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Development of Nutrient Rich Value-added Biscuit through Incorporation of Orange-fleshed Sweetpotato Puree

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Abstract**—** *In Bangladesh bakery and confectionery industry has become almost self-sufficient in meeting the local demand. But the products produce from the factories cannot fulfill nutritional demand of the people of Bangladesh as wheat flour is the main ingredient of the bakery products. Orange Fleshed Sweetpotato is a promising root crop due to high beta carotene content and other vitamins and minerals could be used to reduce the gap of nutritional demand. The experiment was conducted with four BARI (Bangladesh Agricultural Research Institute) released orange fleshed sweetpotato varieties and a local cultivar at the GUK's 'Super Tasty Food' Products Factory, Nashratpur, Gaibandha, Bangladesh during 2020-21 cropping season. The aim of the study was to develop nutrient rich value-added biscuit for the consumers. Eleven treatments (formulations) were used to develop biscuit. The highest amount of beta carotene content was recorded in T_4 treatment (1.67 mg/100g) followed by T_9 treatment (0.84 mg/100g) and the lowest was obtained from T_{11} treatment (0.01 mg/100g). Maximum amount of vitamin C detected in T_5 treatment (1.81 mg/100g) which was statistically similar to T_1 treatment (1.74 gm/100g) and no Vitamin C was found in T_{11} treatment. Zinc content found maximum in T_{11} treatment (2.04 mg/100g) while the lowest was observed in T_5 treatment (1.12 mg/100g). The highest amount of iron was recorded in T_3 treatment (6.52 mg/100g) which is significantly similar to treatment T_2 (6.43 mg/100g) and T_8 (6.09 mg/100g), respectively. The entire sensory attributes of value-added biscuit were accepted as fair to very good and have no remarkable difference from traditional biscuits (T_{11}). The overall acceptability of the biscuit was found to be highest in T_9 treatment (good to very good).*

Keywords**—** ***Sweetpotato puree, sweetpotato biscuit, nutrient analysis, sensory evaluation.***

I. INTRODUCTION

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. Anemia is also highly prevalent among children

in Bangladesh and few programs have been initiated to improve their iron status.

Sweetpotato (*Ipomoea batatus*) is an important staple crop in many parts of the world (Rahaman *et al.* 2016). 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 (Van 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 Bangladesh. There is limited information on processing of OFSP to other products or considering it as an additional ingredient for baked foods (Assefa *et al.,* 2007) 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 (Coronel *et al*., 2005). 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 (Okoye *et al.,* 2008; Vitali *et al.,* 2009).

The production of biscuit is mainly based on wheat flours. In recent studies, new ingredients were included in the production of biscuit products such as black gram 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.*, 2007; Bilgicli *et al*., 2007) to study changes on nutritional and organoleptic characteristics of biscuits. Biscuits can also be prepared by combining sweetpotato flours to wheat flour (Srivastava *et al.,* 2012).

The sweetpotato could be considered as an excellent novel source of natural health-promoting compounds such as β-carotene, zinc and iron, for the functional food market. Also, the 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. 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 import of wheat are increasing. Adding appropriate proportion of OFSP puree to wheat flour could have an advantage on the nutritional and economical aspects. Therefore, the aim of this study was to develop nutrient rich value-added biscuit through incorporation of OFSP puree.

II. MATERIALS AND METHODS

The experiments were carried out at Super Tasty Food Product Factory, Gana Unnayan Kendra (GUK), Nashratpur, Gaibandha district in 2021. The biscuits were developed through incorporation of sweetpotato puree. Four orange-fleshed sweetpotato (OFSP) varieties viz. BARI SP-4, BARI SP-8, BARI SP-12, BARI SP-15 and a popular white flesh local Sweetpotato variety were used in this study. Eleven treatments were used for making biscuits following Completely Randomized Design (CRD). The treatments were as follows , T_1=40% BARI SP 4+60% Wheat Flour, T_2=40% BARI SP 8 +60% Wheat Flour, T_3=40% BARI SP 12+60% Wheat Flour, T_4=40% BARI SP 15+60% Wheat Flour, T_5=40% Local Variety+60% Wheat Flour, T_6=20% BARI SP 4+80% Wheat Flour, T_7=20% BARI SP 8+80% Wheat Flour, T_8=20% BARI SP 12+80% Wheat Flour, T_9=20% BARI SP 15+80% Wheat Flour, T_{10}=20% Local Variety+80% Wheat Flour and T_{11}=100% Wheat Flour. The following steps were followed for making biscuits:

Step-I: Processing of orange-fleshed sweetpotato roots into puree

Initially, four BARI released OFSP varieties viz., BARI SP 4, BARI SP 8, BARI SP 12 and BARI SP 15 were collected from Development and Delivery of Biofortified Crops at Scale (DDBIO) project areas of Gaibandha district. Local variety of sweetpotato was collected from a farmer's field of Gaibandha. The roots were washed to remove all soil and dust particles and then boiled. After boiling, the skins of the roots were removed, and purees were prepared from each variety using an electric mixer.

Step II: Development of baking products

For preparation of biscuits, treatment wise basic ingredients were used. Other ingredients were used the same amount in every baking product for making biscuits. The standard procedures for making biscuit were followed as per GUK's Super Tasty Food Product Factory protocol.

Table 1. Ingredients used in biscuits

SL No.	Name of Ingredients	Amount
1	Sugar	600 gm
2	Oil	250 ml
3	Egg	60 ml
4	Salt	10 gm
5	Flavor	10 gm
6	Dalda	350gm

Nutrient Analysis of Biscuits:

Beta-carotene and vitamin C analyses of biscuits were done at the Food Processing and Preservation Laboratory of Hajee Mohammad Danesh Science and Technology University, Dinajpur and, Zinc and Iron content of bakery products were analyzed at the Soil Resources and Development Institute (SRDI), Dinajpur. β-carotene was determined according to the method of Nagata and Yamashita (1992). Vitamin C content of the products was estimated by titration method (Ranganna, 1986) using 2, 6- dichlorophenol indophenol dye solution. Iron and Zinc content were determined by Atomic Absorption Spectrophotometric methods directly in the undiluted filtrate following analytical method described by Petersen (2016).

Sensory Evaluation:

The biscuits developed through OFSP puree were subjected to sensory evaluation by a 15-members, semi trained panel made up of individuals who are familiar with the quality attributes of the products and do taste testing of the products regularly (factory experts, technical persons and students). The evaluations were done on 13 June 2021. Panelists were evaluated biscuit samples presented in a random order for appearance, color and taste, using scale 5=Very good, 4=Good, 3=Fair, 2=Bad and 1=Very bad and crispiness was evaluated using scale 5= Much more crunchy than I like, 4=More crunchy than I like, 3 = The way I like it; 2=Less crunchy than I like and 1 = Much less crunchy than I like). Overall acceptability was also measured using scale 5= Highly acceptable, 4=Acceptable, 3=Neutral, 2=Less acceptable and 1= Not acceptable.

Method of Data Analysis:

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

III. RESULTS AND DISCUSSION

Determining the beta-carotene, vitamin C, zinc and iron content are important for identifying and recommending acceptance and preference of the biscuits for the potential end users. The result of beta-carotene, vitamin C, zinc and iron content are shown in Table 2 and Table 3. The beta-carotene, vitamin C, zinc and iron content of biscuit, bread and cake varied significantly ($p<0.05$) depending on the formulations (treatment).

A) Beta carotene, vitamin C, zinc and iron content of biscuits

Considering beta carotene content, significant variation was observed in biscuits regardless of treatments. The highest beta carotene content was found in T_4 treatment (1.67 mg/100g) followed by T_9 (0.84 mg/100g) and T_1 (0.80 mg/100g) and the lowest was recorded in T_{11} treatment (0.01 mg/100g) (Table 2). This may be happened due to varietal characteristics of sweetpotato (SP) puree used in the treatments, as higher beta carotene content was recorded in the treatments where OFSP varieties puree was used, on the other hand, lowest beta carotene was recorded in T_{11} treatment where white fleshed SP variety puree was used.

The vitamin C content in biscuit products also varied significantly among the treatments. The vitamin C in biscuits was found the highest in T_5 treatment (1.81 mg/100g) which as statistically similar to T_1 (1.74 mg/100g) and no vitamin C was recorded in T_{11} treatment (Table 2). This may be also observed due to the variation of vitamin C content of the used sweetpotato varieties in different treatments.

Zinc content in biscuits was varied significantly in different treatments. In all the treatments, T_{11} treatment (biscuit made from 100% wheat flour) exhibited the highest zinc content (2.04 mg/100g) followed by T_3 treatment (1.84 mg/100g) and the lowest was recorded in T_5 (1.12 mg/100g) (Table 2). This may be happened due to the presence of higher amount of zinc in wheat flour.

Iron content also showed significant variation among the treatments. The treatment T_3 showed the highest iron content (6.52 mg/100g) which is statistically similar to T_2 (6.43mg/100g) and T_8 (6.09 mg/100g) (Table 2). The lowest iron content was recorded in T_4 treatment (2.84 mg/100g) that was statistically similar to T_5 treatment (2.95 mg/100g) (Table 2).

B) Sensory Evaluation of Biscuits

Sensory quality of any food products measures degree of acceptance (Muresan *et al.*, 2012). Sensory characteristics such as appearance, flavor, taste, crispiness and overall acceptability were considered for this study.

The entire sensory properties of biscuit are presented in Table 3. Appearance is the primary key attributes for accepting any food products by the consumers. Appearance score of the biscuits was ranged from 3.07±0.18 to 4.47±0.17. Biscuit made by T_4 formulation scored the highest compared to other formulations. The result revealed that appearance of biscuits of all formulations were varied from fair to very good.

Table 2. Beta carotene, Vitamin C, Zinc and Iron content of biscuit made from different formulations OFSP puree and wheat flour

Treatments	Beta carotene (mg/100g)	Vitamin C (mg/100g	Zinc content (mg/100g)	Iron Content (mg/100g)
T_1	0.80 b	1.74 a	1.30 e	4.31 b
T_2	0.19 f	1.26 c	1.32 e	6.43 a
T_3	0.59 c	1.55 b	1.84 b	6.52 a
T_4	1.67 a	1.61 b	1.15 f	2.84 d
T_5	0.02 h	1.81 a	1.12 f	2.95 d
T_6	0.40 d	0.91 de	1.22 ef	3.70 c
T_7	0.10 g	0.66 g	1.71 bc	4.37 b
T_8	0.30 e	0.82 f	1.53 d	6.09 a
T_9	0.84 b	0.84 ef	1.63 cd	3.62 c
T_{10}	0.02 h	0.95 d	1.53 d	4.06 bc
T_{11}	0.01 h	0.00 h	2.04 a	3.83 c
CV (%)	3.76	2.30	3.37	3.47

Note: T_1=40% BARI SP 4+60% Wheat Flour, T_2=40% BARI SP 8 +60% Wheat Flour, T_3=40% BARI SP 12+60% Wheat Flour, T_4=40% BARI SP 15+60% Wheat Flour, T_5=40% Local Variety+60% Wheat Flour, T_6=20% BARI SP 4+80% Wheat Flour, T_7=20% BARI SP 8+80% Wheat Flour, T_8=20% BARI SP 12+80% Wheat Flour, T_9=20% BARI SP 15+80% Wheat Flour, T_{10}=20% Local Variety+80% Wheat Flour and T_{11}=100% Wheat Flour; Means with the same letter are not significantly different.

Table 3. Sensory properties of biscuits made from different formulations of OFSP puree and wheat flour

Treatment	Appearance	Flavor	Crispiness	Taste
T_1	3.27±0.25	3.40±0.21	2.87±0.19	3.40±0.19
T_2	4.13±0.24	3.87±0.13	3.53±0.17	3.87±0.19
T_3	3.60±0.16	3.40±0.27	3.87±0.19	3.80±0.22
T_4	4.47±0.17	4.20±0.24	3.27±0.33	3.93±0.25
T_5	3.73±0.18	3.27±0.18	3.67±0.23	3.67±0.21
T_6	3.67±0.21	4.00±0.17	3.87±0.22	3.93±0.18
T_7	4.00±0.10	3.80±0.20	3.80±0.17	3.93±0.12
T_8	4.20±0.17	3.60±0.21	4.07±0.21	4.07±0.18
T_9	4.13±0.09	3.93±0.18	4.33±0.16	4.00±0.14
T_{10}	3.07±0.18	3.93±0.15	3.87±0.13	3.93±0.21
T_{11}	3.91±0.07	3.59±0.11	3.88±0.13	3.75±0.13

Note: T_1=40% BARI SP 4+60% Wheat Flour ,T2=40% BARI SP 8 +60% Wheat Flour, T_3=40% BARI SP 12+60% Wheat Flour, T_4=40% BARI SP 15+60% Wheat Flour, T_5=40% Local Variety+60% Wheat Flour, T_6=20% BARI SP 4+80% Wheat Flour, T_7=20% BARI SP 4+80% Wheat Flour, T_8=20% BARI SP 4+80% Wheat Flour, T_9=20% BARI SP 12+80% Wheat Flour, T_{10}=20% BARI SP 15+80% Wheat Flour, and T_{11}=100% Wheat Flour; Overall Scale: 5-Very good; 4-Good; 3-Fair; 2-Bad and 1-Very bad

Flavor score of the biscuit was between 3.27±0.18 to 4.20±0.24 and it was also ranged from fair to very good of all formulations (Table 3).

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). From the Table 3 shows that crispness score of the biscuits ranged from 2.87±0.19 to 4.33± 0.16. Biscuits made with T_9 formulation recorded higher crispiness (4.33± 0.16) followed by T_8 (4.07±0.21) while the biscuits made with T_1 formulation scored the lowest (2.87±0.19).

Regarding taste scores, the biscuits score ranged between 3.40±0.19 and 4.07±0.18 (Table 3). The taste acceptance score of all biscuits made from different formulations were more or less similar and treated as fair to very good (Table 3).

The overall acceptability score of biscuits was found the highest in T_9 formulation and it was 4.00 and the lowest acceptability score (3.20) was found in T_1 formulation. All the biscuits made from different formulations were accepted as fair to good by the panelist (Fig 1.).

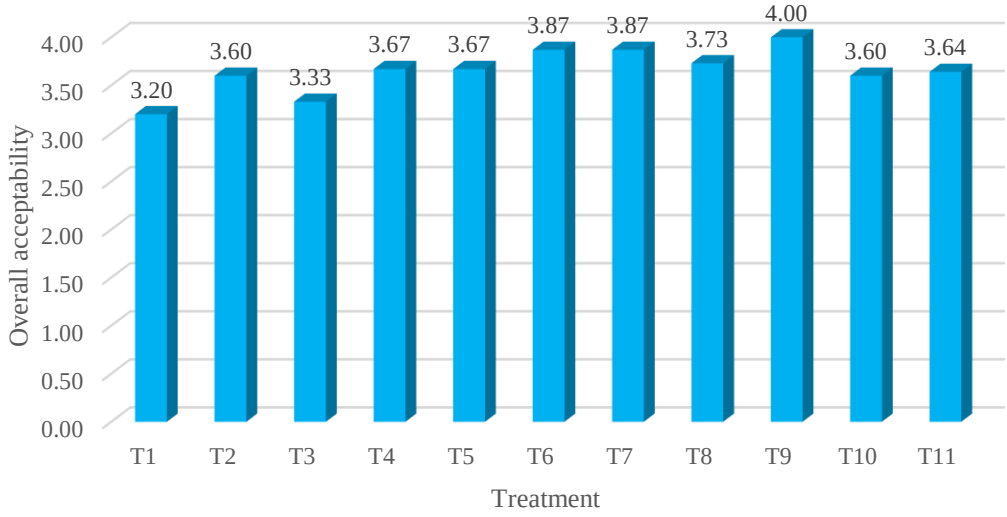

Fig. 1. Overall acceptability of biscuit made from different formulations of OFSP puree and wheat flour

Note: T_1=40% BARI SP 4+60% Wheat Flour T2=40% BARI SP 8 +60% Wheat Flour, T_3=40% BARI SP 12+60% Wheat Flour, T_4=40% BARI SP 15+60% Wheat Flour, T_5=40% local variety+60% Wheat Flour, T_6=20% BARI SP 4+80% Wheat Flour, T_7=20% BARI SP 8+80% Wheat Flour, T_8=20% BARI SP 12+80% Wheat Flour, T_9=20% BARI SP 15+80% Wheat Flour, T_{10}=20% Local Variety+80% Wheat Flour, T_{11}=100% Wheat Flour; Overall Scale: 5= Highly acceptable, 4=Acceptable, 3=Neutral, 2=Less acceptable and 1= Not acceptable

IV. CONCLUSION

According to the findings of the above study, it could be concluded that when orange fleshed sweetpotato puree is potentially used as food ingredient in biscuits preparation, 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 content followed by T_9 formulation, T_5 formulation contributed the highest vitamin C and T_3 formulation contributed maximum iron content followed by T_2 and T_8 in the biscuits. The sensory attributes of the biscuits developed from OFSP puree 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 the development of nutrient rich value-added biscuits which may be the best substitutes for wheat flour and possibly for other baking products in Bangladesh.

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