0.53
a*	8.83^{b}±0.24	8.30^{a}±0.21	8.42^{a}±0.12	8.45^{a}±0.04
b*	19.80^{a}±0.47	19.29^{a}±0.85	18.83^{a}±1.36	18.09^{a}±0.47
Crumb				
L*	65.05^{c}±0.34	53.18^{b} ±1.25	52.27^{b}± 1.60	41.47^{a}±0.81
a*	-7.46^{a}±0.06	-4.56^{b}±0.34	-1.79^{c}±0.29	-1.02^{d}±0.06
b*	21.23^{b}±1.12	23.41^{c}±0.52	23.52^{c}±0.99	13.77^{a}±0.17

[i]WSPSC represents sponge cake without sweet potato flour (control)
[ii]VFSC represents VitAto flour containing sponge cake
[iii]OSPSC represents orange-fleshed sweet potato flour containing sponge cake
[iv]PSPSC represents purple-fleshed sweet potato flour containing sponge cake
Presented data are mean values of three replications±standard deviation.
Mean values in the same row with different superscript letters are significantly different (p<0.05).

According to Matsakidou *et al.* [43], increase the fat content in sponge cake making will imparts moistness and enhances mouthfeel of the baked product.

The replacement of self-rising flour with PFSP at the 20% level significantly (p<0.05) decreased the crude protein (12.73%) content. This was attributed to the PFSP had the lowest protein content among the three cultivars of sweet potato (Table 2). In addition, replacement of self-rising with PFSP at 20% level resulted in dilution of protein content occurs[44]. The crude fiber content of VFSC (0.57%) and PSPSC (0.49%) sponge cakes were significantly higher than WSPSC (0.31%). This result may be associated with the presence of greater fibre content in the VitAto (2.20%) and PSPF (2.73%) (Table 2) than in wheat flour (0.63%) [39].

With regard to the carbohydrate content of the sponge cakes containing OFSP or PFSP (42.78 and 43.85g/100g for OSPSC and PSPSC, respectively), the values were significantly (p<0.05) higher than WSPSC and VFSC (40.77 and 40.13g/100g, respectively). The higher carbohydrate content in sponge cakes containing OFSP (OSPSC) and PFSP (PSPSC) compared with WSPSC and VFSC may be attributed to the OFSP and PFSP had significantly higher carbohydrate content than VitAto (Table 2) and self-rising flour (72.30%) [39]. According to Hoover [45], starch (60% amylopectin and 40% amylose) is the major carbohydrate components in sweet potato. The high level of carbohydrate is desirable in baked products due to starch granules swells with the presence of water upon heating. This may lead subsequently to a formation of gel which is important for the texture and structure development of baked goods [42]. The PSPSC was found to be significantly (p<0.05) higher in calorie value (291.91 kcal/100g) than WSPSC (284.05kcal/100g) and VFSC (282.62kcal/100g).

Colour Properties of Sponge Cakes: The results on the colour (*L**, *a** and *b** values) of sponge cakes are presented in Table 4. The colour analysis results indicated that the PSPSC was statistically different from WSPSC, VFSC and OSPSC for crust colours. The PFSP-containing sponge cake had a significantly (p<0.05) darker (lower *L**

value; 42.10) crust than the WSPSC (44.57), VFSC (44.40) and OSPSC (44.69). The crust of the sponge cake containing PFSP changed from white to brown (lower *L** value). Crust colour is depends on the physicochemical properties of reducing sugars and amino acid contained in batter and the operating conditions applied during baking [46]. According to Hanee [47], starches (*i.e.*, amylose and amylopectin) have shown to affect the quality of cake. Starch gelatinization during baking contributes to the crust colour formation of bakery products such as cake and biscuits. At temperature above 180°C, the starch begins to gelatinize and converted into dextrin and undergoes caramelization.

The *a** value for the crust of the sponge cakes containing composite flour; VFSC, OSPSC and PSPSC (8.30, 8.24 and 8.45, respectively) were positive, which indicates that red hues were present in the crust, which was significantly ($p<0.05$) different from the WSPSC (8.83) (Table 4). The crust of VFSC and OSPSC were found to be not significant difference in *L** *a** and *b** values. This indicates that VFSC and OSPSC have similar lightness, red and yellow colour. This was attributed to the presence of beta-carotene (red-orange pigment) in both the VitAto and orange-flesh sweet potato[48].

As shown in Table 4, crumb colour of sponge cake was significantly affected by replacement of self-rising flour with sweet potato flour (VitAto, OFSP and PFSP). The substitution of PFSP for self-rising flour (PSPSC) resulted a significant lowest in *L** value (41.47) then followed by OSPSC (52.27) < VFSC (53.18), WSPSC (65.05). This indicates that PSPSC had darker crumb colour than the other sponge cakes. The crumb colour is not affected by the temperature. According to Ho *et al.* [44], crumb colour of the baked products is often influenced by the ingredients or raw materials used in the formulation because the temperature reached the crumb is not as high of a temperature as the crust. Thus, the temperature is not sufficient to cause Maillard or caramelization reactions. The statement is in agreement with the results presented in Figure (1) where PFSP showed darker colour (lowest *L** value) than VitAto and OFSP.

Table 4 presents the significantly different in crumb greenness value (-*a**) of the various sponge cake formulations. The replacement of sweet potato flours for self-rising flour resulted in significantly ($p<0.05$) lower *b** values (-1.02 to -4.56) of the sponge cake crumb (VFSC, OSPSC and PSPSC) than the WSPSC (-7.46). The sponge cake containing PFSP showed significant lower *L**, *a** and *b** values than the other sponge cakes in crumb. Therefore, PSPSC had notably darker, less greenish and yellowish than the other sponge cakes. This was attributed to the purple-fleshed sweet potato contains high anthocyanin pigments (red/purple pigment)[48]. This pigment affects the darker and dull colour of sponge cake (PSPSC).

Physical Properties and Texture Profile of Sponge Cakes: Table 5 presented the results for physical properties (weight, height, volume, specific volume and density) of sponge cake. There was a significant increase in the weight of sponge cakes prepared with OFSP (276.24g) and PFSP (273.11g) compared with control (WSPSC) (261.91g). However, itdid not affect the height of the composite cake (4.16, 4.40 and 4.26cm for VFSC, OSPSC and PSPSC, respectively).

The incorporation of sweet potato flours into sponge cake preparation significantly ($p<0.05$) decreased the volume of the composite sponge cakes (1075.00, 1051.66 and 1062.66 cm^3 for VFSC, OSPSC and PSPSC, respectively) compared with control (1195.00 cm^3). This could be counteracted by the dilution of gluten as 20% of self-rising flour was replaced with sweet potato flour (non-wheat flour). Gluten is vital to enhance the structural framework; rising in volume of the baked products [44]. According to Bojòanská *et al.* [49], low amount of gluten can cause reduction in gas retention capacity during baking, thereby reducing the volume of the baked product. The results obtained in the present study are on par with the observations of Masood *et al.* [50], who reported that cake incorporated with apple pomace had decreased the volume of cake. Study performed by Khalil *et al.* [51] showed that the increasing on the replacement level of sweet potato flour for cassava flour progressively reduced the quality of baked products.

The specific volume of the sponge cakes ranged from 3.80 to 4.57 cm^3/g. In this study, VFSC, OSPSC and PSPSC yielded reductions in the specific volumes from 3.80-4.08 cm^3/g. According to Gómez *et al.* [52], the specific volume indicates the amount of air that can remain in the final product where, higher gas retention of the product leads to a higher specific volume. This indicates that all sponge cakes containing sweet potato flours had lower gas retention than the control. As volume and specific volume decreased, the density value of the sponge cake increased (Table 5). Sponge cakes containing VitAto (0.24 g/cm^3), OFSP (0.26 g/cm^3) and PFSP (0.26 g/cm^3) showed significantly ($p<0.05$) denser than the WSPSC (0.22 g/cm^3). Results obtained in the present study are in agreement with Busarawan and Rungnaphar [53] who reported thatcake containing tapioca starch exhibited higher gas retention, thus, lower density which resulting in a higher specific volume.

Table 5: Physical properties and texture profile of sponge cakes

Parameter	WSPSC[i]	VFSC[ii]	OSPSC[iii]	PSPSC[iv]
Physical properties				
Weight (g)	261.91^{a}±8.39	263.40^{ab}±6.64	276.24^{bc}±0.45	273.11^{c}±2.53
Height (cm)	4.50^{a}±0.50	4.16^{a}±0.28	4.40^{a}±0.10	4.26^{a}±0.31
Volume (cm^3)	1195.00^{a}±5.00	1075.00^{b}±5.00	1051.66^{c}±2.89	1062.66^{d}±2.52
Specific volume (cm^3/g)	4.56^{c}±0.17	4.08^{b}±0.12	3.80^{a}±0.02	3.89^{ab}±0.04
Density (g/cm^3)	0.22^{a}±0.01	0.24^{b}±0.01	0.26^{c}±0.00	0.26^{c}±0.00
Texture profile				
Hardness (g)	58.22^{a}±2.84	125.53^{d}±10.38	72.80^{b}±2.29	86.21^{c}±4.16
Gumminess	48.49^{a}±1.62	108.86^{d}±6.37	63.31^{b}±4.15	72.18^{c}±1.15
Chewiness	46.14^{a}±0.70	103.32^{c}±6.09	60.85^{b}±5.52	68.44^{b}±1.21

[i]WSPSC represents sponge cake without sweet potato flour (control)
[ii]VFSC represents VitAto flour containing sponge cake
[iii]OSPSC represents orange-fleshed sweet potato flour containing sponge cake
[iv]PSPSC represents purple-fleshed sweet potato flour containing sponge cake
Presented data are mean values of three replications±standard deviation.
Mean values in the same row with different superscript letters are significantly different ($p<0.05$).

Table 6: Sensory evaluation of sponge cakes

Parameter	WSPSC[i]	VFSC[ii]	OSPSC[iii]	PSPSC[iv]
Colour	5.33^{b}±1.24	4.93^{b}±1.39	5.60^{b}±1.27	4.00^{a}±1.72
Aroma	4.86^{a}±1.27	5.00^{a}±1.33	5.06^{a} ±1.38	4.43^{a}±1.57
Texture	4.73^{a}±1.55	4.63^{a}±1.29	5.13^{a} ±1.19	4.70^{a}±1.48
Flavour	4.83^{a}±1.39	4.90^{a}±1.21	4.86^{a}±1.16	4.46^{a}±1.54
Gumminess	5.53^{d}±0.57	1.53^{a}±0.57	3.56^{c}±0.56	2.50^{b}±0.51
Overall acceptability	4.63^{ab}±1.32	4.86^{ab} ±1.31	5.10^{b}±1.09	4.26^{a}±1.48

[i]WSPSC represents sponge cake without sweet potato flour (control)
[ii]VFSC represents VitAto flour containing sponge cake
[iii]OSPSC represents orange-fleshed sweet potato flour containing sponge cake
[iv]PSPSC represents purple-fleshed sweet potato flour containing sponge cake
Presented data are mean values of three replications±standard deviation.
Mean values in the same row with different superscript letters are significantly different ($p<0.05$).

The texture profile (hardness, gumminess and chewiness) of sponge cakes is shown in Table 5. The replacement of sweet potato flours (VitAto, OFSP and PFSP) for self-rising flour at 20% in the composite sponge cakes resulted in the positive correlation in the parameters of hardness, gumminess and chewiness of crumb. The hardness of the sponge cake crumb was strongly affected by the sweet potato flour substitution. The maximum force (g) required to compress the sponge cake crumb prepared by incorporation sweet potato flour with self-rising flour (VFSC, OSPSC and PSPSC) at 20% level was found to be significant higher than the control (WSPSC). This indicates that VFSC (125.53g), OSPSC (72.80g) and PSPSC (86.21g) were firmed than the WSPSC (58.22g). According to Schiraldi and Fessas [54], crumb firmness is mainly attributed to the matrix of amylose and amylopectin present in the starch remnants which can cause recrystallization and influenced to overall crumb texture. In addition, the low value of density might lead to the increase of hardness value [55]. Therefore, this explains the texture of sponge cake to become more solid and harder with the substitution of sweet potato flour for wheat flour.

Partial substitution of sweet potato flours (VitAto, OFSP and PFSP) for self-rising flour at 20% level sponge cake resulting higher gumminess and chewiness values than the WSPSC which increases from 48.49 (WSPSC) to 108.86 (VFSC), 63.31 (OSPSC) and 72.18 (PSPSC) for gumminess. In addition, the chewiness value obtained in the present study showed an increasing trend from 46.14 (WSPSC) to 103.32 (VFSC), 60.85 (OSPSC) and 68.44 (PSPSC). Similar trends for the crumb gumminess and chewiness were reported by Noor Aziah *et al.* [39], who found that crumb chewiness and gumminess parameters increased as partial replacement of mango pulp and peel flours for self-rising flour in sponge cake making. Sponge cake containing sweet potato flour had higher gumminess and chewiness values than control was attributed to the presence of high starch content in sweet potato flour than in self-rising flour. Starch is gelatinized during baking and this gelling property might contribute to the gummy and chewytexture of crumb.

Sensory Evaluation of Sponge Cakes: The scores of sensory evaluation for colour, aroma, texture, flavour, gumminess and overall acceptability of sponge cakes are presented in Table 6. The substitution of purple-fleshed sweet potato flour at the 20% level was significantly ($p<0.05$) decrease the score for colour attribute (4.00) of the sponge cake as compared to the control (5.33). All sponge cakes colour were considered acceptable by panellists as their average scores for the colour attributes were 4.00 or greater than 4 (neither like nor dislike) (5.33, 4.93 and 5.60 for WSPSC, VFSC and OSPSC). This result may be attributed to the slightly darker crumb colour of PSPSC than WSPSC, VFSC and OSPSC), as mentioned earlier (Table 4). This indicates that consumers may prefer sponge cake with the incorporation of OFSP or PFSP, which would be light in colour. This result was similar to that obtained by Noor Aziah *et al.* [39] and Samia El-Safy [56], who reported that sponge cakes made from mango pulp and peel flours and cladode flour, respectively received lower score than control sponge cake for colour attribute

The replacement of composite flours (VitAto, OFSP and PFSP) at the 20% level for self-rising flour did not affect the aroma, texture and flavour scores during evaluation. This indicates that low specific volume of the sponge cake crumb (Table 5) did not influence the texture score (4.63-5.13) during consumption.

There were significant ($p<0.05$) differences found among the sponge cakes with or without sweet potato flour in crumb gumminess. Sponge cake containing VitAto (VFSC) showed lower score (1.53 = dislike very much) in crumb gumminess than the PSPSC (2.50 = dislike moderately), OSPSC (3.56 = dislike slightly) and WSPSC (5.53 = like slightly). This indicates that all sponge cakes containing sweet potato flour were not acceptable by the panellists as the score was less than 4.00. Consumersdislike crumb adhere to teeth and palate during chewing that causedby higher starch content of the sweet potato flour as compared to self-rising flour. According to Hoover [45], starch plays an important role in influencing gumminess of the final baked products. The present result was supported by the result obtained in texture profile analysis (Table 5), wherein partial substitution of sweet potato flour for wheat flour resulted in an increase of gumminess value.

The overall acceptability is one of the most important attributes because it is associated to the textural and sensorial properties of the food. Good Sensory characteristics remain a key priority as a consumer choice criterion [39]. There were no significant ($p<0.05$) differences in terms of overall acceptability between control (4.63) with sponge cakes containing VitAto flour (4.86) or OFSP flour (5.10) or PFSP (4.26). This indicates that the formulation of sponge cake substituted with sweet potato flours (VitAto, OFSP and PFSP) at the 20% level were comparable to the control sponge cake (WSPSC). Therefore, sweet potato flour has a potential to be used in sponge cake applications.

CONCLUSION

The results from the present study demonstrated that purple-fleshed sweet potato flour (PFSP) had high ash, crude fibre, carbohydrate, energy values, but low moisture, crude fat, crude protein, water activity, bulk density and pH values. It also had darker, less red and yellow colour than VitAto flour (VitAto) and orange-fleshed sweet potato flour (OFSP). The incorporation of VitAto or OFSP or PFSP for self-rising flour had significant influences on the physical, chemical and sensory characteristics of sponge cakes. Substitution of sweet potato flour for self-rising flour improved the nutritional compositions of the final products. However, the incorporation of sweet potato flour to the sponge cake yielded darker crust and crumb, reduced volume, specific volume and weight values. In addition, sponge cakes containing sweet potato flour resulted in harder, gummier, chewy and denser crumb than control sponge cake. Furthermore, the sweet potato flour-incorporated sponge cake did not affect the acceptability scores by the panellists. However, sponge cake containing OFSP (OSPSC) received higher ratings in overall acceptability than sponge cake containing PFSP (PSPSC). Sweet potato flours can be incorporated into other bakery products as well for improving the nutritional value of end-use products.

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