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Production and Quality Evaluation of Cookies Enriched with β-Carotene by Blending Orange-Fleshed Sweet Potato and Wheat flours for Alleviation of Nutritional Insecurity

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Abstract The study was conducted to evaluate the supplementing effect of orange-fleshed sweet potato (OFSP) root flour to wheat flour at 0, 10, 20, 30 and 40% (BP_0, BP_1, BP_2, BP_3 and BP_4 respectively) level on nutritional and organoleptic acceptability of supplemented cookies. The data generated were statistically analyzed by one way analysis of variance (ANOVA) model using the SAS software program, version 9.3.1 standard methods. The proximate composition of composite flours cookies ash, crude fat, crude fiber and energy, β-carotene and iron contents increases as the proportion of OFSP flours increases in the blend. Whereas, crude protein, utilizable carbohydrates, zinc and phytate contents decreased as the proportion of OFSP flour increases in the composite flours. The minerals (iron and zinc) were bioavailable in the composite flours cookies and the effect of phytate could not hinder their bioavailability. Adding OFSP to wheat flour in 10, 20, 30 and 40% proportion showed more than average of panelist scores in overall acceptability of developed cookies. The present study showed potential of cookies enriched with OFSP for combating vitamin A deficiency (VAD). It is suggested that these product could be promoted as the new developed product to the VAD consumer to alleviating nutritional insecurity.

Keywords Phytate, Cookies, Composite flour, β-Carotene, Sensory evaluation

1. Introduction

Orange-fleshed sweet potato (OFSP) is one of locally available food crops used to overcome vitamin A deficiency (VAD) in East Africa (Low *et al.,* 1997). Ethiopia is one of the East Africa tropical countries with optimum good climate for cultivation of different varieties of sweet potato. In developing countries like Ethiopia OFSP is consumed in boiled, chip and flour forms. A large segment of the world's population especially in developing countries consume foods that are deficient in some micronutrients like vitamin A, iron and zinc (Long *et al*., 2007). Vitamin A deficiency (VAD) is a major public health risk in developing countries; children and pregnant/lactating women being the most vulnerable (FAO, 2002). Consumption of locally available vitamin A rich foods that can be grown in home gardens is one of the strategies to combat VAD due to its technical feasibility and cost-effectiveness. Orange-fleshed sweet potato (OFSP) flour can serve as a source of energy and nutrients, β-carotene (pro-vitamin A), minerals (Ca, P, Fe, Zn and K) and can add natural sweetness, color, flavor and dietary fiber to processed food products (Woolfe, 1992). Processing OFSP in to flour can make it more accepted as a traditionally processed food and possibility of incorporating β-carotene in cookies. The high fiber contents of sweet potato flour increases its utility in various new food product developments. Addition of various proportion of OFSP flour in wheat can increase the fiber and carotenoids nutritive values that help in lowering the wheat gluten level and prevents from celiac disease (Tilman *et al.,* 2003). Cookies are ready-to-eat with rich sources of protein, fat, carbohydrate, energy and minerals and convenient food product that are consumed among all age groups in many countries (Olaoye *et al.,* 2007). The aim of this study was also focus on developing pro-vitamin A rich cookies from composite flour of OFSP evaluating its nutritional contents and orgaloleptic acceptability. It is designed to combat VAD through food approaches by using cookies as vehicle.

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2. Materials and Methods

2.1. Materials

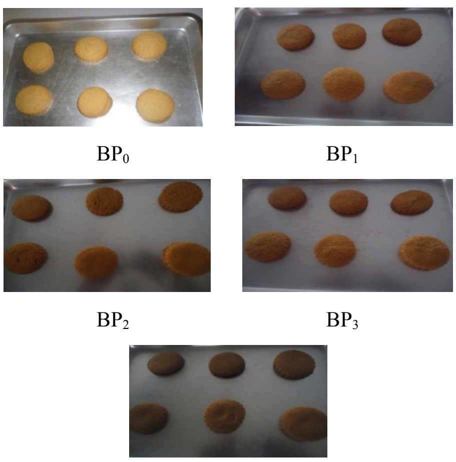
Orange-fleshed sweet potato (OFSP) of Kulfo variety was collected from Hawassa Agricultural Center. Five months old OFSP manually harvested in November, 2012 from Wondo Genet Woreda (district); 274 km south from Addis Ababa, Ethiopia. The orange-fleshed sweet potato (OFSP) was randomly taken and packed by sack and transported to Food Science Technology Laboratory, Hawassa University. The ingredients and wheat for making of cookies were purchased from the local market.

2.2. Sample Analysis

Chemical analyses were carried out at Public Health Research Institute, Addis Ababa, Ethiopia. All chemicals and reagents used in sample analyses were of analytical grade.

2.3. Preparation of Orange-Fleshed Sweet Potato (OFSP) and Wheat Flours

The non-damaged OFSP were sorted, washed by tap water, peeled by peeler (model W119901, H. Biaugeaud) and cut in to cubes by stainless steel knife and sliced into 2 mm by (model-CL 30, robot @ couple) slicer. The slices were immersed in 1% NaCl solution for 30 minutes. The sample was dried by solar dryer and milled in to flour using laboratory cutter-mixer (model R 23, robot @ couple). The milled OFSP flour was passed through 710 µm (Fritsch test sieve, Germany) to obtain uniform size flour. The flour was then packed in high-density poly ethylene (HDPE) bag, labeled and stored in dry and dark places till further use. Raw wheat was sorted, washed by potable water, sun dried, milled, sieved with similar sieve size, packed with HDPE bag and stored as above.



BP_0 BP_1 BP_2 BP_3 BP_4

BP_0 = OFSP: Wheat-0:100, BP_1 = OFSP: Wheat-10:90, BP_2 = OFSP: Wheat-20:80, BP_3 = OFSP: Wheat-30:70, and BP_4= OFSP: Wheat-40:60.

Figure 1. Orange-fleshed sweet potato & wheat flour blended baked cookies

2.4. Formulations of Composite Flour and Recipes

The formulations of composite flours were done according to the method of Tilman *et al.* (2003) with slight modifications. Blending of OFSP flour to wheat flour in the proportion of 10:90, 20:80, 30:70 and 40:60, and 100% soft wheat flour as control were made for cookies preparation. The recipes used in the development of cookies were composite flour (380 g), vegetable shortening (100 g), granulated cane sugar (225 g), beaten whole egg (21 g), salt (3.75 g), baking powder (1.8 g) and water (36 mL). Cookies were prepared using the procedure described by McWatters *et al.* (2003) with slight modifications (Figure 1).

2.5. Chemical Analysis of OFSP Flour Enriched Cookies

2.5.1. Proximate Analyses

Proximate analyses were determined according to the standard methods of (AOAC, 2000). Total nitrogen (TN) was determined using the micro-kjeldahl method. The crude protein content was obtained by multiplying TN by the conversion factor of 6.25 (% Protein = TN x 6.25), the crude fat, crude fiber, ash content, moisture content of the sample were determined using (AOAC, 2000). The utilizable carbohydrate content was determined by difference as follows: 100 – (ash + protein + fiber + fat + moisture). The energy content in kcal/100g was determined by adding percentages of crude fat, crude protein and carbohydrate after multiplying by factors of 9, 4 and 4 respectively (Shrestha and Noomhorm, 2002).

2.5.2. ß-Carotene Content of Cookies

The ß-carotene content of cookies was analyzed by following the procedure developed by Kimura & Rodriguez-Amaya (2003). Ten g of cookie sample was filtered in to 100 mL volumetric flask after it was blended by mortar and pestle with enough acetone. Mortar, funnel and residue was washed with small amount of acetone was received in flask. The residue was returned to the mortar to macerate, wash and filter as before again by adding fresh acetone. The extraction and filtration was repeated 3 times until the residue was devoid of any color and washings were colorless. After 25 mL of petroleum ether was poured in to a separator funnel; acetone extract was added in to it and shacked well. Small amount of distilled water was added to separate the two phases and to discard lower aqueous-acetone phase. It was washed 3 times with water to remove residual acetone. Petroleum ether phase was collected and dried with sodium sulphate and transferred to drying flask and evaporate to dryness on a rotary evaporator. The residue was dissolved in about 1 mL of petroleum ether and introduced the solution in to chromatogram column. The solution was eluted with petroleum ether and the β-carotene was collected in a flask goes through a column as a yellow pigment. The volume of β-carotene elutes was measured and the absorbance was read at 440 nm by Spectrophotometer based on the method of Khalil and Varananis (1996). The values of β-carotene was calculated by using the equation:

$$\beta\text{-carotenet } (\mu g/g) = \frac{A * V(mL) * 10^4}{A_{1\%,1cm} * W} \qquad (1)$$

Where: A - Absorbance, $A_{1\%, 1cm}$ - Absorption co-efficient 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 of the sample in gram

Conversion factor 12 β-carotene = 1RAE (USIM, 2001).

2.5.3. Phytate Content Determination

Phytate content of the samples were determined according to AOAC (2000). About 0.1 g of samples were extracted with 10 mL 2.4% HCl acid in mechanical shaker for 1 hour at an ambient temperature and centrifuged at 3000 rpm for 30 minutes. The clear supernatant was used for phytate estimation of the sample. One mL of Wade reagent (containing 0.03% solution of $FeCl_3.6H_2O$ and 0.3% of sulfosalicilic acid in water) was added to 3 mL of the sample solution (supernatant) and the mixture were mixed on a vortex mixer for 5 seconds. The absorbance of the sample solutions were measured at 500 nm using UV-Vis spectrophotometer. Three mL of standard were added into 15 mL of centrifuge tubes with 3 mL of water; which were used as a zero level (blank). One mL of the wade reagent was added to each test tube and the solution was mixed on a vortex mixer for 5 seconds. The mixture was centrifuged for 10 minutes and the absorbance of the solutions (both the sample and standard) were measured at 500 nm by using deionized water as sample blank. Values were expressed as of phytatic acids in mg/100 g dry weight by using the equation:

$$\text{Phytic acid in mg/100 g} = \{[(\text{Absorbance} - \text{Intercept})/(\text{Slop} * \text{Density} * \text{Weight of sample})] *10\} \quad (2)$$

2.5.4. Determination of Iron and Zinc Contents

Two gram of sample was weighed in to crucibles and ashen in a muffle furnace at 550°C for 1 hour. The crucibles were taken out from furnace and moisten with few drops of deionized water. The water on hot plate was evaporated and the sample ashen once more for 30 minutes at 550°C. After cooling the crucibles some drops of deionized water and 5 drops of concentrated HNO_3 was added. Finally the sample was ashen as above for 30 minutes at the same temperature and weighed after the crucibles was cooled in a desiccators for 50 minutes. The dissolution was held on by treating the ash by adding 5 mL 6N HCl with 15 mL of 3N HCl and filtered in to graduated flask. The blank was also prepared on the same procedures of sample and transferred to coded polyethylene bottles with samples. Iron and Zinc contents were determined by using flame atomic absorption spectrophotometer (FAAS) (model AA-20 Plus, Varian Spectra, Australia).

$$\text{Minerals content (mg/100 g)} = [(C_s - C_b) * V] / [10 * W] \quad (3)$$

Whereas: C_s - concentration of sample in ppm, C_b - concentration of blank in ppm, V - volume (mL) of extract, W - weight (g) of samples

2.5.5. Bioavailability

The bioavailability of iron and zinc was determined by measuring the molar ratio of phytate/minerals (iron or zinc) in the cookies based on the method of Morris and Ellis (1989). The calculated molar ratios were compared with critical value of phytate: zinc = 1.5 and phytate: iron = 0.4 (Frontela *et al*., 2008).

2.6. Physical Parameters

The diameter from the physical parameters of cookies was determined by placing six cookies edge to edge and by measuring it with ruler of mm and by rotating at an angle of 90° and the thickness by placing six cookies on top of one another based on method of AOAC (2000). Spread factor was determined from the calculated ratio of diameter to thickness and multiplied by 10 according to the method of Shrestha and Noomhorm (2002).

2.7. Sensory Evaluation

The sensory quality attributes of cookies were determined according to the procedures of McWatters *et al.* (2003). Ten (10) panelists were used from students of the School of nutrition, food science and technology, Hawassa University, Ethiopia. A nine-point hedonic scale with ranging from 1-9 was used. In the hedonic scale, 9 represented the highest score (like extremely), 8 (like very much), 7 (like moderately, 6 (like slightly), 5 (neither like nor dislike), 4 (dislike slightly), 3 (dislike moderately), 2 (dislike very much) and 1 (dislike extremely). Color, taste, texture, aroma and overall acceptability were the attributes selected to be evaluated. Prior to the day of the sensory evaluation, the panelists were given training in order to acquaint them with the test procedure and ensure that they give honest, individual opinion. They were reminded not to discuss with other panelists during the period of evaluation. They were instructed to rinse their mouths with water provided after tasting each sample. The sensory evaluation took place by mid-morning (10 am - 12 pm). This was to ensure that the panelists were neither hungry nor full during the evaluation period. Five samples were prepared and presented to the panelists. The samples were prepared using equal amounts of water and were presented in same type and color of plates.

2.8. Experimental Design and Statistical Analysis

Complete Randomized Design (CRD) was employed to observe the effect of blend proportion on the nutritional composition; physical and sensory parameters of the OFSP enriched cookies. Five cookies samples were prepared in triplicates. Data were analyzed by one way analysis of variance (ANOVA) model using the SAS software program, version 9.3.1 for windows. The results were reported as an average value of triplicate analysis (mean ± SD) to test the main effect of proportions in the formulation. Differences between treatments were determined by Fisher's Least

Significance Difference (LSD) method and statistical significance was set at $p < 0.05$.

3. Results

3.1. Nutritional Analysis of Composite Flours Cookies

3.1.1. Proximate Analysis of Orange-Fleshed Sweet Potato (OFSP) and Wheat Flour Cookies

The blended flour cookies proximate analysis of moisture, ash, crude protein, crude fat, crude fiber, carbohydrates and energy were determined according to standard methods are presented in (Table 1).

3.1.2. β-carotene

β-carotene is a major source and precursor of dietary vitamin A to human health and its contents are presented in (Figure 2).

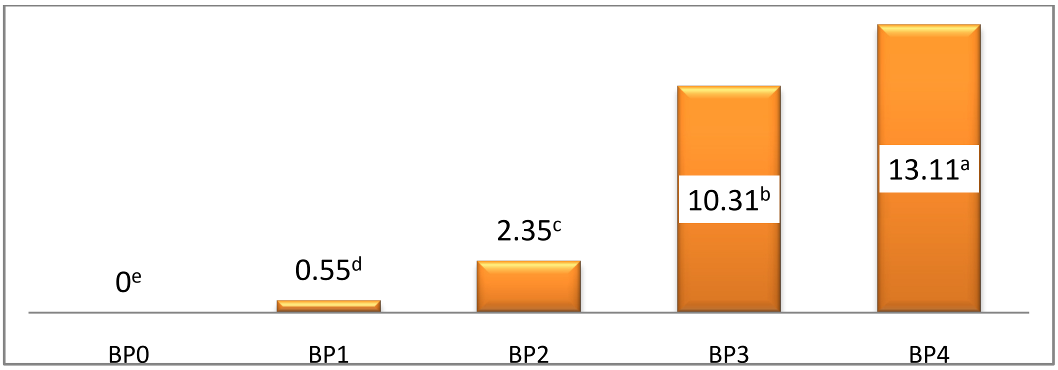
3.1.3. Iron, Zinc and Phytate Contents of Cookies Made from Composite Flours

Iron and zinc are essential trace elements in human nutrition and their deficiencies are major public health threats worldwide. Phytate is one of the anti-nutrients that make iron and zinc unavailable for human body utilization by forming complex ion with them. Iron, zinc and phytate contents and & bioavailability of iron and zinc values are presented in (Table 2).

Table 1. Effect of blending ratios on cookies proximate composition on dry weight basis (%)

s Blend	Moisture	Ash	Crude protein	Crude fat	Crude fiber	Carbohydrate	Energy (Kcal/100 g)
BP_0	12.27 ± 02^a	0.82 ± 0.01^e	6.32 ± 0.10^a	16.69 ± 0.02^e	0.11 ± 0.08^d	63.79 ± 0.11^a	431.56 ± 8.05^c
BP_1	11.15 ± 0.12^b	0.88 ± 0.01^d	6.13 ± 0.03^b	18.38 ± 0.15^d	0.13 ± 0.02^d	63.32 ± 0.13^a	444.63 ± 2.14^b
BP_2	10.66 ± 0.08^c	1.31 ± 0.03^c	5.93 ± 0.09^c	18.79 ± 0.07^c	0.22 ± 0.01^c	63.10 ± 0.04^{ab}	445.48 ± 0.32^b
BP_3	9.90 ± 0.02^d	1.51 ± 0.01^b	5.59 ± 0.05^d	19.46 ± 0.06^b	0.40 ± 0.04^b	63.01 ± 0.06^b	449.57 ± 0.60^{ab}
BP_4	9.66 ± 0.04^e	1.64 ± 0.02^a	5.36 ± 0.10^e	20.34 ± 0.09^a	0.57 ± 0.04^a	62.56 ± 0.25^c	454.57 ± 0.17^a

BP_0 = OFSP: Wheat-100:0.0, BP_1 = OFSP:Wheat-10:90, BP_2 = OFSP:Wheat-20:80, BP_3 = OFSP:Wheat-30:70, and BP_4= OFSP: Wheat-40:60.
Values with the same column with different superscript letters are significantly different with each other ($p < 0.05$) and values are means ± SD.



BP_0 = OFSP: Wheat-100:0.0, BP_1 = OFSP: Wheat-10:90, BP_2 = OFSP: Wheat-20:80, BP_3 = OFSP: Wheat-30:70 and BP_4=OFSP: Wheat-40:60.
Results are mean values of triplicate determination. $^{a-e}$ Means with different superscript letters in a figure are significantly different ($p < 0.05$).

Figure 2. β-carotene (μg/g) contents of the cookies developed from composite flours

Table 2. Iron, zinc and phytate contents and bioavailability of Fe and Zn of cookies made from composite flours (mg/100 g)

Blends	Iron	Zinc	Phytate	Py : Fe		Py : Zn	
				Cv	Mv	Cv	Mv
BP_0	9.14 ± 0.34^e	10.54 ± 0.20^a	14.04 ± 0.69^a	0.4	0.136	1.5	0.136
BP_1	10.77 ± 0.11^d	6.52 ± 0.10^b	12.07 ± 0.41^b	0.4	0.108	1.5	0.210
BP_2	14.84 ± 0.02^c	2.25 ± 0.20^c	9.62 ± 0.80^c	0.4	0.057	1.5	0.429
BP_3	16.36 ± 0.30^b	2.00 ± 0.05^c	9.79 ± 0.40^c	0.4	0.048	1.5	0.452
BP_4	22.14 ± 0.11^a	0.50 ± 0.04^d	7.46 ± 0.78^d	0.4	0.031	1.5	1.375

BP_0 = OFSP: Wheat -100:0.0, BP_1 = OFSP: Wheat-10:90, BP_2 = OFSP: Wheat-20:80, BP_3 = OFSP: Wheat-30:70, and BP_4= OFSP: Wheat-40:60.
Results are mean values of triplicate determination. Values with the same column with different superscript letters are significantly different with each other ($p < 0.05$) and values are means ± SD. Note: Py - phytate, Fe - iron, Zn - zinc, Cv- Critical value, Mv - Measured value

Table 3. Effect of blending ratios on physical parameters of cookies baked from composite flours

Blends	Width (mm)	Thickness (mm)	Spread factor
BP_0	38.13 ± 0.10[a]	10.13 ± 0.09[a]	37.62 ± 0.27[a]
BP_1	37.18 ± 0.34[ab]	10.07 ± 0.16[a]	36.93 ± 0.27[ab]
BP_2	36.36 ± 0.22[b]	9.86 ± 0.09[b]	36.88 ± 0.13[ab]
BP_3	35.27 ± 1.99[c]	9.67 ± 0.10[bc]	36.50 ± 1.23[ab]
BP_4	34.67 ± 0.11[c]	9.49 ± 0.06[c]	36.57 ± 0.42[b]

BP_0 = OFSP: Wheat-100:0.0, BP_1 = OFSP: Wheat-10:90, BP_2 = OFSP: Wheat-20:80, BP_3 = OFSP: Wheat-30:70, and BP_4= OFSP: Wheat-40:60. Values with the same column with different superscript letters are significantly different with each other ($p < 0.05$) and values are means ± SD.

Table 4. Sensory quality evaluation of cookies prepared from composite flours

Blends	Appearance	Texture	Aroma	Taste	Overall acceptability
BP_0	7.80±0.66[a]	8.00±0.64[a]	7.53±0.68[a]	7.80±0.75[a]	7.87±0.68[a]
BP_1	7.30±0.65[b]	7.33±0.61[b]	7.10±0.76[b]	7.03±0.72[b]	7.80±0.61[a]
BP_2	6.83±0.65[c]	6.87±0.68[c]	6.53±0.51[c]	6.53±0.68[c]	6.87±0.63[b]
BP_3	6.77±0.68[cd]	6.17±0.79[d]	6.67±0.61[c]	6.47±0.68[c]	6.47±0.57[c]
BP_4	6.47±0.68[d]	6.17±0.65[d]	6.37±0.49[c]	6.57± 0.73[c]	6.47±0.57[c]

BP_0 = OFSP: Wheat-100:0.0, BP_1 = OFSP: Wheat-10:90, BP_2 = OFSP: Wheat-20:80, BP_3 = OFSP: Wheat-30:70, and BP_4= OFSP: Wheat-40:60. Values with the same column with different superscript letters are significantly different with each other ($p < 0.05$) and values are means ± SD.

3.2. Physical Evaluation of Cookies

The values of cookies physical parameters are presented in (Table 3).

3.3. Sensory Evaluation of Cookies Made from Composite Flours

The sensory evaluation values are presented in (Table 4).

4. Discussions

4.1. Proximate Composition of OFSP and Wheat Flour Cookies

The moisture contents of composite flours cookies were significantly ($p < 0.05$) lower than the BP_0 (control, 12.27 ± 0.02%) shown in Table 1. The moisture content decreased as the proportion of OFSP increased in the composite flour. This might be due to the less moisture content of OFSP (7.36%) than soft wheat flour (10.5%). Among the composite flours cookies the lowest moisture content value was found for BP_4 (9.66 ± 0.04%). At lower moisture content the deterioration of baked product would be lowered due to reduced activity of microorganisms. Ezeama (2007) also reported that microbial proliferation was minimum at low moisture content and it confers higher shelf-life stability of the cookies.

The ash content of the composite flour cookies in BP_4 (1.64 ± 0.02%) was significantly ($p < 0.05$) higher than the BP_0 (control). As the OFSP proportion increases in the composite flours the ash contents of the blend increases. The ash contents of soft wheat and OFSP cookies reported by Okorie and Onyeneke (2012) were in agreement with the present study, which showed increasing of ash contents when more OFSP was added to wheat flour cookies. In general the increment of ash in the composite flour cookies indicates the high amounts of minerals were found in the developed cookies.

The crude protein content of composite flour cookies were significantly ($p < 0.05$) lower than BP_0 (control). Crude protein contents of the composite flour cookies were reduced with increasing of OFSP flour proportion in the composite flour. This may be loss of more nitrogen in OFSP supplemented cookies than wheat cookies at the time of preparing it at 160°C. The elevated temperature in baked products destructs more protein nutrients in OFSP than wheat as it was reported by Singh *et al.* (2008). Moreover, Shazia *et al.,* 2012 and Okorie, 2012 were reported the decrease of crude protein contents when more OFSP was added in the composite flours of cookies.

The fat content of the composite flours cookies were significantly ($p < 0.05$) higher than the BP_0 (control) cookies. The values of crude fat content in blend proportion showed progressive increment with addition of OFSP to wheat flour. An increase in crude fat content of blend proportions due to addition of OFSP was also confirmed by the finding of Oboh and Akindahunsi (2003); who reported fats present in a small extent in wheat than OFSP.

The crude fiber content of composite flour cookies were significantly ($p < 0.05$) higher than the BP_0 (control) flour cookie. The crude fiber content was increased when more OFSP was added to the wheat flour in developing cookies. This was due to the increased fiber contents of OFSP flour than soft wheat. Singh *et al*. (2008) also reported the crude fiber values of cookie increased from (1.70 - 1.75%) when more OFSP was added to the wheat were in agreement with the present study. Foods with more fiber are important to easily passage of waste by expanding the inside walls of the colon, make an effective anti-constipation, lowered cholesterol level in the blood and reduced the risk of various cancers (Wardlaw and Kessel, 2005). However, emphasis has been placed on the importance of keeping fiber intake low in the nutrition of infants and weaning children because high fiber levels in weaning diet can lead to irritation of the gut mucosa (Bello *et al*., 2008).

The carbohydrate content of cookies from composite flours were significantly ($p<0.05$) lower than control. The carbohydrate contents of cookies decreased when more OFSP was added in soft wheat flour. This may be due to wheat flour has more starch granules than the OFSP; which gave more carbohydrate content to the control cookies. The high carbohydrate favors better production of energy in meeting the daily activities.

The utilizable energy contents of cookies are ranged from 431.56 ± 8.05 to 454.57 ± 0.17 Kcal/100 g. The maximum value was recorded in BP_4 and the minimum one in control. An increase in energy level was observed where the proportion of OFSP flour was increased. This may be due to the increment of the crude fat content with an increase in OFSP outweighs the decrease of carbohydrate and crude protein contents. The recommended minimum daily requirement of energy for average man in Ethiopia based on FAO (2004) was 1820 kilocalories per person per day. The present study cookies can cover about 23.7 - 25% of daily requirement of energy for an average man per day.

4.2. β -Carotene Contents of Composite Flour Cookies

The contents of β-carotene are presented in Figure 2. The β-carotene content in BP_4 was 13.11 ± 0.02 µg/g and in control it was below the detection level or 0.00. This is due to the absence of β-carotene in wheat flour. The content of β-carotene increased when more OFSP added to the wheat flour in the composite cookies. Simonne *et al*. (1993) reported that OFSP has higher β-carotene content than the other root crops. The consumption of the present study cookies from OFSP and wheat blend with different ratios could reduce VAD in children and pregnant/lactating women and other consumers in some amounts. β-carotene is a major source and precursor of dietary vitamin A to human health. The β-carotene from plant sources converted to vitamin A in human body to improve the diet of population in food based approach. Consumption of vitamin A rich OFSP can provide households with direct access to foods rich in β-carotene and the alleviation of VAD (Faber *et al.,* 2002). The recommended dietary allowance (RDA) of vitamin A for pregnant/lactating women and children (6-59 months) was 800 and 400 µg/100 g respectively based on WHO (2005). The measured weight of the present study cookie was 61 g in dry weight bases; and one can get 800 µg β-carotene or 67 µg vitamin A/RE for RDA by consuming one cookie. Vulnerable to VAD pregnant/lactating women and children (6-59 months) can get 100% of RDA of vitamin A per day by consuming 12 and 6 cookies in BP_4 of the present study, respectively.

4.3. Iron, Zinc and Phytate Contents of Cookies Made from Composite Flours

The iron (Fe) contents of cookies in blend proportion are given in Table 2. The highest content of iron (22.14 ± 0.11 mg/100 g) was recorded to the BP_4 and the lowest (9.14 ± 0.34 mg/100 g) was recorded in the control. The iron contents of cookies value were significantly different ($p < 0.05$) with each other. The iron contents of composite flours cookies were significantly ($p < 0.05$) higher than the control (BP_0). This may be due to OFSP iron content was greater than the wheat flour. The iron content values of the present study were in agreement with the reported values (7.23 - 20.96 mg/100 g) of iron by Gamal *et al.* (2012). Iron is an important element in the diet to prevent anemia and other related diseases (Oluyemi *et al*., 2006). Based on the WHO (2005) report the daily recommended intake of iron for pregnant/lactating women and children (6-59 months) were 27 and 5.8 mg/100 g, respectively. They can get RDA of iron 82 and 382% respectively by consuming the present study cookies with BP_4.

The values of zinc in the present findings are given in Table 2. The value of zinc recorded by control (10.54 ± 0.20 mg/100 g) was the highest and the BP_4 (0.5 ± 0.04 mg/100 g) was the lowest. The zinc content decreased when more OFSP was added to the soft wheat flour cookies. This may be due to the content of zinc was more in cereal (wheat) than roots (OFSP) based on the report of Sandsteed (2000). The daily recommended allowance of zinc content for pregnant/ lactating women and children were 10.0 and 4.1 mg/100 g, respectively based on WHO (2005). The present study composite flour cookie in BP_4 zinc content could be estimated for pregnant/lactating women and children (6-59 months) as about 5 and 12.2% RDA respectively.

The phytate contents of cookies in Table 2 are found in the range from 7.46 ± 0.78 to 14.04 ± 0.69 mg/100 g. The phytate content of control (BP_0) was significantly ($p < 0.05$) higher than the composite flour cookies phytate content. The phytate content decreased when more OFSP was added in the wheat flour during cookies development. This may be due to high amount phytate is found in wheat flour than OFSP based on the report of Alpers *et al.* (1996). The reduction of phytate is expected to enhance the bioavailability of proteins and dietary minerals of the food products (Phillippy *et al.,* 2004). The cookies in present study were safe to consumers due the processing methods and preparing cookies in the oven decreased the phytate content. The report of Plaami (1997) was stated that phytic acid decreased during bakery product making due to the action of phytase as well as cooking temperature.

4.4. Bioavailability of Iron and Zinc

Bioavailabilities of iron and zinc values of cookies are presented in Table 2. The values shown that iron and zinc of the cookies were bioavailable to consumers without the binding effect of phytate. This is due to the molar ratio of phytate: iron values were below the critical value (0.4) and phytate: zinc values were also below the critical value (1.5). The measured values of phytate: iron decreased progressively when OFSP amounts were increased; so bioavailability of iron is more when OFSP was more in the blended cookies. The measured values of phytate: zinc increased when the amount of OFSP increased in the developed cookies. This may decrease the zinc bioavailability in more OFSP added cookies due to high values of phytate: zinc ratios. The iron and zinc contents in the present study cookies can be taken without hindering effect of the phytate. Generally, the phytate contents of the composite flours cookies and the molar ratios of phytate: minerals imply that, phytate in the cookies of the present study could not impair the bioavailability of iron and zinc to consumers.

4.5. Physical Evaluation of Cookies

The results in Table 3 shown that the control cookie exhibited maximum width (38.13 ± 0.10 mm); while BP_4 recorded the minimum width (34.67 ± 0.11 mm). The data regarding blending proportion on width of cookies showed a decreasing trend with the proportionate increase of OFSP supplementation on wheat flour. The decrease in width with addition of OFSP may be smaller protein content in OFSP flour than soft wheat flour based on the report of Pareyt and Delcour (2008). Shazia *et al.* (2012) reported the width of cookies developed from wheat and OFSP blend flour measured 26.4 - 32 mm which were in line with the results of the present study results.

The control cookies exhibited maximum thickness (10.13 ± 0.09 mm); while minimum thickness (9.49 ± 0.06 mm) was measured in $BP_{4.}$ The thickness of cookies decreased when more OFSP flour was added to wheat during the cookies development. This may be due to the heat applied to cookies during baking decreased the thickness of cookies with more OFSP than wheat. Shazia *et al.* (2012) reported that thickness of cookies developed from OFSP supplemented with wheat flour was reduced from 6.89 to 6.50 mm with addition of more OFSP. The finding of the present study is similar to the finding of Shazia *et al.* (2012) and Sukhcharn *et al.* (2008) in line of thickness decreasing when more OFSP added with wheat flour cookies. The spread is one of the parameter used to adjust the product specification. The maximum value (37.62 ± 0.27) of spread factor was observed in control, while minimum value (36.57 ± 0.42) was observed in $BP_{4.}$ The spread factor values of cookies were shown decreasing with the proportionate increase of OFSP supplementation. The present study results are similar to the findings of Sharif *et al.* (2009), who reported that spread factor of OFSP supplemented wheat cookies decreased with the increasing of OFSP flour. This may be due to water absorption capacity difference of OFSP and wheat flour. The rapid partitioning would be created after free water goes to hydrophilic sites of OFSP flour higher than wheat flour. Therefore, OFSP flour addition limits the spreading of cookies. During mixing dough viscosity increases in more OFSP and which also limits cookies spread factor. Sukhcharn *et al.* (2008) reported spread factor of cookies developed from control was recorded 66.67 and wheat with OFSP blends was 65.43. The literature reported spread factor was greater for cookies made from wheat flour and decreased significantly with increasing of OFSP proportion. The findings are in line with the present study due to decreasing of spread factor by addition of more OFSP in wheat during cookies developing, even though the reported values were greater than the present study cookies spread factor values.

4.6. Sensory Evaluation of Cookies Made from Composite Flours

The results in Table 4 showed that the control cookies scored the highest (7.80 ± 0.66) and BP_4 scored the lowest (6.47 ± 0.68) values of appearance. Organoleptic evaluation score of appearance were significantly ($p < 0.05$) different to each other except for BP_3 and BP_4. As the level of OFSP flour supplementation increased in the wheat flour the appearance of the cookies decreased. The decrease of appearance may be due to cookies with more OFSP subjected to the dark brown in color. This is confirmed by previous reports of Mebpa *et al.* (2007) that supplementing bakery products with OFSP increased the deterioration in appearance as a result of maillard' reaction.

The cookie prepared from wheat was found to be having texture value (8.00 ± 0.64) which is significantly ($p < 0.05$) higher than others, while the lowest value was recorded for BP_4 (6.17 ± 0.65). The texture of cookies value decreased as OFSP blend proportion increased. This is due to the creation of roughness, evenness and dullness of the surface texture in more OFSP flour added cookies. The present study texture score was in line with the texture value of cookies (7.43 - 7.05) developed from wheat and vitamin A fortified reported by Shahid *et al.* (2008). Moreover, Alam *et al*. (2007) and Sukhcharn *et al.* (2008) also reported similar results of texture decreased as OFSP amount increases on cookies prepared from OFSP and wheat.

The attribute aroma score values was not significantly different ($p > 0.05$) to each other except for the values of BP_0 and BP_1. The aroma values of cookies developed from the wheat (control) was highest (7.53 ± 0.68), while cookie in BP_4 was lowest (6.37 ± 0.49). The value of cookies aroma scored decreased as the amount of OFSP flour increased in the composite flours. This may be due to consumer-oriented panelists were not familiar with such newly developed products aroma like wheat cookies. Sharif *et al*. (2009) also reported aroma of wheat and OFSP blend biscuit shown decreasing when more OFSP added to the developed biscuits agrees the present study finding.

The highest scored value of taste was recorded for wheat flour cookie (7.80 ± 0.75) and the lowest (6.57 ± 0.73) for BP_4 (Table 4). The composite flours cookies panelist taste score value were significantly ($p < 0.05$) different except for cookies in BP_2, BP_3 and BP_4 having the same value. The taste of cookies decreased in more OFSP supplemented to the wheat flour. Alam *et al*. (2007) reported similar results of cookie taste decreasing as the amount of OFSP supplementation increase in wheat flour.

The overall acceptability of cookies maximum score value (7.87 ± 0.68) was obtained by wheat flour (control) cookie; while, minimum score value (6.47 ± 0.57) was scored by composite flour cookie (BP_4). The overall acceptability value of the cookies decreased when more OFSP was added to the wheat flour. This may be due to the results of appearance, texture, aroma and taste of the cookies. Changing the staple foods of a population in a certain society can influence the overall acceptability of new products. The present study findings were similar with Singh (2008) who developed biscuits by incorporating OFSP flour up to 40% level and wheat with improved overall acceptability. It was interesting to notice that up to 40% incorporation of OFSP flour to develop cookie did not make negative impact concerning the overall acceptability of the new product by consumer-oriented panelists.

5. Conclusions

The study was attempted to investigate the possibility of using home garden growing orange-fleshed sweet potato (OFSP) flour for the production of β-carotene cookies by blending with wheat flour. The proximate composition of cookies made from composite flours recorded more ash, crude fat, crude fiber and energy values as the addition of OFSP increased in the blend. The moisture, crude protein and carbohydrate contents decreased when more OFSP added to soft wheat flour. Cookies developed up to 40% OFSP supplementation with wheat flour was superior in β-carotene than the wheat flour (control) and it was more preferable to vulnerable groups who need pro-vitamin A to combat vitamin A deficiency. The iron and zinc were estimated to be bio available in control /wheat flour, and cookies developed from composite flours namely: BP_1, BP_2, BP_3 and BP_4. The physical parameters like width, height and spread factor measurements of cookies with more OFSP supplementation were shown less bulky, which reduced the packaging, storing and distribution costs of the product. In view of the results of the present study, the use of OFSP-wheat flour blend in cookies formulation appeared to be promising from nutritional quality, acceptability and economical point of view.

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