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Development of pro-vitamin A and energy rich biscuits: Blending of orange-fleshed sweet potato (*Ipomea batatas* L.) with wheat (*Triticum vulgare*) flour and altering baking temperature and time

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Orange-fleshed sweet potato (OFSP) is a promising root crop due to its high β -carotene content which could help to reduce vitamin A deficiency (VAD). However, it is a less utilized perishable crop. In order to use OFSP tubers, incorporation with other flours in processing and baked products can be considered. The aim of this study was to develop pro-vitamin A and energy rich biscuits through incorporation of OFSP and altering baking time and temperature. In this experiment, OFSP flour was blended with wheat flour in the ratio of 30%. Dough was formed and baked at 200°C for 12 and 15 min and at 220°C for 9 and 12 min. The biscuits were then subjected to nutritional and acceptability tests. The moisture content ranged between 4.02 and 11.19%, crude protein (9.88 - 11.06%), crude fiber (0.17 - 2.68%), crude fat (1.32 - 2.34%), ash (0.81 - 2.91%), carbohydrate (73.72 - 79.19%), β -carotene (0.54- 6.01 μ g/g) and energy (360.7 - 379.0 kcal/100 g). The entire sensory test score of the biscuits was in acceptable range. The finding of this study shows that blending of OFSP, baking time and temperature altered the pro-vitamin A and energy content of the developed biscuits. Hence, OFSP blending, baking time and temperature could be manipulated to prepare nutritionally rich and organoleptically acceptable biscuits.

Key words: Orange-fleshed sweet potato, baking, biscuits, β -carotene, nutrition, sensory property.

INTRODUCTION

Vitamin A is an essential micronutrient required for the normal functioning of the vision system, immunity, epithelial integrity, cellular differentiation, growth and development, and possibly reproduction (Gibson, 2005;

WHO, 2009). Vitamin A deficiency (VAD) remains a serious public-health problem in the developing world (West, 2002). Preschool children and pregnant women suffer the most widespread and severe effects of VAD

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(WHO, 2009). Studies conducted over decades consistently indicated the public-health significance of VAD in Ethiopia (Gebremedhin et al., 2009). However, the full extent of the problem in pregnant women is not clearly known as most of the studies were carried on preschool children. Although, WHO estimated 13.2% prevalence of VAD in pregnant women in Ethiopia (WHO, 2009), the available three studies (Wondmikun, 2005; Gibson et al., 2008; Mulu et al., 2011) conducted in the southern and north-western part of the country reported higher prevalence figures ranging from 17 to 27%.

Sweet potato (*Ipomoea batatas*) is well known and established crop in Ethiopia (Ermias et al., 2013). It is a good source of carbohydrate, β -carotene, vitamins (C and E), dietary fiber, minerals (K, Ca and Fe), low in protein, fat and cholesterol, and considerable amount of thiamin (B_1), riboflavin (B_2), niacin (B_3), pantothenic acid (B_5), pyridoxine (B_6) and folic acid (B_9) (Benjamin, 2007). Development of orange-fleshed sweet potato (OFSP) cultivar with high content of β -carotene and sufficient dry matter has opened up new vistas in industrial applications apart from traditional usage as food and feed (Nedunchezhiyan et al., 2012). OFSP food products supply significant amounts of β -carotene and energy simultaneously, thus helping to reduce both vitamin A deficiency (VAD) and under-nutrition in both young children, pregnant and lactating women (Bouis, 2002; HarvestPlus, 2003; Jaarsveld et al., 2006). However, the utilization of sweet potato for foods is limited to traditional snacks. Therefore, diversification of sweet potato food products as well as promotion of health benefit sweet potato as functional food would help to increase the consumption, image and added value of sweet potato products. Orange-fleshed sweet potato is a potential source of dietary pro-vitamin A as it contains carotenoids. The predominant component of carotenoids is beta-carotene and it possesses the highest vitamin A activity among carotenoids (Khoo et al., 2011; Burri, 2011). The beta-carotene content of orange-fleshed sweet potato depends highly on the sweet potato varieties (Burri, 2011) and it may reach up to 20,000 $\mu\text{g}/100\text{ g wb}$, which is higher than that of pumpkin and carrot (490 - 1, 500 μg and 7, 975 - 8, 840 $\mu\text{g}/100\text{ g}$, respectively) (Itle and Kabelka, 2009; Maiani et al., 2009; Jaswir et al., 2011).

OFSP contains a diverse array of vitamins and minerals with potential nutritional benefits to meet easily the intake needs and reduce VAD and under-nutrition (Jaarsveld et al., 2006). However, the utilization is very low and commonly consumed in the limited form like boiled and cooked meals in traditional dishes of Ethiopia (Tesfaye et al., 2002). OFSP is also subjected to postharvest losses due to lack of storage technology and preservation (Ray and Ravi, 2005). The limited information on processing OFSP to other products or considering it as additional ingredients for baked foods (Assefa et al., 2007; Bezabih and Mengistu, 2011) is the also limiting factor for OFSP consumption. Numerous

studies have been conducted to develop nutritious food products from OFSP and other supplementary food sources (ADA, 2002; Coronel et al., 2005). It has been stated that chips, cookies, breads, snacks, alcoholic and non-alcoholic beverage can be developed from OFSP with or without flavoring (Dansby and Bovell-Benjamin, 2003; Mills et al., 2003; Ridley et al., 2005; Wireko, 2010).

Snack foods such as biscuits and crackers are widely consumed, relatively longer in shelf life, good in eating quality and highly palatable foods that can be modified to suit specific nutritional needs of any target population (Elkhalifa and Ei-Tinay, 2002; Okoye et al., 2008; Vitali et al., 2009). The production of biscuits is based on wheat flours (Okoye et al., 2008). The principal ingredients are wheat flour, fat, sugar and water; while other ingredients include milk, salt, flouring agent and aerating agent. However, a report by Burrier et al. (2003) stated that improvement of nutritional quality of biscuit depends on the type of flour, granular size, kneading time, dough rising time, thickness of the dough sheet, baking time, baking temperature, range of heating and packaging, and storage condition. There is occurrence of changes in nutritional value of OFSP roots during preparation and processing (Coronel et al., 2005; Ahmad et al., 2006; Chun and Yoo, 2006; Bengtsson et al., 2010). Other similar reports described that processing could induce alteration of physico-chemical, nutritional and organoleptic properties (Akhtar et al., 2010; Chun and Yoo, 2006; Coronel et al., 2005; Leksrisompong et al., 2011).

Development of biscuits from composite flours is the recent trend in bakery industry (Hooda and Jood, 2005). In recent studies, new ingredients were included in the production of biscuit products such as black gram, fenugreek flour (Hooda and Jood, 2005), mustard flour (Tyagi et al., 2007), soy flour (Vitali et al., 2009), fibers from different cereals and fruits (Sudha et al., 2007a,b; Bilgicli et al., 2007) to study changes on nutritional, rheological and organoleptic characteristics of biscuits. Biscuits can also be prepared by incorporating sweet potato flours to wheat flour (Srivastava et al., 2012). Shih et al. (2006) reported that sweet potato flour is used as a dough conditioner for bread, biscuit and cake processing (it may substitute up to 20% of wheat flour), as well as in gluten-free pancake preparation. The sweet potato could be considered as an excellent novel source of natural health-promoting compounds, such as β -carotene and anthocyanins, for the functional food market. Also, the high concentration of anthocyanin and β -carotene in sweet potato, combined with the high stability of the color extract make it a promising and healthier alternative to synthetic coloring agents in food systems. Starch and flour processing from sweet potato can create new economic and employment activities for farmers and rural households, and can add nutritional value to food systems (Bovell-Benjamin, 2007). However, the introduction of foods is to be made with caution, and

issues such as safety, acceptability and nutrient bioavailability need to be considered.

The demand for bakery products and importation of wheat are increasing (CSA, 2011), replacing relative proportion of flours from OFSP could have an advantage on the nutritional and economical aspects. Therefore, the aim of this study was to develop pro-vitamin A and energy rich biscuits from blend of OFSP and wheat flours by altering the baking time and temperature. Nutritional composition analysis and sensory acceptability tests were conducted to support the objectives of this study.

MATERIALS AND METHODS

Sample preparation

OFSP (*Ipomoea batatas*) locally called *Kullfo* variety was collected from Areka Agricultural Research Institute and the wheat flour was obtained from Hawassa flour factory (Hawassa, Ethiopia). Ingredients like shortenings, sugar, baking powder and milk were purchased from Hawassa local market (Hawassa, Ethiopia). The matured and sorted OFSP tubers were cleaned and washed with tap water to remove any adhering soil, dirt and dust. The tubers were then peeled by mechanical potato peeler (EP5, Buccedox, France) and sliced to 2 mm thickness by vegetable slicer (CL 30, Robot Coupe Snc, Vincennes, France) to facilitate drying and milling. The sliced OFSP was soaked in 1% salt solution for 30 min to reduce browning reaction and drained before drying. The material was then dried in solar drier (Alvant blanch, Withshier, England) for 72 h till it reached 12% moisture and grounded by miller (Thomas-Wiley laboratory mill, ILCA 5789, Philadelphia PA, USA) with 500 μm screen. The flour sample was packed in airtight black HDPE plastic using impulse sealer (HM3000 Polythene heat sealer, hulmemartin, UK) and kept at 15 - 18°C until use (these samples were not stored too long and the use of the samples was immediate after the day of preparation).

Preparation of biscuit

Biscuits were produced using the method described by Srivastava et al. (2012) with a modification in baking temperature and time. The OFSP and wheat flours were first blended and the blends were then thoroughly mixed. Ingredients required to make biscuit were added in similar amount to the different treatments in the experiment [sugar (20%), milk (5%), beaten egg (15%), water (35%), baking powder (0.5%) and salt (0.5%)] and were mixed thoroughly. The dough was kneaded on wooden table by rolling stick to get the desired thickness. The dough was later cut to round shape with the aid of biscuit cutter having 5 cm diameter (Bita biscuit cutter, 1288, China). The biscuit was baked in oven (Ed 23-binder, USA). The samples were allowed to cool to room temperature and packed in black HDPE bags using impulse sealer (HM3000 Polythene heat sealer, hulmemartin, UK.) till analysis was conducted.

In the experimental set-up of this study, two formulations (100% wheat flour and substitution of 30% OFSP flour), two baking temperatures (200 and 220°C) and two baking times (12 and 15 min for 200°C; 9 and 12 min for 220°C) were considered. Biscuits from 100% wheat flour baked at 200°C for 12 min were used as a control (Srivastava et al., 2012).

Proximate composition determination

Proximate composition (moisture, crude protein, crude fiber, crude

fat and ash) of the developed biscuits were analyzed using the method of AOAC (2000). Carbohydrate (CHO) and gross energy contents of the samples were determined by difference (FAO, 2002; Menezes et al., 2004) and calculated using Equations 1 and 2, respectively.

$$\%CHO = 100 - (\%Fat + \%Protein + \%Ash + \%Moisture) \quad (1)$$

$$Energy(\text{kcal}/100\text{g}) = (4 \times CHO) + (4 \times protein) + (9 \times Fat) \quad (2)$$

Determination of β -carotene

Beta-carotene was determined by high performance liquid chromatography (HPLC) method as described by Rodriguez-Amaya (1988). A homogenous representative sample weighing 2 g was taken, mixed and mashed with mortar and pestle in the presence of enough acetone. Then, the mashed and extracted sample was filtered into 100 ml volumetric flask using tissue paper. The mortar, funnel and residue was washed with small amount of acetone and filtered in flask containing the extract and the residue was returned to the mortar once again. The extraction and filtration was repeated until the residue was devoid of any color and washings were colorless.

Petroleum ether and acetone extract of 25 ml was put in a separator funnel and shaken well. Small amount of distilled water was added to separate the two phase and the lower aqueous-acetone phase was discarded. The separator funnel was washed 2-3 times with water and residue acetone was removed. Then, the petroleum ether phase was collected, dried with sodium sulphate until some crystal become loose, transferred to drying flask and evaporated in rotary evaporator. The residue was dissolved in about 1 ml of petroleum ether and the solution was introduced in a chromatographic column. The column was eluted with petroleum ether and the β -carotene was collected in a flask and allowed to pass through the column as a yellow pigment. Finally, the volume of β -carotene was measured using measuring cylinder and the absorbance was taken at 440 nm in a spectrophotometer (Atomic Absorption Spectrophotometer, AA-6800, Shimadzu, Japan) and calculated using Equation 3.

$$\beta\text{-carotene}(\mu\text{g/g}) = \frac{A \times V(\text{ml}) \times 10^4}{A_{1\%1\text{cm}} \times W} \quad (3)$$

Where, A = Absorbance, $A_{1\%1\text{cm}}$ = absorption coefficient of carotenoid in solvent used, petroleum ether is 2592, V (ml) = volume of the solution that gives an absorbance of A at specified wavelength, W = weight (g) of the sample.

Sensory evaluation

Sensory acceptability of the biscuits was evaluated using 9-point hedonic scale (Muresan et al., 2012). Panelists (50 judges) were requested for their willingness and selected for the sensory evaluation according to expertise. The panelists were given a hedonic questionnaire and 3-digits coded samples to evaluate the appearance, flavor, color, crispiness, texture and overall acceptability of the biscuits. The analysis was conducted in triplicate with the 9-point hedonic scale (1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much and 9 = like extremely).

Table 1. Proximate composition of developed biscuits.

Composition (%)	Biscuits				
	B ₀	B ₁	B ₂	B ₃	B ₄
Moisture	11.19 ± 0.05 ^a	7.98 ± 0.23 ^c	4.02 ± 0.09 ^e	10.61 ± 0.01 ^b	4.85 ± 0.03 ^d
Crude protein	11.06 ± 0.14 ^a	10.08 ± 0.16 ^{cd}	10.40 ± 0.08 ^b	9.88 ± 0.11 ^d	10.26 ± 0.09 ^{cb}
Crude fibre	0.17 ± 0.04 ^c	1.78 ± 0.01 ^b	1.76 ± 0.04 ^b	2.08 ± 0.16 ^b	2.68 ± 0.28 ^a
Crude fat	2.15 ± 0.24 ^a	2.28 ± 0.07 ^a	2.34 ± 0.11 ^a	2.19 ± 0.11 ^a	1.32 ± 0.01 ^b
Ash	0.81 ± 0.39 ^b	2.91 ± 0.87 ^a	2.36 ± 0.54 ^{ab}	1.53 ± 0.76 ^b	1.71 ± 0.29 ^b
Carbohydrate	74.63 ± 0.01 ^b	74.99 ± 1.18 ^b	79.13 ± 0.39 ^a	73.72 ± 0.91 ^b	79.19 ± 0.46 ^a

Values are mean ± standard deviation (n=4). Values within the same row with different superscript letters are significantly different from each other ($p < 0.05$). B₀ (control biscuit prepared from 100% wheat flour at 200°C for 12 min), B₁ (70% wheat flour and 30% OFSP at 200°C for 12 min), B₂ (70% wheat flour with 30% OFSP at 200°C for 15 min), B₃ (70% wheat flour with 30% OFSP at 220°C for 9 min) and B₄ (70% wheat flour with 30% OFSP at 220°C for 12 min).

Data analysis

The data collected, nutritional and sensory characteristics of the biscuits were analyzed using two-way ANOVA. General linear model (GLM) with Duncan's multiplier mean comparison test was used. All comparison was made at significance level of 5% using Statistical Analysis System (SAS) for windows version 9.1.3 (SAS, USA).

RESULTS AND DISCUSSION

Proximate composition of developed biscuits

Determining the composition is important for identifying and recommending the potential end user, acceptance and preference of the biscuits. The result of the composition (moisture, protein, fiber, fat, ash and carbohydrate contents) is shown in Table 1. The proximate composition of the biscuits varied significantly ($p < 0.05$) depending on the formulation and baking temperature and time.

The moisture content of the biscuits varied significantly from 4.02 ± 0.09 to 11.19 ± 0.05%. Higher moisture content was recorded for B₀ biscuit; this was due to that B₀ contained higher wheat flour than other samples and baked at lower baking time. Biscuits B₃, B₁, and B₄ had medium moisture contents with significant difference with each other. Biscuit B₂ recorded lower moisture content; this might be due to the high baking temperature, time and level of OFSP flour. Incorporating OFSP in wheat products reduce the moisture content due to the difference in the flour structure and water holding capacities (Mais, 2008; Richelle et al., 2013). Increase in baking temperature and time resulted in rapid loss of moisture during baking. Similar finding was reported by Oluwole et al. (2014) and Kalekristos (2010). Lower moisture content of baked products is considered for prolonging the shelf life (Galić et al., 2009).

The protein content of the biscuits varied significantly between 9.88 ± 0.11 and 11.06 ± 0.14%. Biscuit B₀ had higher protein content and this was due to the higher

amount wheat flour in the blend (wheat flour is high in protein than OFSP). B₁, B₂ and B₄ were in medium level with no significant difference with each other and this is due to the combined effect of blending OFSP and baking at extended time which could result to protein concentration and moisture loss (Oluwole et al., 2014). Lower protein content was recorded in B₃ biscuits. The study by Oluwole et al. (2014) stated that baking temperature and time could result in slight increase of crude protein content of the biscuits may be due to the loss of moisture that made the protein to concentrate. The decrease in protein with the inclusion OFSP flour is due to the lower concentration of protein in OFSP as compared to wheat flour (Khaliduzzaman et al., 2010; Mais, 2008).

Fiber content of the biscuits ranged from 0.17 ± 0.04 to 2.68 ± 0.28%. Higher and lower fiber content was recorded for B₄ and B₀, respectively. Medium values were observed for B₁, B₂ and B₃ biscuits with no significance difference with each other. The higher fiber in B₄ biscuit could be attributed to the addition of OFSP flour and the effect of high baking temperature and time that make slight increase in fiber. The reason for low fiber contents of B₀ is due to the higher wheat flour that is contained in the blend as wheat flour is low in fiber content as compared to OFSP flour (Srivastava et al., 2012). Gebremedhin et al. (2013) and Mais (2008) reported increased fiber content due to increased addition of OFSP flour in other baked products.

The fat content of the biscuits was between 1.32 ± 0.02 and 2.34 ± 0.11%. Lower fat content was recorded for B₄ biscuit. This might be due to the high baking temperature and time used that would result in reduction of fat content (Kalekristos, 2010). Relatively higher fat content was observed in B₀, B₁ and B₃ biscuits with no significant difference with each other.

The ash content of food material could be used as an index of mineral constituents (Sanni et al., 2008). Ash content of the biscuits varied significantly between 0.81 ± 0.39 and 2.91 ± 0.87%. High ash content was recorded

Table 2. β -Carotene and energy of the developed biscuits.

Nutritional aspects	Biscuits				
	B ₀	B ₁	B ₂	B ₃	B ₄
β -carotene ($\mu\text{g/g}$)	0.54 ± 0.01^e	6.01 ± 0.00^a	3.96 ± 0.00^c	5.55 ± 0.00^b	2.86 ± 0.01^d
Energy(kcal/100g)	362.1 ± 1.90^{bc}	360.7 ± 4.9^c	379.0 ± 2.9^a	354.4 ± 3.1^c	369.7 ± 2.1^b

Values are mean \pm standard deviation (n=4). Values within the same row with different superscript letters are significantly different from each other ($p < 0.05$). B₀ (control biscuit prepared from 100% wheat flour at 200°C for 12 min), B₁ (70% wheat flour and 30% OFSP at 200°C for 12 min), B₂ (70% wheat flour with 30% OFSP at 200°C for 15 min), B₃ (70% wheat flour with 30% OFSP at 220°C for 9 min) and B₄ (70% wheat flour with 30% OFSP at 220°C for 12 min).

for B₁ and B₂ with no significant difference in between. This could be attributed to the combined effect of OFSP flour and lower baking temperature and time. The ash content of B₀, B₃ and B₄ biscuits were lower with no significant difference with each other. Ash content was not affected by baking temperature and time, but it was rather dependent on the blend (Kalekristos, 2010).

As shown in Table 1, the carbohydrate content of the biscuits ranged from 73.72 ± 0.91 to $79.19 \pm 0.46\%$. Biscuits that had high carbohydrate content were B₂ and B₄. Lower content of carbohydrate was observed in B₀, B₁ and B₃ biscuits with no significant difference among the respective samples. This could be due to the effect of the blending OFSP and higher baking temperature and time. OFSP have higher carbohydrate content as compared to wheat (Onabanjo and Dickson, 2014) and using higher baking temperature and time could result in a concentrated carbohydrate (Oluwole et al., 2014).

Beta-carotene and energy contents

The content of β -carotene for all biscuits is presented in Table 2. The contents varied significantly ($p < 0.05$) between 0.54 and 6.01 $\mu\text{g/g}$ according to the treatments. Biscuit B₁ is higher in β -carotene content. This could be attributed to the lower baking temperature and time (200°C for 12 min) as well as the added OFSP flour. OFSP flour is rich in β -carotene than wheat flour (Gebremedhin et al., 2013). β -Carotene is susceptible to heat degradation, thus the lower temperature and time of heating and baking could not cause much degradation (Ranhotra et al., 1995), which could contribute to the increased concentration. Next to biscuits B₁, B₃ had high beta-carotene content among the samples. This is due to the short baking time used. Longer heating time of foods could result in reduced amount of β -carotene due to degradation (Ranhotra et al., 1995; Anjum et al., 2008; Idah et al., 2010). The combined effect of OFSP blending and high baking temperature and time made B₂ and B₄ biscuits to have medium β -carotene content. β -Carotene is highly reduced when products are dried and baked at higher temperature and extended time (Anjum et al., 2008). Biscuit B₀ was lower in beta-carotene content due to the higher percentage of wheat flour, since OFSP was

not included in the blend to contribute to higher level of β -carotene. β -Carotene is the major pro-vitamin A component of most carotenoid containing foods (Jaarsveld et al., 2006) and it is essential to combat VAD. β -Carotene conversion to retinol equivalent (RE) should be considered and one RE is equivalent to 0.001 mg of retinol, or 0.006 mg of β -carotene, or 3.3 International Units of vitamin A, 1 μg beta carotene = 0.167 μg RE (FAO/WHO, 2002; West, 2000; West et al., 2002). Therefore, with this regard, the biscuits of this experiment could contribute higher RE; hence it will enhance the intake of pro-vitamin A to contribute in reduction of the VAD burden (Stein et al., 2005).

As indicated in Table 2, the energy content of the biscuits ranged significantly from 354.4 ± 3.1 to 379.0 ± 2.9 kcal/100 g. The higher energy content was recorded for B₂ biscuit. This is due to the increase in baking temperature and time and addition of the OFSP flour. The OFSP flour is rich carbohydrate source and baking at high temperature and time could make the products to have concentrated energy source (Okoye et al., 2008; Oluwole et al., 2014). Similar explanations can be considered for the higher energy content of B₄. The lower energy contents were recorded for B₀, B₁ and B₃ biscuits with no significant difference among the samples. This can be attributed to low levels of OFSP (particularly for B₀), low baking temperature and time (B₁ and B₃).

Sensory properties of the developed biscuits

Sensory quality of food products measures degree of acceptance (Muresan et al., 2012). Sensory characteristics such as color, appearance, taste, texture, crispiness and overall acceptability were considered for this study. These sensory properties are determining factors for acceptability of the food products including biscuits (Gernah and Anyam, 2014). The results are shown in Table 3 and the sensory scores were significantly different ($p < 0.05$). The entire sensory test score of the biscuits was in acceptable range (5.57 - 7.19).

Color is recognized as the only attribute that consumer can base their purchasing decisions on (Surkan et al., 2009). Color acceptability score of the biscuits

Table 3. Sensory evaluation of developed biscuits.

Sensory properties	Products				
	B ₀	B ₁	B ₂	B ₃	B ₄
Color	5.57 ± 1.91 ^d	6.13 ± 1.19 ^c	6.90 ± 1.23 ^{ab}	7.18 ± 1.11 ^a	6.83 ± 1.39 ^b
Appearance	5.58 ± 1.83 ^d	6.07 ± 1.17 ^c	6.83 ± 1.21 ^{ab}	7.08 ± 1.12 ^a	6.71 ± 1.36 ^b
Taste	5.85 ± 1.65 ^c	6.21 ± 1.28 ^b	6.90 ± 1.13 ^a	7.19 ± 1.17 ^a	6.92 ± 1.19 ^a
Crispiness	5.80 ± 1.41 ^c	6.11 ± 1.31 ^b	6.83 ± 1.19 ^a	7.10 ± 1.22 ^a	6.93 ± 1.34 ^a
Overall acceptability	6.02 ± 1.25 ^c	6.30 ± 1.13 ^b	6.93 ± 1.00 ^a	7.18 ± 1.12 ^a	6.93 ± 1.13 ^a

Values within the same row with different superscript letters are significantly different from each other ($p < 0.05$) and values are presented in mean ± standard deviation ($n=4$). Where B₀ (control biscuit prepared from 100% wheat flour at 200°C for 12 min), B₁ (Biscuit prepared from 70% wheat flour with 30% OFSP at 200°C for 12 min), B₂ (Biscuit prepared from 70% wheat flour with 30% OFSP at 200°C for 15 min), B₃ (Biscuit prepared from 70% wheat flour with 30% OFSP at 220°C for 9 min) and B₄ (Biscuit prepared from 70% wheat flour with 30% OFSP at 220°C for 12 min).

significantly ($p < 0.05$) ranged from 5.57 ± 1.91 to 7.38 ± 0.99 . Biscuits B₃ and B₂ recorded higher scores of color acceptance with no significance difference among. This could be due to higher baking temperature and time as well as the OFSP flour. The enhanced Maillard and other browning reactions chiefly due to higher baking temperature and time as well as addition of OFSP flour could be responsible for development of the attractive color (Lindenmeier and Hofmann, 2004). Medium level color score was observed for B₁ and B₄ biscuits, due to the combined effect of relatively low baking temperature, time and OFSP. B₀ biscuit recorded lower scores. This could be attributed to the low baking temperature and time as well as the absence of OFSP which could not enhance Maillard and other browning reactions (Siddiqui and Nasreen, 2014).

Appearance scores of the biscuits was between 5.58 ± 1.83 and 7.24 ± 0.98 and were significantly ($p < 0.05$) different. Appearance score followed similar trend as the color score. Biscuits B₃ and B₂ recorded higher score, B₁ and B₄ biscuits had medium score and B₀ recorded lower score. The result revealed that appearance acceptability was increased with the addition of OFSP flour, along with the increase in baking time at 200°C and baking temperature.

With regard to taste acceptability scores, the biscuits score ranged significantly ($p < 0.05$) between 5.85 ± 1.65 and 6.92 ± 1.19 . Biscuits B₄, B₃ and B₂ recorded higher taste acceptability score with no significance difference among the samples. This could be due to the addition of OFSP flour and the high baking temperature and time. The sweet taste of OFSP and the extraction of sugars during high baking temperature and time could contribute to the result (Maaruf et al., 2011). Biscuits B₁ and B₀ scored lower taste score due to the fact that OFSP was not added to B₀ and the relatively low baking temperature and time of baking for B₁.

Crispiness represents the key textural attributes of dry snacks products; denoting freshness and high quality, generally a crisp should be firm and snaps easily when bent, emitting a crunchy sound (Dueik et al., 2010).

Crispness score of the biscuits was significantly different and ranged ($p < 0.05$) from 5.80 ± 1.41 to 7.10 ± 1.22 . Biscuits B₄, B₃ and B₂ recorded higher crispiness score with no significance difference with each other. This can be attributed to the high baking temperature and time and addition of OFSP flour, which may result in high moisture loss and dry product. Biscuit B₁ and B₀ scored lower crispiness score due the fact that OFSP was not added to B₀; and the low baking temperature and time for B₁.

The overall acceptability score of the biscuits varied significantly. The overall acceptability results followed similar trend with that of the taste and crispiness. Biscuit B₄, B₃ and B₂ recorded higher acceptability score with no significant difference with each other. This is due to the higher baking temperature, baking time and OFSP flour used during baking. Biscuits B₁ and B₀ had lower acceptability score due the fact that OFSP was not added to B₀ and the low temperature and time of baking for B₁. Generally, the result revealed that the overall acceptability of the biscuits was increased with the addition of OFSP flour (Nazni et al., 2009; Khaliduzzaman et al., 2010; Srivastava et al., 2012) and with the increase of baking temperature from 200 to 220°C at 12 min. A slight decrease was observed as a baking time increase from 9 to 12 min at 220°C.

Conclusion

Orange-fleshed sweet potato is rich in carotenoids, which can potentially be used as a natural food ingredient and colorant. According to the findings of this study, the nutritional properties of the biscuits were changed due to the OFSP incorporating and altering of baking temperature and time, while all the sensory attributes were at acceptable range. Protein and moisture tends to decrease due to addition OFSP flour, high baking temperature and prolonged baking time. Fiber content followed decrease trend and there was no clear trend for fat, ash and carbohydrate. Biscuit prepared with 30% OFSP at 200°C for 12 min (B₁) and at 220°C for 9 min

(B₃) were rich in β -carotene. Biscuit prepared with 30% OFSP at 200°C for 15 min (B₂) and at 220°C for 12 min (B₄) were better in energy content. Addition of OFSP to biscuit and baking it at relative low temperature and time (200°C for 12 min) produced a product with high β -carotene content, while energy content of the biscuits found to be higher in OFSP added product baked at high temperature and time. Due to the susceptibility of β -carotene to degradation at high temperature and time, attaining a product that is superior in β -carotene and energy at the same time was not attained. Therefore, process optimization can be considered to attain better contents of energy and β -carotene.

Conflict of Interests

The authors have not declared any conflict of interests.

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