ECRONICON OPEN ACCESS
EC NUTRITION
Research Article

Improving Nutritional Content of Bakery Products by Using Orange-Fleshed Sweet Potato Puree

Md. Monower Hossain[1]*, EHMS Rahaman[1], Debashish Chanda[1], Simon Heck[2], Shreef Mahmood[3] and Mohammad Humayun Kabir[4]

[1]International Potato Center, Banani, Dhaka, Bangladesh

[2]International Potato Center, Nairobi, Kenya

[3]Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh

[4]Sher-E-Bangla Agricultural University, Sher-E-Bangla Nagar, Dhaka, Bangladesh

***Corresponding Author:** Md. Monower Hossain, International Potato Center, Banani, Dhaka, Bangladesh.

Received: November 28, 2022; **Published:** November 30, 2022

Abstract

The present experiment was conducted at Super Tasty Food Products Factory, GUK, Gaibandha, Bangladesh 2021. The aim of the study was to improve nutritional content of bakery products by using orange-fleshed sweetpotato (OFSP) puree. Four OFSP and a WFSP varieties were used for making cake and bread at 50%, 30% and 0% substitution levels of wheat flour, respectively. Other ingredients were maintained following standard bread and cake making procedure of the factory. Eleven treatments combinations were used for this purpose. The bakery products thereafter subjected to nutrient analysis and sensatory evaluation. The highest amount of beta carotene content was recorded in T_4 treatment (2.91 mg/100g in bread and 1.04 mg/100g in cake) followed by T_9 treatment (1.69 mg/100g in bread and 0.63 mg/100g in cake). Iron was noted maximum in T_2 treatment (7.46 mg/100g in bread and 5.58 mg/100 in cake). The entire sensory attributes of prepared bakery products were accepted as fair to very good and have no remarkable difference of traditional products of bread and cake. The overall acceptability of the product was observed highest (good to very good) in T_9 treatment.

Keywords: *Orange-Fleshed Sweetpotato; Puree; Bakery Product; Bread; Cake; Sensory Evaluation*

Introduction

Sweetpotato (*Ipomoea batatus*), is an important staple crop in many parts of the world [1]. It is an important supplementary food crop in Bangladesh, ranked fourth among food crops in terms of production, but most of the current production consists of white fleshed varieties that lack in Vit A. The crop is normally grown in the winter season, planting takes place after flooding subsides between mid-October to early November and harvesting in March-April takes place just before the rainy season. The crop is grown under rain-fed conditions mainly along riverbanks and on 'Char' and saline areas and is mostly single cropped, though there are some systems where sweetpotato is relay cropped with rice and sometimes other crops like jute and pulses. The country produces about 245,719 tons of sweetpotato in 2019 from 24,553 ha of land, with an average yield of 10.01 t/ha [2]. Demand of orange fleshed sweetpotato is increasing day by day in Bangladesh. At present about 1% of the produced sweetpotato is orange fleshed in Bangladesh [3]. The high nutritional and the high market value makes sweetpotato an important commodity Bangladesh in addition to rice [4].

Malnutrition is a common phenomenon in Bangladesh. The children, especially of low-income households/families (both in rural and urban) suffer from high rates of micronutrient deficiencies, particularly vitamin A, iron, iodine and zinc deficiency. Though the country has made some significant progress in reducing vitamin A deficiency (VAD) among preschool children over the past 15 years, consumption of vitamin A rich foods is still low, suggesting that the underlying causes of VAD require further attention and support. Orange-fleshed sweetpotato (OFSP), rich in beta-carotene, is an extremely effective source of pro-Vitamin A and can make major contributions to reducing malnutrition in Bangladesh.

Sweetpotato considered as an excellent source of different important nutritional such as β-carotene, zinc and iron, for the functional food market. Orange fleshed sweetpotato (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 [5]. Though sweetpotato is a good source of carbohydrates, but this is not harmful for the diabetic patients and World Health Food Organization (WHFO) has acknowledged this root crop with "antidiabetic" activity [6]. Studies results concluded that the carbohydrate from SP stabilizes the sugar levels in blood and decreases the resistance to insulin [7]. However, the utilization is very low and commonly consumed in the limited form like boiled and cooked meals in traditional dishes of Bangladesh. There is limited information on processing of OFSP to other products or considering it as an additional ingredient for baked foods [8,9] which is also a limiting factor for OFSP consumption. Numerous studies have been conducted to develop nutritious food products from OFSP and other supplementary food sources [10,11]. Snack foods such as biscuits and crackers are widely consumed, with 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 [12-14].

High concentration of β-carotene in OFSP, combined with the high stability of the color extract make it a promising and healthier alternative to synthetic coloring agents in food systems. Bread prepared from OFSP puree can create new economic and employment opportunities for farmers and rural households and can add nutritional value to food systems. The demand for bakery products and import of wheat are increasing day by day in Bangladesh. Adding an appropriate proportion of OFSP puree to wheat flour could have an advantage on the nutritional as well as economical aspects of any bakery products.

Objective of the Study

The main objective of the present study was to improve nutritional content of bakery products (viz., bread and cake) by incorporating OFSP puree.

Materials and Methods

The experiments were carried out at Super Tasty Food Product Factory, GUK, Nashratpur, Gaibandha, Bangladesh in 2021. Two types of baking products e.g. bread and cake were developed through incorporation of OFSP puree. The varieties used were four orange-fleshed sweet potato varieties viz. BARI SP-4, BARI SP-8, BARI SP-12, BARI SP-15 and a local variety. The study was conducted following Completely Randomized Design (CRD) with eleven treatments for making breads and cakes. The treatments were followed as; T_1 = 50% BARI SP 4+50% Wheat Flour, T_2 = 50% BARI SP 8+50% Wheat Flour, T_3 = 50% BARI SP 12+50% Wheat Flour, T_4 = 50% BARI SP 15+50% Wheat Flour, T_5 = 50% Local Variety+50% Wheat Flour, T_6 = 30% BARI SP 4+70% Wheat Flour, T_7 = 30% BARI SP 8+70% Wheat Flour, T_8 = 30% BARI SP 12+70% Wheat Flour, T_9 = 30% BARI SP 15+70% Wheat Flour, T_{10} = 30% Local Variety+70% Wheat Flour and T_{11} = 100% Wheat Flour. For all the treatment combinations, the following steps were followed for making breads and cakes from sweetpotato roots.

Making sweetpotato puree

The roots of orange fleshed sweetpotato varieties viz., BARI SP 4, BARI SP 8, BARI SP 12 and BARI SP 15 were collected from the farmers field of DDBIO project (Development and Delivery of Biofortified Crops at Scale - a project funded by UKaid) at Gaibandha district.

Local white fleshed sweetpotato variety was also collected from the farmer's field of the same area. The collected roots were then washed carefully to remove all soil and dust particles and after that boiled separately. After boiling, the skins of the roots were removed, and purees were prepared from each variety using an electric mixer.

Preparation of cakes and breads

For preparation of baking products, the basic ingredients (wheat flour and sweetpotato puree) were used as per eleven treatment combinations. Other ingredients were the same in every treatment of cake and bread preparation. The standard procedures for making cake and bread were followed as per GUK's super tasty food product factory protocol.

SL No.	For 1200 gm Cake		For 800 gm Bread	
	Ingredients	Ingredients	Ingredients	Amount
1	Sugar	250 gm	Sugar	80 gm
2	Oil	250 ml	Oil	50 ml
3	Egg	250 ml	Egg	60 ml
4	Milk	15 gm	Milk	20 gm
5	Salt	1gm	Salt	8 gm
6	Flavor	5 gm	Flavor	5 gm
7	Baking Powder	5 gm	Bread Improver	5 gm
8	Yeast	-	Yeast	12 gm

***Table 1:** Ingredients used in baking products (Cake and bread).*

Nutritional composition analysis of cakes and breads

To know the different nutrient components of the baking products, the prepared cake and breads were subjected to chemical analyses following different methods. For this analysis, the present study was performed with three sets of experiments with triplicates in each set.

***β-carotene content* (mg/100 gfw):** *β*-carotene in baking products was determined according to the method mentioned by Nagata and Yamashita [15]. One gram of baking product was mixed with 10 ml of acetone: hexane mixture (4:6) and vortexed for 5 minutes. Then the mixture was filtered through Whatman filter paper No.1 and afterward the absorbance was measured in spectrophotometer at 453 nm, 505 nm, 645 nm and 663 nm. *β*-carotene content was calculated according to the following equation:

$$\beta\text{-carotene (mg/100 ml)} = 0.216\, A_{663} - 1.22\, A_{645} - 0.304\, A_{505} + 0.452\, A_{453}$$

Note: A_{663}, A_{645}, A_{505} and A_{453} are absorbance at 663 nm, 645 nm, 505 nm and 453 nm respectively.

β-carotene were finally expressed as mg/100g fresh weight (fw).

Vitamin C (mg/100g): For ascorbic acid measurement, 10g baking product was homogenized in 50 ml of 3% cold metaphosphoric acid (HPO_3) using a blender for 2 minutes and filtered through Whatman filter paper No. 1. The clear supernatant was then collected for assaying ascorbic acid by 2, 6-dichlorophenolindophenol titration following the method mentioned by Ranganna [16]. Ten milliliters of aliquot were titrated with 0.1% 2, 6- dichlorophenolindophenol solution until the filtrate changed to pink color persisted for at least 15 seconds and the titration volume of 2, 6-dichlorophenolindophenol was recorded. Prior to titration 2, 6-dichlorophenolindophenol solution was calibrated by ascorbic acid standard solution. Ascorbic acid content was calculated according to the titration volume of 2, 6-dichlorophenolindophenol and results were expressed as mg/100g fresh weight:

$$\text{Ascorbic acid content (mg/100 g)} = \frac{T \times D \times V1 \times 100}{V2 \times W}$$

Where, T = Titre, D = Dye factor, V_1 = Volume made up, V_2 = Volume of extract taken for estimation, W = Weight of sample taken for estimation.

Iron content (mg/100g): Iron content of baking products (Cake and Bread) were determined by Atomic Absorption Spectrophotometric (AAS) methods directly in the undiluted filtrate following analytical method described by Petersen [17]. Exactly 1g of oven product sample was taken in a 250 ml volumetric flask. 10 - 15 ml of di-acid mixture was added to it (Previously prepared by adding HNO_3 and HCL in 2:1 ratio). Then the flask was placed on an electric hot plate. The content was heated at 180 - 200ºC until the white fume appeared. A few ml of (approximately 5 ml) of di acid mixture was added to the flask if the content becomes dry before the end of digestion is over. The flask was removed from the hot plate and was cooled. About 20 - 30 ml of distill water was added to it. The solution was filtered with filter paper in 100 ml volumetric flasks. The conical flask was washed several times to ensure that all the minerals are transferred to the volumetric flask. The volume was made up to the mark with distilled water. Thus, the extract was prepared and ready to analysis for iron content. The content of these elements was measured by atomic absorption spectrophotometer (AAS) directly in the undiluted filtrate.

The calculation was done by the following formula:

mg per kg material = d x 50/c

Where, d = mg/l iron measured on AAS.

c = g material weighed into the digestion tube.

50 = dilution factor.

Then the iron content was converted in mg/100g.

Zinc content (mg/100g): Iron content of selected tuberous roots of sweet potato was determined by Atomic Absorption Spectrophotometric (AAS) methods directly in the undiluted filtrate following analytical method described by Petersen [17]. The procedure of zinc content determination was followed like iron content determination.

Sensory evaluation

The organoleptic evaluations of cakes and breads were carried out on 14th and 15th June 2021, respectively. This evaluation was performed with a panel made up with 15 semi-trained panelists. The panelists included factory experts, technical persons and students of Gaibandha who were familiar with the sensory attributes like appearance, color, flavor and taste of the samples. The 11 samples of baking products were presented on 11 identical plates and coded with 3-digit random number. A 5-point hedonic scale was designed to measure the degree of preference of the samples in reference to appearance, color, flavor, and taste. The categories were converted to numerical scores using scale 5 to 1, where 5 = Very good, 4 = Good, 3 = Fair, 2 = Bad and 1 = Very bad. Overall acceptability was also measured using scale 5 = Highly acceptable, 4 = Acceptable, 3 = Neutral, 2 = Less acceptable and 1 = Not acceptable.

Before evaluation, the basic rules of evaluation were explained to the members of the panels using simple words. Each panelist was given a structured evaluation form which was used to record the evaluation in reference to the appearance, color, flavor, taste and overall acceptability of the product. Each panelist evaluated product by product and washed his/her mouth with mineral water before moving on to the next sample.

Statistical analysis

Data on different parameters were analyzed performing the STAR (Statistical Tools for Agriculture Research) software. Sensory evaluation results were expressed as the mean ± standard error (SE).

Results and Discussion

Orange-fleshed sweet potato (OFSP) and their products are highly promoting in the different African countries such as Kenya, Uganda, Ethiopia, Mali by local governments and NGOs with the help of international research organizations [18]. The role of OFSP is successfully reported in the vitamin A management (VAM) in developing countries. Scientists successfully prepared the different food products both in liquid and in solid forms by OFSP base [19]. Low., *et al.* [20] mentioned OFSP consumed frequently in family diets of different sub-Saharan African countries by boiling, steaming, roasting, and drying. Researchers are now concentrated on the methods to develop retention of the carotenes by the processing and are trying to develop the traditional foods by incorporating OFSP such as bread [21], cookies [22] and porridge [23]. So, determining beta-carotene, vitamin C, zinc and iron content is important for identifying and recommending the potential end user, acceptance and preference of the prepared breads and cakes. The result of present study on beta-carotene, vitamin C, zinc and iron content are depicted in table 2 and 3 where the results varied significantly ($p < 0.05$) depending on the formulations (treatments).

Beta carotene, vitamin C, zinc and iron content of bread

There was a significant variation among the treatments regarding beta carotene content of bread when prepared from wheat flour and different sweetpotato varieties. Scientists found in varietal differences on nutritional compositions of sweetpotato as Jaarsveld., *et al*. [5] reported that higher amount of anthocyanin and carotenes are present in purple and orange-fleshed sweetpotato, respectively in comparison with white-fleshed cultivars. In the present study, T_4 treatment exhibited the highest beta carotene (2.91 mg/100g) followed by T_9 Treatment (1.69 mg/100g) and T_1 treatment (1.34 mg/100g). A slight amount (0.03 mg/100 gm) of beta carotene was recorded in bread prepared from 100% flour (T_{11}) which was statistically alike to T_5 and T_{10} treatment (Table 2) where white flesh sweetpotato variety puree was used for making breads. Alam., *et al.* [24] and Islam., *et al.* [25] also found the similar trends of results while using different sweetpotato varieties.

Adult men and women require 90 and 75 mg of the Vit. C as the RDA, respectively [35]. Vitamin C in bread also varied significantly among the treatments. The maximum vitamin C was found in T_5 (2.92 mg/100g) followed by T_1 (2.82 mg/100g) which is very low compared to the daily requirement. This finding is also supported by Grace., *et al.* [26] where he found that Vit. C concentration in OFSP as 870 µg/g (db) of ascorbic acid, which is very less than the different fruits and vegetables. On the other hand, no vitamin C was recorded when the breads were prepared from 100% wheat flour (T_{11}) (Table 2).

Zinc is essential micronutrient for human immune system function, cell growth, wound healing, and insulin function [27]. About 0.24 - 0.93 mg/100g of zinc was reported to be in Orange fleshed sweetpotato (OFSP) which is low compare to maize (2.21 mg/100 g), rice (1.09 mg/100g), and wheat (2.65 mg/100g) that have high concentration of the Zn, whereas, potatoes (0.29 mg/100g), cassava (0.34 mg/100g), white flesh sweetpotato (0.3 mg/100g), and yam (0.24 mg/100g) contain the zinc as present in OFSP [28-30]. Though OFSP contains very small amounts of Zn, the bioavailability is more comparative to cereals and grains because of no or very minimum presence to antinutritional factors like phytate [31]. Regarding zinc content in the present study, a significant variation was observed among treatments. The zinc content in bread in all treatments ranged from 4.40 to 2.20 mg/100g. In the formulation T_{11} showed the highest zinc content (4.40 mg/100g) that was statistically like T_7 treatment (4.14 mg/100g). The lowest zinc content was recorded in T_5 formulations (2.20 mg/100g) (Table 2).

OFSP was reported to be 0.63 - 15.26 mg/100g of iron, whereas maize (2.71 mg/100g), rice (0.8 mg/100g), wheat (3.19 mg/100g), potato (0.78 mg/100g), cassava (0.27 mg/100g), WFSP (0.61 mg/100g), and yam (0.54 mg/100g) reported to be lesser than the OFSP [36]. The RDA of iron is 1.8 mg in adults, and merely 10% - 30% of the Fe in diet is bioavailable [29,30]. Considering iron content, significant variations were recorded among the treatments. The T_2 formulation exhibited maximum (7.46 mg/100g) amount of iron content followed by T_3 (6.84 mg/100g) while the lowest (3.66 mg/100g) was observed in T_{11} when the breads prepared only with wheat flour (Table 2),

Treatments	Beta carotene (mg/100g)	Vitamin C (mg/100g)	Zinc content (mg/100g)	Iron Content (mg/100g)
T_1	1.34 c	2.82 a	2.66 bc	6.07 c
T_2	0.32 g	2.04 c	2.90 b	7.46 a
T_3	0.98 d	2.52 b	2.87 b	6.84 b
T_4	2.91 a	2.61 b	2.51 c	5.88 c
T_5	0.05 i	2.92 a	2.20 d	4.17 gh
T_6	0.80 e	1.66 d	2.72 bc	4.15 gh
T_7	0.20 h	1.20 f	4.14 a	5.18 de
T_8	0.60 f	1.48 e	2.64bc	5.56 cd
T_9	1.69 b	1.53 e	2.83 b	4.74 cf
T_{10}	0.04 i	1.72 d	2.72 bc	4.43 fg
T_{11}	0.03 i	0.00 g	4.40 a	3.66 h
CV (%)	3.01	2.32	3.12	3.46

***Table 2**: Beta carotene, vitamin c, zinc and iron content of breads made from OFSP puree and wheat flour.*

Note: T_1 = 50% BARI SP 4+50% Wheat Flour, T_2 = 50% BARI SP 8+50% Wheat Flour, T_3 = 50% BARI SP 12+50% Wheat Flour, T_4 = 50% BARI SP 15+50% Wheat Flour, T_5 = 50% local variety+50% Wheat Flour, T_6 = 30% BARI SP 4+70% Wheat Flour, T_7 = 30% BARI SP 8+70% Wheat Flour, T_8 = 30% BARI SP 12+70% Wheat Flour, T_9 = 30% BARI SP 15+70% Wheat Flour, T_{10} = 30% Local Variety SP 4+70% Wheat Flour and T_{11} = 100% Wheat Flour; Means with the same letter are not significantly different.

this variation on iron content due to the use of puree of different sweetpotato varieties and wheat flour used for making breads. The present study suggested that, considering the bioavailability of iron in diets (10 - 30%), around 70 - 100% of the daily requirement of iron can easily be met up when a person consumes breads made of OFSP.

Beta carotene, vitamin C, zinc and iron content of cake

Carotenes are very high in OFSP compared to the common consuming yellow to orange vegetables and fruits. The minerals are moderately present in OFSP, calcium, magnesium, zinc and sodium are reported in very less concentrations, but phosphorus and potassium are reported in moderate concentrations, and iron is reported in good concentrations [19]. As reported by the Khalid Gul., *et al.* [32] the carotenoid concentration in different foods, such as carrot (43.5 - 88.4 μg/g), mango (10.9 - 12.1 μg/g), and tomato (2.17 - 2.83 μg/g), contain the lower concentration of the BC than the OFSP. OFSP varieties have been recognized as an excellent source of β-carotene where light yellow and purple flesh samples contain in range of 0.1 to 0.6 mg/100g FW [33]. In our present study, β-carotene content in cake varied significantly among the treatments. The highest beta carotene (1.04 mg/100g) was noted in T_4 formulation followed by T_9 formulation (0.63 mg/100g). In T_5, T_{10} and T_{11} formulations, the beta carotene content was very low, and it was 0.02 mg/100g (Table 3). As mentioned by Grace., *et al.* [26] that the carotenoid content of OFSP can vary depending on cultivar and growing environment also.

Vit. C is known as one of the most effective nutrients, and involves in immune system functions, prenatal health problems, eye disease, and skin wrinkling [34]. Adult men and women require 90 and 75 mg of the Vit. C as the RDA, respectively [35]. Considering the present study, vitamin C content varied significantly among the studied formulations. The maximum vitamin C content was recorded in T_5 treatment (1.07 mg/100g) which was statistically identical to T_1 treatment (1.04 mg/100g) which is very minimal compared to the daily requirement. Present findings are also in agreement with the finding of Grace *et al.* [26] where they reported that, Vit. C concentration in OFSP is 870 µg/g (db), which is very less than the different fruits and vegetables. On the other hand, the cake prepared using T_{11} formulation showed no vitamin C concentration at all (Table 3).

Zinc content in cake showed significant variation among the treatments. The present study revealed that cake made from 100% wheat flour (T_{11}) contained the highest amount of zinc compere to other combinations with sweetpotato puree. Table 3 shows the maximum zinc content was recorded in T_{11} treatment (1.43 mg/100g) followed by T_5 treatment (1.29 mg/100g) and T_9 treatment (1.25 mg/100g) and the lowest was noted in T_1 treatment (0.91 mg/100g). Endrias., *et al.* [28]; Lyimo., *et al.* [29]; Nicanuru., *et al.* [30] also reported the same results where OFSP contained lower amount of zinc (0.24 - 0.93 mg/100g) compared to wheat (2.65 mg/100g).

According to USDA [36], OFSP contained higher amount to iron (0.63 - 15.26 mg/100g) compared to wheat (3.19 mg/100g) and Recommended Dietary Allowances (RDAs) of iron is 1.80 mg/day in adults, and nearly 10 - 30% of the Fe in diet is bioavailable [29,30]. In the present study, significant variation was recorded among different treatments in terms of iron content of cake. Results showed that the iron content in the cake ranged from 5.58 to 3.39 mg/100g. The highest iron content (5.58 mg/100g) recorded in treatment T_2 while, the lowest (3.39 mg/100g) was found in T_{11} treatment (Table 3), the present findings supported the statement mentioned by USDA [36]. So, the present study suggested that cakes prepared from sweetpotato is good source of iron that can easily meet up 60 - 93% of the daily requirement of iron of a person if we consider 10 - 30% bioavailability of iron in diets.

Treatments	Beta carotene (mg/100g)	Vitamin C (mg/100g)	Zinc content (mg/100g)	Iron Content (mg/100g)
T_1	0.48 c	1.04 a	0.91 d	3.95 f
T_2	0.12 g	0.75 c	1.00 cd	5.58 a
T_3	0.37 d	0.93 b	0.94 d	4.61c
T_4	1.04 a	0.96 b	1.02 cd	4.31e
T_5	0.02 i	1.07 a	1.29 ab	4.44 d
T_6	0.30 e	0.63 d	1.21 b	3.61gh
T_7	0.08 h	0.45 f	1.21 b	5.30 b
T_8	0.22 f	0.56 e	1.17 bc	3.72 g
T_9	0.63 b	0.57 e	1.25 ab	3.59 h
T_{10}	0.02 i	0.64 d	1.22 b	3.63 gh
T_{11}	0.02 i	0.00 g	1.43 a	3.39 i
CV (%)	3.21	2.28	5.37	0.99

Table 3: *Beta carotene, vitamin C, zinc and iron content of cake made from OFSP puree and wheat flour.*

Note: T_1 = 50% BARI SP 4+50% Wheat Flour ,T_2 = 50% BARI SP 8+50% Wheat Flour, T_3 = 50% BARI SP 12+50% Wheat Flour, T_4 = 50% BARI SP 15+50% Wheat Flour, T_5 = 50% Local Variety+50% Wheat Flour, T_6 = 30% BARI SP 4+70% Wheat Flour, T_7 = 30% BARI SP 8+70% Wheat Flour, T_8 = 30% BARI SP 12+70% Wheat Flour, T_9 = 30% BARI SP 15+70% Wheat Flour, T_{10} = 30% Local Variety SP 4+70% Wheat Flour and T_{11} = 100% Wheat Flour; Means with the same letter are not significantly different.

Sensory evaluation

Sensory quality of food products measures degree of acceptance [37]. Sensory characteristics such as appearance, color, flavor, taste and overall acceptability were considered for this study.

Sensory evaluation of bread

The sensory evaluation score of the bread is presented in table 4. Appearance scores of the bread were fair to very good except T_7 formulation. The highest appearance scores were recorded in T_9 formulation (4.80 ± 0.11) followed by T_{11} formulations (4.33 ± 0.12) and the lowest was observed in T_7 (2.53 ± 0.26).

Color is recognized as the only attribute that consumers can base their purchasing decisions on [38]. The color acceptability of the bread was raged from 4.40 ± 0.16 to 2.87 ± 0.31 and it was between fair to good in all formulations except T_7 formulation (Table 4).

The flavor acceptability score of the breads was between 3.27 ± 0.25 and 3.93 ± 0.23 and had no remarkable difference among them. The flavors of breads of all formulations were between fair to good. (Table 4).

Regarding taste acceptability scores, the bread score ranged between 3.40 ± 0.25 and 4.07 ± 0.21 that was fair to very good in all formulations of breads. The bread made through T_9 formulations recorded the highest score 4.07 ± 0.21 (good to very good) (Table 4).

Treatment	Appearance	Color	Flavor	Taste
T_1	3.73 ± 0.25	3.80 ± 0.17	3.27 ± 0.18	3.67 ± 0.13
T_2	3.20 ± 0.33	3.33 ± 0.27	3.53 ± 0.26	3.67 ± 0.27
T_3	3.80 ± 0.26	3.60 ± 0.24	3.33 ± 0.29	3.47 ± 0.27
T_4	4.33 ± 0.16	4.20 ± 0.17	3.53 ± 0.13	3.87 ± 0.17
T_5	3.87 ± 0.19	3.87 ± 0.13	3.47 ± 0.27	3.4 ± 0.21
T_6	3.93 ± 0.15	3.87 ± 0.17	3.87 ± 0.17	3.93 ± 0.15
T_7	2.53 ± 0.26	2.87 ± 0.31	3.27 ± 0.25	3.40 ± 0.25
T_8	3.87 ± 0.17	3.80 ± 0.17	3.67 ± 0.19	3.67 ± 0.25
T_9	4.80 ± 0.11	4.40 ± 0.16	3.93 ± 0.23	4.07 ± 0.21
T_{10}	3.93 ± 0.15	3.93 ± 0.07	3.87 ± 0.19	3.80 ± 0.17
T_{11}	4.33 ± 0.12	4.23 ± 0.15	3.83 ± 0.11	3.71 ± 0.15

Table 4: *Sensory properties of bread made from different formulations of OFSP puree and wheat flour.*

Note: T_1 = 50% BARI SP 4+50% Wheat Flour, T_2 = 50% BARI SP 8+50% Wheat Flour, T_3 = 50% BARI SP 12+50% Wheat Flour, T_4 = 50% BARI SP 15+50% Wheat Flour, T_5 = 50% local variety+50% Wheat Flour, T_6 = 30% BARI SP 4+70% Wheat Flour, T_7 = 30% BARI SP 8+70% Wheat Flour, T_8 = 30% BARI SP 12+70% Wheat Flour, T_9 = 30% BARI SP 15+70% Wheat Flour, T_{10} = 30% BARI SP 4+70% Wheat Flour and T_{11} = 100% Wheat Flour; and Overall Scale: 5 = Very good; 4 = Good; 3 = Fair; 2 = Bad and 1 = Very bad.

The overall acceptability score of bread ranged between 2.93 to 4.20. At T_9 formulation, the overall acceptability was noted maximum (4.20) followed by T_6 and T_{10} (4.00) and the lowest acceptability score (2.93) was found in T_2 Formulation. Considering sensory attributes, the panelists accepted all the breads made from different formulations except T_2 formulation as fair to very good (Figure 1).

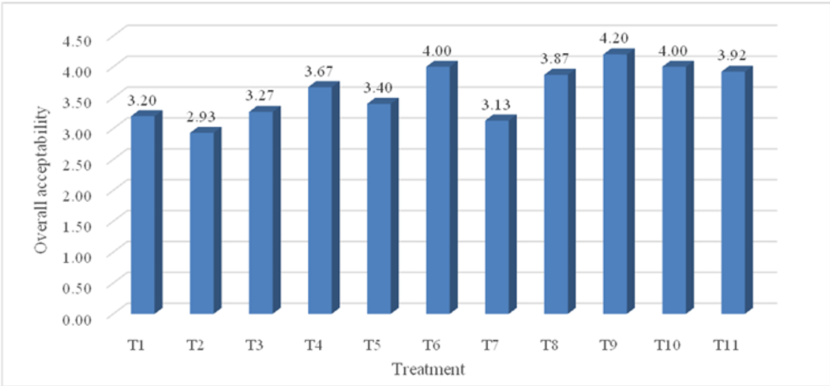

Figure 1: *Overall acceptability of bread made from different formulations of OFSP puree and wheat flour.*

Note: T_1 = 50% BARI SP 4+50% Wheat Flour, T_2 = 50% BARI SP 8+50% Wheat Flour, T_3 = 50% BARI SP 12+50% Wheat Flour, T_4 = 50% BARI SP 15+50% Wheat Flour, T_5 = 50% local variety+50% Wheat Flour, T_6 = 30% BARI SP 4+70% Wheat Flour, T_7 = 30% BARI SP 8+70% Wheat Flour, T_8 = 30% BARI SP 12+70% Wheat Flour, T_9 = 30% BARI SP 15+70% Wheat Flour, T_{10} = 30% BARI SP 4+70% Wheat Flour and T_{11} = 100% Wheat Flour; and Overall Scale:5 = Highly acceptable, 4 = Acceptable, 3 = Neutral, 2 = Less acceptable and 1 = Not acceptable.

Sensory evaluation of cake

According to appearance of the cake, the highest score was recorded in T_9 formulations (4.27 ± 0.18) and the lowest was observed in T_5 formulation (2.80 ± 0.20). The appearance acceptance of the cake was treated as fair to good by the panelist except T_5 and T_3 formulation (Table 5). Considering color of the cake, from table 5 it was revealed that the highest score of color was recorded in T_9 formulation (4.07 ± 0.18) and the lowest (2.80 ± 0.17) was recorded in T_5 formulation (Table 5).

Regarding flavor acceptability of cakes, the score ranged between 3.13 ± 0.24 and 3.87 ± 0.19 and all the cakes made from different formulations were treated as fair to good by the panelists (Table 5). The taste score of cake was also treated as fair to good. Table 5 revealed that the highest score (4.00 ± 0.17) was found in cake made from T_8 formulation and the lowest was recorded in T_5 formulation (3.13 ± 0.24).

Treatment	Appearance	Color	Flavor	Taste
T_1	3.47 ± 0.17	2.93 ± 0.23	3.33 ± 0.19	3.27 ± 0.23
T_2	3.80 ± 0.11	3.93 ± 0.21	3.47 ± 0.19	3.93 ± 0.18
T_3	2.93 ± 0.15	3.27 ± 0.21	3.53 ± 0.22	3.27 ± 0.28
T_4	3.47 ± 0.24	3.60 ± 0.21	3.53 ± 0.24	3.80 ± 0.24
T_5	2.80 ± 0.20	2.80 ± 0.17	3.13 ± 0.24	3.13 ± 0.24
T_6	3.80 ± 0.14	3.27 ± 0.12	3.73 ± 0.15	3.80 ± 0.11
T_7	3.87 ± 0.13	3.80 ± 0.14	3.87 ± 0.19	3.80 ± 0.22
T_8	3.80 ± 0.22	3.80 ± 0.17	3.53 ± 0.17	4.00 ± 0.17
T_9	4.27 ± 0.18	4.07 ± 0.18	3.67 ± 0.19	3.93 ± 0.18
T_{10}	3.33 ± 0.25	3.77 ± 0.26	3.40 ± 0.24	3.47 ± 0.24
T_{11}	3.99 ± 0.16	3.71 ± 0.18	3.56 ± 0.16	3.57 ± 0.17

Table 5: *Sensory properties of cake made from different formulations of OFSP puree and wheat flour.*

Note: T_1 = 50% BARI SP 4+50% Wheat Flour T_2 = 50% BARI SP 8+50% Wheat Flour, T_3 = 50% BARI SP 12+50% Wheat Flour, T_4 = 50% BARI SP 15+50% Wheat Flour, T_5 = 50% local variety+50% Wheat Flour, T_6 = 30% BARI SP 4+70% Wheat Flour, T_7 = 30% BARI SP 8+70% Wheat Flour, T_8 = 30% BARI SP 12+70% Wheat Flour, T_9 = 30% BARI SP 15+70% Wheat Flour, T_{10} = 30% Local Variety+70% Wheat Flour, T_{11} = 100% Wheat Flour; and Overall Scale: 5 = Very good; 4 = Good; 3 = Fair; 2 = Bad and 1 = Very bad.

The overall acceptability score of cakes made from different formulations were accepted as fair to good except T_1 and T_3 formulation. The highest (3.87) overall acceptability score of cake was found with T_9 formulations and the lowest (2.87) was recorded in cake made with T_1 and T_3 formulations (Figure 2).

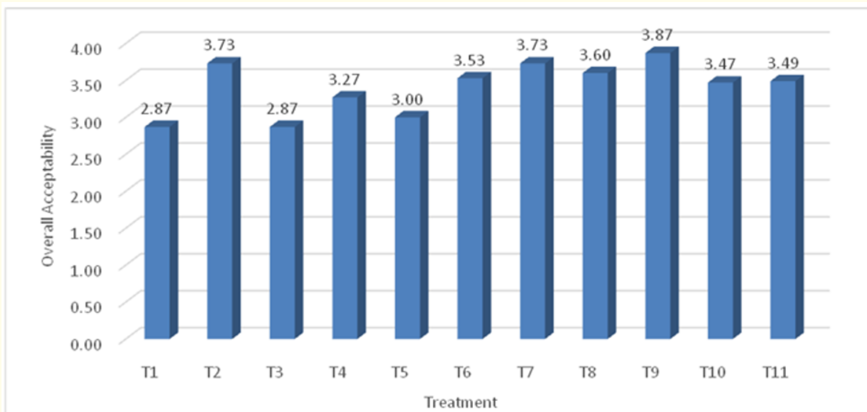

***Figure 2:** Overall acceptability of cake made from different formulations of OFSP puree and wheat flour.*

Note: T_1 = 50% BARI SP 4+50% Wheat Flour, T_2 = 50% BARI SP 8+50% Wheat Flour, T_3 = 50% BARI SP 12+50% Wheat Flour, T_4 = 50% BARI SP 15+50% Wheat Flour, T_5 = 50% Local Variety+50% Wheat Flour, T_6 = 30% BARI SP 4+70% Wheat Flour, T_7 = 30% BARI SP 8+70% Wheat Flour, T_8 = 30% BARI SP 12+70% Wheat Flour, T_9 = 30% BARI SP 15+70% Wheat Flour, T_{10} = 30% Local Variety+70% Wheat Flour and T_{11} = 100% Wheat Flour; and Overall Scale: 5 = Highly acceptable, 4 = Acceptable, 3 = Neutral, 2 = Less acceptable and 1 = Not acceptable.

Conclusion

According to the findings of the above study, it could be concluded that when orange fleshed sweet potato puree is potentially used as food ingredient in baking products (bread, and cake), it can enrich beta carotene, vitamin C and iron content but not enriches zinc content. Based on their overall nutrient contribution, T_4 formulation contributed the highest beta carotene followed by T_9 formulation, T_5 formulation contributed the highest vitamin C and T_2 formulation contributed maximum iron content in the baking products. The sensory attributes of the products developed from OFSP puree were accepted by the panelists as fair to very good, indicating that all are accepted but T_9 formulation are well accepted. Due to higher acceptability, T_9 formulation could be used for improving nutritional content of bakery products, especially bread, and cake as well as being good substitutes for wheat flour and possibly for other baking products.

Bibliography

1. Rahaman EHMS., *et al*. “Farmers’ preference and suitability assessment of BARI released orange-fleshed sweet potato varieties in charlands of Gaibandha”. *Bangladesh Horticulture* 2.2 (2016): 1-11.
2. BBS. Yearbook of Agricultural Statistics. Bangladesh Bureau of Statistics, Statistics and Informatics Division, Ministry of Planning, Government of The Peoples Republic of Bangladesh, Dhaka (2020): 358.
3. Rabbani MG. “Rapid Market Survey on Sweetpotato for SUSTAIN Project”. *International Potato Center, Dhaka, Bangladesh* (2015): 46.

4. Sorwar MA., *et al*. "Value chain analysis of sweet potato in two districts of Bangladesh". *International Journal of Agricultural Marketing* 2.3 (2015): 078-083.
5. Jaarsveld PJV., *et al*. "Retention of carotene in boiled, mashed orange-fleshed sweet potato". *Journal of Food Composition and Analysis* 19 (2006): 321-329.
6. Anbuselvi S., *et al*. "A comparative study on biochemical constituents of sweet potatoes from Orissa and Tamilnadu and its curd formation". *Journal of Chemical and Pharmaceutical Research* 4.11 (2012): 4879-4882.
7. Mohanraj R and Sivasankar S. "Sweet potato (*Ipomoea batatas* [L.]) - A valuable medicinal food: A review". *Journal of Medicinal Food* 17.7 (2014): 733-741.
8. Assefa T., *et al*. "Summary of progress on orange fleshed sweet potato research and development in Ethiopia". Proceedings of the 13th ISTRC Symposium, Ethiopia (2007): 728-773.
9. Bezabih E and N Mengistu. "Potato value chain analysis and development in Ethiopia case of Tigray and SNNPR regions". International Potato Center (CIP-Ethiopia), Addis Ababa Ethiopia (2011): 31-45.
10. ADA (The American Dietetic Association). Position of the American Dietetic Association". Food Fortification and Dietary Supplements (2002).
11. Coronel P., *et al*. "Aseptic processing of sweet potato purees using a continuous flow microwave system". *Journal of Food Science* 70 (2005): 531-536.
12. Elkhalifa AE and AH El-Tinay. "Effect of cysteine on bakery products from wheat-sorghum blends". *Food Chemistry* 77 (2002): 133-137.
13. Okoye JI., *et al*. "Production, proximate composition and consumer acceptability of biscuits from wheat/soybean flour blends". *Continental Journal of Food Science and Technology* 2 (2008): 6-13.
14. Vitali D., *et al*. "Effects of incorporation of integral raw materials and dietary fiber on the selected nutritional and functional properties of biscuits". *Food Chemistry* 114 (2009): 1462-1469.
15. Nagata M and Yamashita I. "Simple Method for Simultaneous Determinations of Chlorophyll and Carotenoids in Tomato Fruit". *Nippon Shokuhin Kogyo Gakkaish* 39 (1992): 925-928.
16. Ranganna S. "Handbook of Analysis and Quality Control for Fruits and Vegetable Products". 7th Edition, Tata McGraw Hill Book Co., New Delhi (2001): 594-625.
17. Peterson L. "Analytical methods Soil, water Plant Material, Fertilizer, SRDI". 3rd edition (2016).
18. Abidin PE., *et al*. "Training of trainers' module for orange-fleshed sweetpotato (OFSP)". *Sub-Saharan Africa: Nutrition Department of the Ghana Health Service* (2015).
19. Neela S and Fanta SW. "Review on nutritional composition of orange-fleshed sweet potato and its role in management of vitamin A deficiency". *Food Science and Nutrition* 7.6 (2019): 1920-1945.
20. Low JW., *et al*. "A food-based approach introducing orange-fleshed sweet potatoes increased vitamin A intake and serum retinol concentrations in young children in rural Mozambique". *Journal of Nutrition* 137.5 (2007): 1320-1327.

21. Nzamwita M., *et al*. "Stability of β-carotene during baking of orange-fleshed sweet potato-wheat composite bread and estimated contribution to vitamin A requirements". *Food Chemistry* 228 (2017): 85-90.

22. Kolawole FL., *et al*. "Physicochemical properties of novel cookies produced from orange-fleshed sweet potato cookies enriched with sclerotium of edible mushroom (*Pleurotus tuber regium*)". *Journal of the Saudi Society of Agricultural Sciences* (2018): 1-5.

23. Pillay K., *et al*. "Acceptance of an orange- fleshed sweet potato complementary food by infant caregivers in KwaZulu-Natal Province - A preliminary study". *The South African Journal of Child Health* 12.3 (2018): 100-104.

24. Alam MK., *et al*. "Comparison of the proximate composition, total carotenoids and total polyphenol content of nine orange-fleshed sweet potato varieties grown in Bangladesh". *Foods* 5 (2016): 1-10.

25. Islam SN., *et al*. "Carotenoids and β-carotene in orange fleshed sweet potato: A possible solution to vitamin A deficiency". *Food Chemistry* 199 (2016): 628-631.

26. Grace MH., *et al*. "Phytochemical changes in phenolics, anthocyanins, ascorbic acid, and carotenoids associated with sweetpotato storage and impacts on bioactive properties". *Food Chemistry* 145 (2014): 717-724.

27. Chausmer AB. "Zinc, insulin and diabetes". *Journal of the American College of Nutrition* 17.2 (1998): 109-115.

28. Endrias D., *et al*. "Comparison of three sweet potato (*Ipomoea batatas* (L.) Lam) varieties on nutritional and anti-nutritional factors". *Global Journal of Science Frontier Research: D Agriculture and Veterinary* 16.4 (2016): 1-11.

29. Lyimo M., *et al*. "Effect of processing methods on nutrient contents of six sweet potato varieties grown in lake zone of Tanzania". *Tanzania Journal of Agricultural Sciences* 10.1 (2010): 55-61.

30. Nicanuru C., *et al*. "Effect of sun- drying on nutrient content of orange fleshed sweet potato tubers in Tanzania". *Sky Journal of Food Science* 4.7 (2015): 91-101.

31. Wanasundera JPD and Ravindran G. "Nutritional assessment of yam (*Dioscorea alata*) tubers". *Plant Foods for Human Nutrition* 46.1 (1994): 33-39.

32. Khalid Gul., *et al*. "Chemistry, encapsulation, and health benefits of β-carotene - A review". *Cogent Food and Agriculture* 1 (2015): 1.

33. Teow CC., *et al*. "Antioxidant activities, phenolic and β-carotene contents of sweet potato genotypes with varying flesh colours". *Food Chemistry* 103.3 (2007): 829-838.

34. Vitamin C and Eye Health. "Handbook of nutrition and ophthalmology Totowa". NJ: Humana Press (2007): 371-390.

35. Naidu KA. "Vitamin C in human health and disease is still a mystery? An overview". *Nutrition Journal* 2 (2003): 7.

36. USDA. USDA food compositional database (2018).

37. Muresan C., *et al*. "Sensory evaluation of bakery products and its role in determining of the consumer preferences". *Journal of Agroalimentary Processes and Technologies* 18.4 (2012): 304-306.

38. Surkan S., *et al*. "Influence of storage conditions on sensory shelf-life of yerba mate". *Journal of Food Quality* 32 (2009): 58-72.

Volume 17 Issue 12 December 2022