Production and Quality Evaluation of Cookies Enriched with β-carotene by Blending Orange-fleshed Sweet Potato *(Ipomoea batatas L.)* and Wheat *(Triticum aestivum L.) Flours for Alleviation of Nutritional Insecurity*

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1. Introduction

Background of the Study

- A large segment of the world's population especially in developing countries including Ethiopia are consuming foods that are deficient in micronutrients like vitamin A, iron and zinc (Long *et al*., 2007).
- To overcome vitamin A deficiency (VAD) orange-fleshed sweet potato (OFSP) with β-carotene was processed in to flour and blended with wheat to develop new product (cookies).

Background Cont…

- Cookies are baked product liked by all age groups; containing flour, sugar and fat and the one which blended with OFSP is used to combat VAD through dietary approaches (Pareyt and Delcour, 2008).

- Processing OFSP in to flour and blending with dietary staple wheat increases utilization of OFSP as an important pro-vitamin A food and is the base of the present study.

Statement of the Problem

- Based on WHO (2006) about 140 million pre-school children and more than 7 million pregnant/lactating women suffer from vitamin A deficiency (VAD) every year around worldwide.
- In many parts of Ethiopia most peoples are vulnerable to VAD due to:
  - ✓ consuming vitamin A deficient diet
  - ✓less access of vitamin A rich foods
  - ✓lack of new food products developed from OFSP and dietary staple.

Objectives

- The general objective of the study was to develop pro-vitamin A rich cookies from composite flour of orange-fleshed sweet potato with wheat and evaluating cookies chemical and sensory properties.

Objectives Cont…

The Specific Objectives

- To produce cookies from blend of orange-fleshed sweet potato and wheat flours in different ratios.

- To analyze proximate composition, iron, zinc, phytate, β-carotene and bioavailability of iron and zinc of cookies.

- To analyze organoleptic acceptability of cookies.

Significance

The study will contribute

- To tackle VAD of vulnerable groups when they consume cookies enriched with β-carotene.
- To give the direction in improving nutritional quality and the recipes of cookies.
- To benefit policy makers, new product development practitioners, enterprises team and farmers.
- To give insight for researchers further investigation.

2. Materials and Methods

- **Sources of Raw Materials and Study Area**

- OFSP of Kulfo variety was collected from Hawassa Agricultural Research Center. While, ingredients for making of cookies were purchased from the local market.
- Chemicals and reagents used in laboratory analysis were of analytical grade.
- Samples chemical analyses were carried out in EPHI (former EHNRI), Addis Ababa.

Orange-fleshed Sweet Potato (OFSP) Flour Preparation

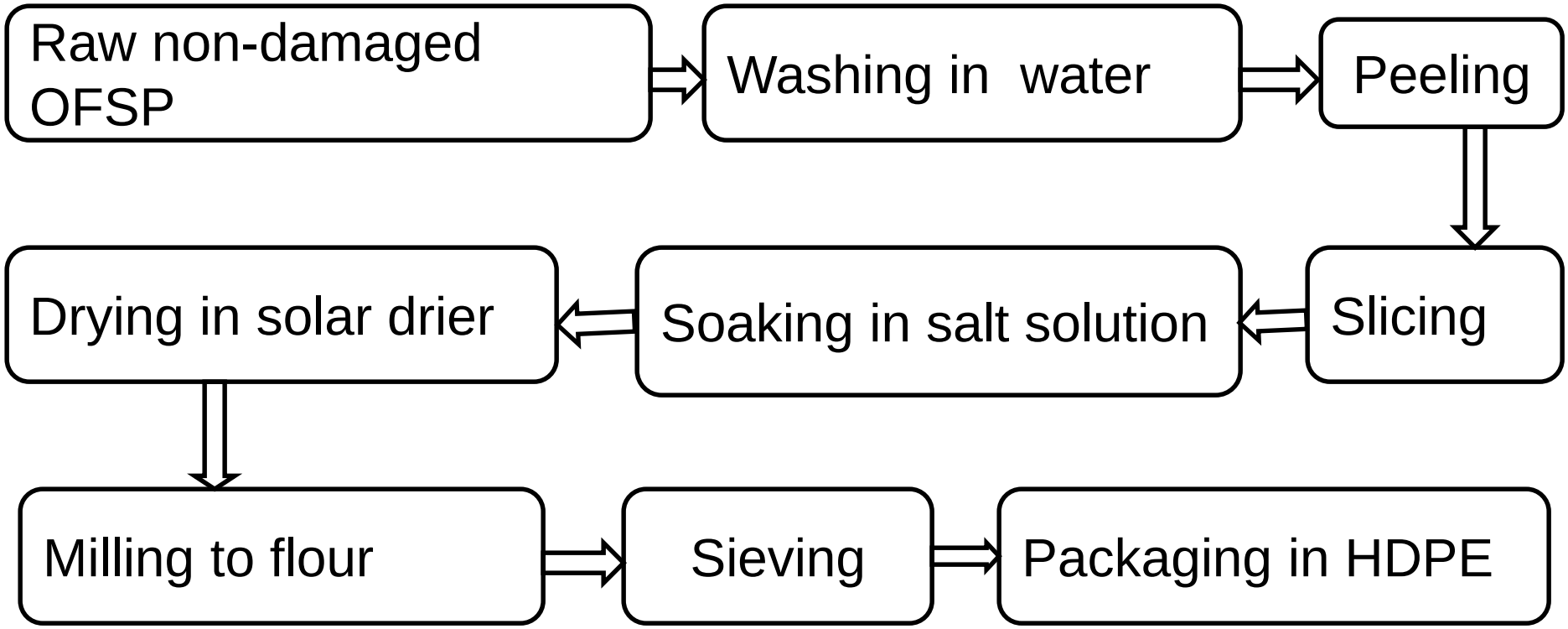


Fig. 2.1: Flow diagram for preparation of OFSP flour based on Shazia *et al.,* 2012.
HDPE - high density polyethylene

Blend Proportion

Table 2.1: Blends proportion of flours for making cookies

Composite flour blends	(% Wheat to OFSP flour proportion)
BP_0 (control)	100 : 0
BP_1	90 : 10
BP_2	80 : 20
BP_3	70 : 30
BP_4	60 : 40

BP - Blends proportion, OFSP - Orange-fleshed sweet potato

Standard Recipes

Table 2.2: Standard recipes of cookie processing

Ingredients	Quantity
Flour blend	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
Water	36 mL

Source: McWatters *et al*. (2003).

Cookies Preparation

Dry ingredients were weighed and mixed

⇩

Vegetable shortening, egg and water were added

⇩

Dough was rolled to 13mm thick and cut to diameter of 60 mm

⇩

Baked at 160°C for 20 minutes in hot air oven

⇩

Packed in high density polyethylene (HDPE) after it was cooled

Fig. 2.2: Flow diagram for cookies preparation

Source: McWaters *et al.* (2003)

Determination of Cookies Proximate Compositions

- Moisture contents
- Ash contents
- Crude protein
- Crude fat
- Crude fiber
- Carbohydrates
- Energy

Based on AOAC (2000)

β-carotene, Iron, Zinc and Phytate Contents of Cookies

✓ determined by using the standard of AOAC (2000).

- **Bioavailability of Iron and Zinc**

✓ determined by measuring the molar ratio of phytate to iron/zinc contents based on the methods of Morris and Ellis (1989) and by comparing the values with critical values reported by Frontela *et al*. (2008).

- **The Sensory Parameters**

✓Appearance

✓Texture

✓Aroma

✓Taste

✓Overall acceptability

Ouyoun *et al*. (2010), by 10 panelists and by using 9 point hedonic scale

Statistical Analysis

- Data were analyzed by the one way Analysis of Variance (ANOVA) model using the Statistical Analysis System (SAS) software program, version 9.3.1 for windows.

- The results were reported as an average value of triplicate analysis (mean ± SD).

- Differences between treatments were determined by Fisher's Least Significance Difference (LSD) method and statistical significance was set at $p < 0.05$.

3. Results and Discussions

Proximate Composition of the Cookies

Blends	Moisture contents	Ash contents	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}

Proximate Composition Cont…

- The moisture content decreases as the proportion of OFSP increases might be due to the less moisture contents of OFSP than wheat flours reported by Shazia *et al.* (2012).

- The lowering of moisture contents by addition of OFSP flour is in agreement with the findings of Olitino *et al.* (2007).

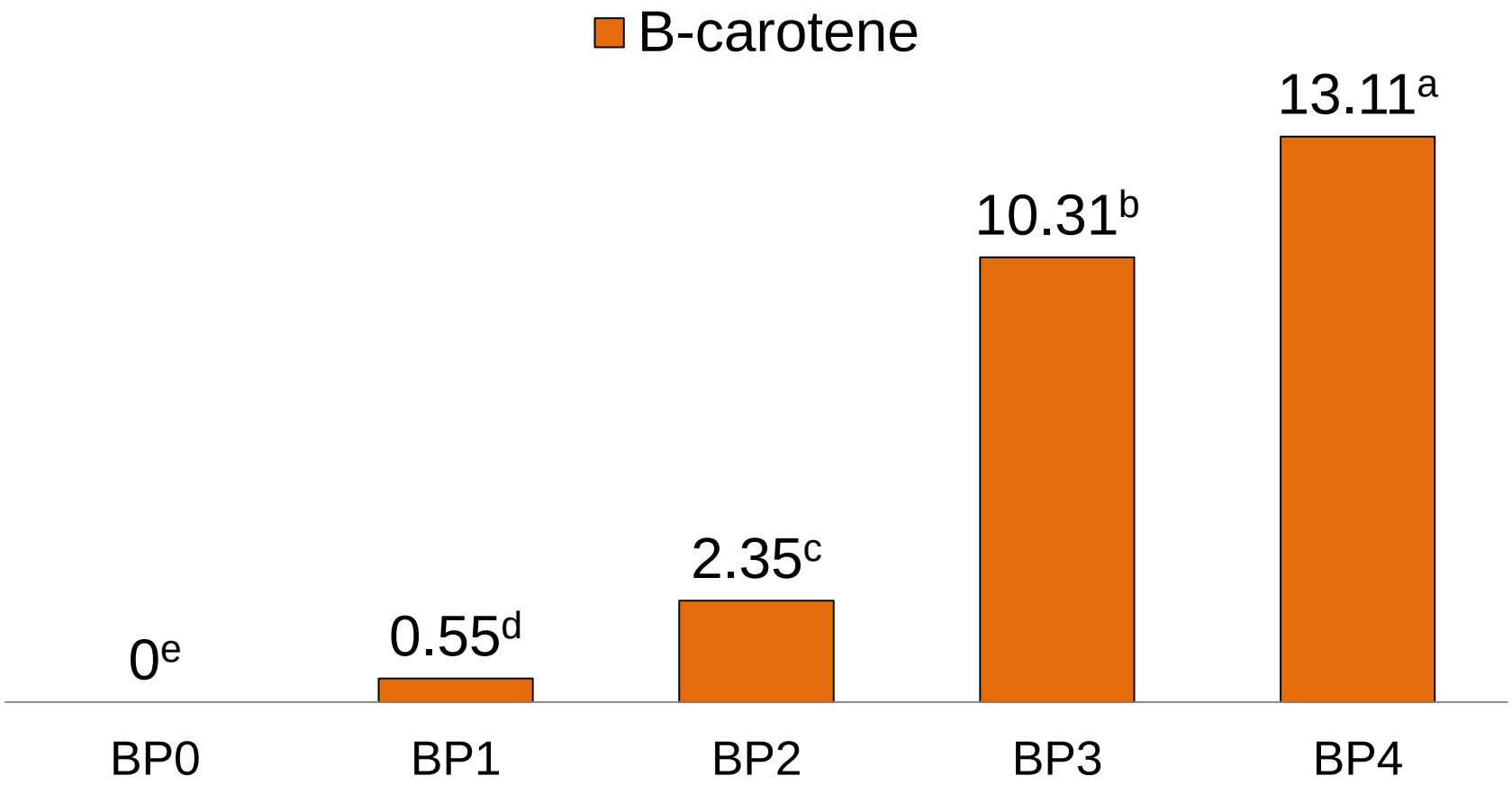
- The ash contents of the present study are in agreement with the reported value of Okorie and Onyeneke (2012), which showed increasing of ash contents when more OFSP was added to wheat flour cookies.

Proximate Composition Cont…

- Crude protein contents of the composite flour cookies were reduced with increasing of OFSP may be due to loss of more nitrogen in OFSP supplemented cookies than wheat cookies in processing.
- Shazia *et al.* (2012) findings were in agreement with the present study due to decreasing of crude protein when more OFSP was added to the wheat cookie.
- An increase in crude fat content of blend proportions due to addition of OFSP conforms the finding of Li *et al.* (1999); who reported fats present in a small extent in wheat than OFSP.

Proximate Composition Cont…

- The increase of crude fiber in cookie with more OFSP flour was due to the increased fiber contents of OFSP flour than wheat.
- The present study crude fiber finding is in agreement with Shazia *et al.* (2012) and Oboh and Elusiyan (2007) due to increments of crude fiber when more OFSP was added.
- The carbohydrate contents of cookies were decreased when more OFSP was added in wheat flour may be due to wheat flour has more starch granules than the OFSP.
- An increase in energy was observed in more OFSP flour due to the increment of crude fat content with an increase in OFSP.



Control - 100 % wheat flour, BP_1 - 90 % wheat & 10 % OFSP flour, BP_2 - 80 % wheat & 20 % OFSP flour, BP_3 - 70 % wheat & 30 % OFSP flour & BP_4 - 60 % wheat & 40 % OFSP flour. Results are mean values of triplicate determination. $^{a-e}$ Means with different superscript letters in a figure are significantly different ($p < 0.05$).

Fig. 3.1: Beta-carotene (µg/g) contents of cookies

β-carotene

- The content of β-carotene was increased when more OFSP added to the wheat flour in cookies due to the presence β-carotene source OFSP in the developed cookies.
- Consumption of the present study OFSP and wheat blend cookies could reduce vitamin A deficiency (VAD) in children and pregnant/lactating women and others consumers in some amounts.
- Pregnant/lactating women and children (6-59 months) can get 13.65 % and 27.31 % of RDA of vitamin A respectively by consuming one (61 g) of the present study cookie in BP_4 based on the report of WHO (2005) RDA.

Iron, Zinc and Phytate Contents of Cookies

Table 3-2: Iron, zinc and phytate contents of cookies (mg/100 g)

Blends	Iron	Zinc	Phytate
BP_0	9.14 ± 0.34 ^{e}	10.54 ± 0.20^{a}	14.04 ± 0.69^{a}
BP_1	10.77 ± 0.11 ^{d}	6.52 ± 0.10 ^{b}	12.07 ± 0.41^{b}
BP_2	14.84 ± 0.02 ^{c}	2.25 ± 0.20 ^{c}	9.62 ± 0.80^{c}
BP_3	16.36 ± 0.30 ^{b}	2.00 ± 0.05^{c}	9.79 ± 0.40^{c}
BP_4	22.14 ± 0.11^{a}	0.5 ± 0.04 ^{d}	7.46 ± 0.78^{d}

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

Iron, Zinc and Phytate Cont…

- The iron content is more with more OFSP due to OFSP iron content is greater than the wheat flour. The iron content values of the present study were in agreement with the reported values of Gamal *et al.* (2012) and Olivares *et al*. (2004).
- The zinc content decreased when more OFSP was added to the wheat flour may be the content of zinc was more in cereal (wheat) than roots (OFSP) based on the report of Sandsteed (2000).
- The phytate content was decreased when more OFSP was added due to phytate is found in high amount in wheat flour than OFSP and it agrees with findings of Alpers *et al.* (1996).

Bioavailability of Iron and Zinc

Table 3.3: Bioavailability of iron and zinc in cookies

Blends	P: Fe		P: Z	
	Cv	Mv	Cv	Mv
BP_0	0.4	0.136	1.5	0.136
BP_1	0.4	0.108	1.5	0.210
BP_2	0.4	0.057	1.5	0.429
BP_3	0.4	0.048	1.5	0.452
BP_4	0.4	0.031	1.5	1.375

P - phytate, Fe - iron, Zn - zinc, Cv- Critical value, Mv - Measured value

BP_0 (control) - 100 % wheat flour, BP_1 - 90 % wheat & 10 % OFSP flour, BP_2 - 80 % wheat & 20 % OFSP flour, BP_3 - 70 % wheat & 30 % OFSP flour and BP_4 - 60 % wheat & 40 % OFSP flour.

Bioavailability Cont…

- Iron and zinc of the cookies were bioavailable to consumers.

- This is due to the measured molar ratio of phytate: iron and phytate: zinc values were below the critical values.

- The result shows that iron and zinc may not be hindered by the phytate content of the developed composite flours cookies.

Sensory Evaluation of Cookies

Table 3.4: Sensory quality evaluation of cookies

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

BP_0 (control) - 100 % wheat flour, BP_1 - 90 % wheat & 10 % OFSP flour, BP_2 - 80 % wheat & 20 % OFSP flour, BP_3 - 70 % wheat & 30 % OFSP flour & BP_4 - 60 % wheat & 40 % OFSP flour.

Values with the same column with different superscript letters are significantly different with each other ($p < 0.05$) & values are means ± SD.

Sensory Cont…

- The decrease of appearance may be due to cookies with more OFSP subjected to the dark brown in color. The report of Mebpa *et al.* (2007) confirm that supplementing bakery products with OFSP increases the deterioration in appearance as a result of mallards' reaction.
- The texture of cookies value was decreased as OFSP blend proportion increases due to the creation of roughness, evenness and dullness of the surface texture in more OFSP added cookies.
- Aroma decreased when more OFSP added to wheat agrees the report of Sharif *et al*. (2009). This may be due to the newly developed product of OFSP added aroma were not familiar to consumer-oriented panelists like wheat cookie.

Sensory Cont…

- The taste of cookies decreased in more OFSP supplemented to the wheat flour agrees with the report of Shahid *et al.* (2008) . This may be due to the typical flavor component and caramalization of free sugar in more OFSP flour added cookies during baking.
- 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 and may be OFSP is newly launched than locally staple wheat.
- In general, the newly developed cookies measured sensory attributes were having more than average score values, even though panelists scores values are less than the wheat flour cookie.

4. Conclusions and Recommendations

Conclusions

- The proximate composition of cookies made from composite flours was recorded the more ash, crude fat, crude fiber and energy values as the addition of OFSP increase in the blend.
- The consumers would be beneficial by consuming cookies with more OFSP due to increased β-carotene, minerals, crude fat, crude fiber and energy contents.

Conclusions cont…

- The moisture, crude protein and carbohydrate contents were decreased when more OFSP was supplemented with wheat flour.
- Cookies developed with up to 40 % OFSP supplementation with wheat flour were superior in β-carotene than the others.
- The iron and zinc were estimated to be bioavailable in control and cookies developed from composite flours .

Recommendation

- To Promote OFSP varieties for their food and nutrition security, nutritional value and income generating potential in Ethiopia more emphasis should be given to:

✓ Incorporate OFSP flour in other recipes by using locally available crops.

✓ Encouraging the use of OFSP blended cookies and develop OFSP based new products.

✓ A comprehensive study on optimization of OFSP in the composite flours of cookies with nutritional requirement of age groups.

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Cookies Enriched with β-Ca...

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THANK YOU !