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Development of Maize Based Orange – Fleshed Sweet Potato Flat Bread for Lactating Mothers at Hawassa Zuria Woreda, SNNPRS, Ethiopia

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Abstract Vitamin A deficiency continues to be a major public health problem in Ethiopia in spite of the various intervention measures since 1989. Food based strategies are cost effective, easy, long-term and sustainable for the prevention of vitamin A deficiency both in rural and urban settings. To improve the vitamin A content of traditional (staple) flat bread prepared from maize, three formulations of maize-based breads were prepared by incorporating Orange Fleshed Sweet Potato (OFSP) flour at 25%, 30% and 35%. Traditional maize-based flat bread served as control. Sensory evaluation was carried-out using a 9-point hedonic rating scale by panelists at the laboratory level. While, community level sensory evaluation (acceptability trial) was done by lactating mothers using a 5- point hedonic rating scale. The proximate composition values of flours and the four flat bread samples were determined using AOAC (2000) methods and open column chromatography method was used to determine the values of β-carotene. All the formulations were accepted both at laboratory and community levels. The proximate composition results showed an increase in the values of crude fiber and ash for OFSP incorporated flat breads compared to the control. The vitamin A contents (µg RAE) of maize and OFSP flours were found to be 0 and 888.01 µg RAE per 100 gm respectively. The vitamin A (µg RAE) content of the control bread was observed to be 0. Among the flat breads samples in which OFSP flour was incorporated, the vitamin A content was highest (269.63µg RAE) for the sample supplemented with 35% of orange fleshed sweet potato flour. OFSP flour up till 35% can be successfully incorporated in traditional maize based flat bread which can be used as a potential food source of vitamin A for lactating mothers residing in the study area.

Keywords Orange fleshed sweet potato, Retinol activity equivalent, Flat bread, Vitamin A

1. Introduction

Low vitamin A intake during nutritionally demanding periods in life, such as infancy, childhood, pregnancy and lactation greatly raises the risk of vitamin A deficiency disorders (VADD). Risk factors for vitamin A deficiency include age, season, cultural factors, physiological status, infection, sex, diet and breast feeding [1].

Vitamin A deficiency (VAD) remains an important public health problem in Ethiopia just as in other developing countries [2]. In Ethiopia, studies had indicated that national prevalence rates of 1.7% and 0.8% for Bitot's spots and night-blindness among children respectively and 1.8% for night blindness among mothers [3]. According to WHO standards, a prevalence of night blindness greater than 5% indicate a public health problem while the EDHS report on night blindness at the national level and in SNNPR was 6% and 2.6% in pregnant mothers respectively [4].

A number of different intervention strategies to address VAD are being promoted in developing countries these include fortification and supplementation these efforts have reduced on the levels of cases affected by the deficiency. However, an inadequate health infrastructure and limited financial resources of many poor rural households call for another alternative strategy. The diversified use of staple foods has been justified as a sustainable food based approach to reach a large section of the rural population who may not be reached by the above mentioned intervention strategies [5].

Most sweet potato varieties grown in Ethiopia are white in colour which is a staple food for 13 million people in the Southern Regional State that contain negligible amounts of beta-carotene. The OFSP have emerged as one of the most promising plant sources of Vitamin A and stand to be a cheaper and a complementary source of vitamin A to the rural and urban poor families. Laboratory studies have proved that the daily addition of 100 g of the sweet potato to

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the diet can prevent vitamin A deficiency in children and can reduce maternal mortality [6]. Hence, the aim of this study is to improve the β- carotien content of the traditional (staple) food of lactating mothers by incorporating OFSP flour in their staple food and taste acceptability in the study.

2. Materials and Methods

2.1. Description of the Study Area and Period

The study was conducted at Hawassa Zuria Woreda, Southern Nations, Nationalities and Peoples Regional state (SNNPR) of Ethiopia. The district is 297 km far from Addis Ababa, the capital of Ethiopia. It consists of 23 kebeles comprising of a total of 28,473 households. The total populations living in the district were 139,520 and out of this 70,361 are males and 69,159 are females. The main crops of the community are maize, red pepper, enset, varicosum, potato and kidney beans [7]. Laboratory and community level sensory evaluations were done from May 10-12, 2011 and from June 29-July 1, 2011, respectively. Nutrient analysis was conducted in Ethiopian Public Health Institute (EPHI) from November 21- 25, 2011.

2.2. Sample Selection, Proportion of Maize and OFSP Flour and Procedure of Baking Flat Bread Samples

The maize grains were sorted to remove stones, dust and light materials, glumes, stalks, and broken, undersized and immature grains. Sorted maize grains were afterwards milled into flour in a commercial mill house. Lastly, the flour was packed in a polyethylene bag and stored in deep freeze till nutrient analysis was done.

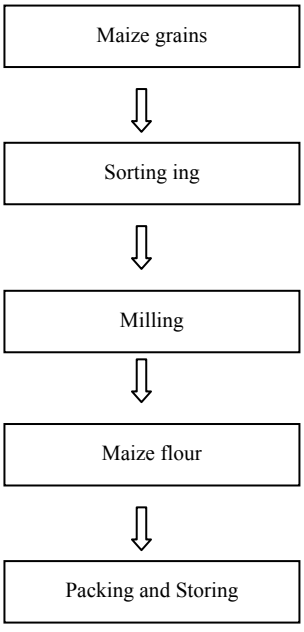


Figure 1. Flow chart of flour preparation from maize grains [23]

Tula varity of Orange Flashed Sweet Potato (OFSP), (Ipomoea batatas) was used. Unwanted parts of fresh orange fleshed sweet potato roots were manually removed with a sharp knife. Then, the roots were washed using clean tap water in large buckets and were pre dried on a raised perforated rack. This was followed by peeling and slicing the roots manually with a sharp knife. The slices were soaked in tap water for 90 mins and then were sun dried for 3 days until they become brittle. Dried chips were sorted and milled using local mortar and pestle to produce OFSP flour. Finally, the flour was packed in a black polyethylene bag and stored in deep freeze till nutrient analysis was carried- out.

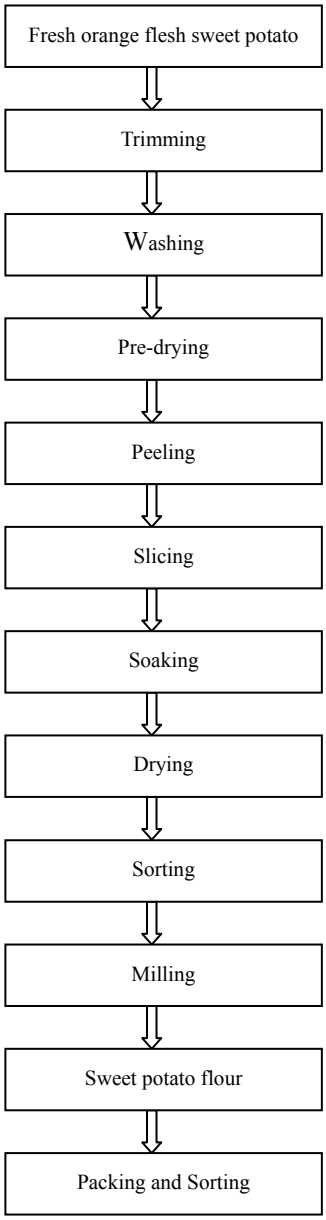


Figure 2. Flow chart of flour preparation from orange fleshed sweet potato [18]

All the samples received the same treatment for storage and cooking throughout the preparation

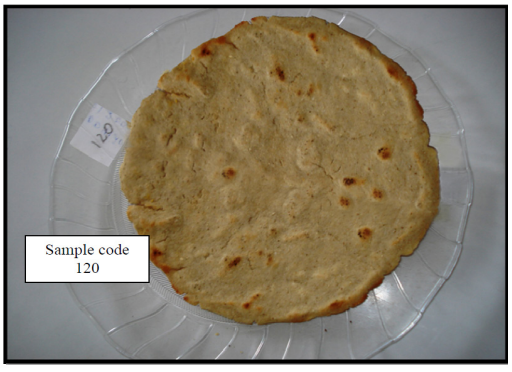
Table 1. Proportion of maize - OFSP composite flour based on [25]

Samples code	Maize Flour	OFSP Flour
S 120 (Control)	100%	0%
S 168	75%	25%
S 175	70%	30%
S 254	65%	35%

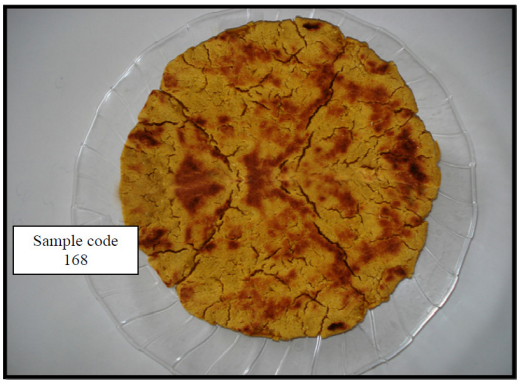
Procedure of baking maize based OFSP incorporated flat bread

- A 100 grams of ingredients with different proportion were put and mixed together in three bowls: maize and orange fleshed sweet potato flour and one bowl with maize flour only
- The ingredients in each bowl were mixed until they became uniform and sieved three times by similar sieve having series opening of 1.00 mm
- Salt and one tea spoon of oil were added and mixed during the preparation
- Warm water was added a little at a time while mixing and kneading the dough until it became smooth
- The dough was sheeted and baked in a hot oven with a constant time (10 minutes) and maximum temperature of 78°C.
- The flat bread samples were removed from the oven and allowed to cool down
- Finally the flat bread samples were sealed separately in a black Polyethylene bags and were put in a deep freezer till nutrient analysis was carried out

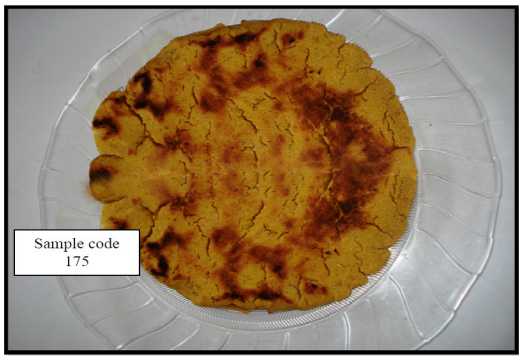
Pictures of four flat bread samples



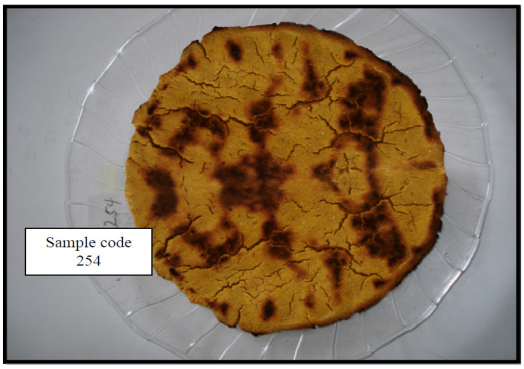
Control (120) = Maize: OFSP (100 %:0%)



Sample 168 = Maize: OFSP (75%: 25%)



Sample 175 = Maize: OFSP (70%: 30%)



Sample 254 = Maize: OFSP (65%: 35%)

2.3. Sensory Evaluation and Nutrient Analysis

2.3.1. At the Laboratory Level

Developed products were evaluated thrice for their acepta ability by 15 panellists. Panellists (students and staff) were randomly selected from School of Nutrition, Food Science and Technology who were asked to score the products for appearance, color, flavor, taste and overall acceptability using 9 points hedonic rating scale (9 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) [8].

2.3.2. At the Community Level (Acceptability Trial)

Three kebeles were randomly selected from the study area. The lists of all lactating mothers living in the three selected kebeles were obtained from health extension workers. From these lists, 50 lactating mothers were randomly selected using a random number table. Acceptability test was done for 3 days to determine how much the samples were liked based on a 5-point hedonic scale for a set of attributes (where 5 = like very much, 4 = like a little, 3 = neither like nor dislike, 2 = dislike a little and 1 = dislike very much [9]. Panellists were instructed to test samples and rinse their mouths with water between samples to minimize any residual effect.

2.3.3. Nutrient Analysis

Nutrient contents of the entire products were analysed.

All determinations were carried out in triplicate. All chemicals and reagents used in laboratory analysis were of analytical grade. Polyethylene bags were used for the collection and storage of the samples. Food samples were kept in refrigerators until analysis was done. These are crude protein, crude fat, crude fiber, total ash and moisture were analysed using AOAC (2000) [21] and total carbohydrate by difference. Open column chromatography method was used to determine the values of β-carotene [22].

2.4. Data Analysis

The data were entered, cleaned and analysed using SPSS statistical software version 20. Results were calculated as means and standard deviations of scores. A one-way analysis of variance (ANOVA) was employed to test for significant differences ($p < 0.05$) in the scores of sensory attributes (appearance, flavour, taste, colour, texture and overall acceptability) between OFSP incorporated and the traditional maize-based flat breads. The significance of mean difference was determined by Fischer's Least Significant Difference (LSD).

2.5. Ethical Considerations

Ethical approval was obtained from Hawassa University ethical review committee. The purpose of the study was explained in detail to the study participants and their consents were sought. Respondents were involved in the study only when they agreed and signed the consent forms.

3. Results

3.1. Sensory Evaluation and Nutritional Analsis of OFSP Incorporated and Traditional Maize - based Flat Bread

3.1.1. Sensory Evaluation of Flat Breads

3.1.1.1. Sensory Score of Flat Breads by Panellists

The result of sensory score by panelists is shown in Table 2.There exist a non significant difference ($p >0.05$) for color, flavor, texture and taste among all the samples. Sample 175 obtained the highest mean scores for its appearance as compared to other samples and it was statistically different from sample 120 (control) and 254 but not from sample 168 ($p < 0.05$). Mean score for over all acceptability was lowest for sample 254 and highest for sample 168. Sample 168 was significantly higher ($p < 0.05$) than sample 254 for overall acceptability but the difference of both samples from the control sample was statistically not significant ($p >0.05$).

Table 2. Sensory score of OFSP incorporated and traditional maize – based flat breads by panellists (Mean ± SD)

Treament	Color	Flavor	Appearance	Texture	Taste	Overall acceptability
120	7.04±1.55^{a}	6.71±1.71^{a}	6.56±1.5^{b}	6.71±1.42^{a}	7.42 ±1.44^{a}	6.96 ±1.19^{ab}
168	7.09±1.40^{a}	7.27±1.47^{a}	6.64±1.61^{ab}	6.58±1.98^{a}	7.07±1.92^{a}	7.31±1.31^{a}
175	7.24 ±1.46^{a}	7.13±1.46^{a}	7.51±1.36^{a}	6.58 ±1.94^{a}	7.24±1.55^{a}	7.18 ±1.60^{ab}
254	6.40 ±1.99^{a}	6.73 ±1.70^{a}	6.02 ±2.16^{b}	6.76 ±1.72^{a}	6.84±1.82^{a}	6.36 ±2.08^{b}

Responses are based on 9 point hedonic scale
Control (120) = Maize: OFSP (100 %:0%)
Sample 168 = Maize: OFSP (75%: 25 %)
Sample 175 = Maize: OFSP (70%: 30%)
Sample 254 = Maize: OFSP (65%: 35%)
Values with different superscripts in the same column are significantly different at $p< 0.05$

Table 3. Score of acceptability trial of OFSP incorporated and traditional maize - based flat breads by lactating mothers (Mean ± SD)

Treatment	Color	Flavor	Appearance	Texture	Taste	Overall acceptability
120	4.36 ±0.53^{a}	4.20 ±0.40^{a}	4.12 ±0.48^{a}	4.40 ±0.70^{a}	3.78 ±0.68^{a}	4.26 ±0.49^{a}
168	4.06 ±0.55^{b}	4.08 ±0.53^{ab}	4.12 ±0.33^{a}	4.50 ±0.61^{a}	3.82 ±0.63^{a}	4.38 ±0.49^{a}
175	4.04 ±0.49^{b}	3.94 ±0.51^{b}	4.16 ±0.47^{a}	4.44 ±0.54^{a}	3.74 ±0.57^{a}	4.28 ±0.54^{a}
254	3.78 ±0.62^{b}	3.92 ±0.53^{b}	4.04 ±0.57^{a}	4.50±0.51^{a}	3.74±0.66^{a}	4.22 ±0.65^{a}

Responses are based on 5 point hedonic scale
Control (120) = Maize: OFSP (100%:0%)
Sample 168 = Maize: OFSP (75%: 25%)
Sample 175 = Maize: OFSP (70%: 30%)
Sample 254 = Maize: OFSP (65%: 35%)
Values with different superscripts in the same column are significantly different at $p< 0.05$

3.1.1.2. Score of Acceptability Trial (Sensory Evaluation) of Flat Breads by Lactating Mothers

The result of acceptability trial of flat bread by lactating mothers on the community is shown in Table 3. It was found non-significant differences ($p > 0.05$) in the score exists for flavour, taste, texture and overall acceptability of all samples prepared with various combinations. Mean color and appearance scores of sample 120 (control) were highest that were 4.36 and 4.20, respectively. Its (sample 120) color was significantly different ($p < 0.05$) from other samples but the appearance was significantly higher from samples 175 and 254 but there exist non significant difference ($p > 0.05$) between sample 120 (control) and 168.

3.1.2. Nutrient Analysis

3.1.2.1. Proximate Composition of Ingredients of Composite Flours

Results of the proximate composition of maize and OFSP flour are shown in Table 4. It was observed that moisture; crude protein, crude fat and crude fiber values of maize flour were 7.53%, 6.10%, 4.32% and 2.30% respectively. The moisture, crude protein, crude fat and crude fiber values of OFSP flour (in %) were 7.37, 4.62, 1.51 and 4.91 respectively.

Table 4. Proximate composition of ingredients of composite flours (Mean ± SD)

Composition (%)	Maize flour	OFSP flour
Moisture	7.53 ± 0.00	7.37 ± 0.00
Crude protein	6.10 ± 0.03	4.62 ± 0.09
Crude fat	4.32 ± 0.00	1.51 ± 0.00
Crude fiber	2.30 ± 0.00	4.91 ± 0.00
Crude Ash	1.26 ± 0.00	5.36 ± 0.00
Total Carbohydrate	78.49 ± 0.01	81.15 ± 0.04
Total energy in Kcal	377.24 ± 0.03	356.66 ± 0.06

3.1.2.2. Value of Vitamin A (RAE per 100gm) of Maize and OFSP Flour

The result on mean value of vitamin A (µg RAE per 1 00gm) of maize and OFSP flour in which the conversion factor used for this research was 13 µg β- carotene: 1 µg retinol [10]. The value of vitamin A contents of maize flour was observed to be zero. However, value of vitamin A content of OFSP flour was found out to be 888 µg RAE.

3.1.2.3. Proximate Composition of OFSP Incorporated and Traditional Maize Based Flat Bread

Results of the proximate composition of the four flat breads are presented in Table 5. It was observed that values of the moisture content of the control sample was significantly lower ($p < 0.05$) than the samples in which OFSP were incorporated. In addition, the moisture value increases as the proportion of OFSP flour increase. Values for crude fiber was significantly lower ($p < 0.05$) in the control than the samples in which OFSP flour was incorporated. The crude protein value of the control sample was found to significantly higher ($p < 0.05$) for the control (6.00%) sample of flat bread than the samples in which OFSP flour was incorporated. Value for crude fat was found to be significantly higher ($p < 0.05$) for the control (6.92%) sample of flat bread than the samples in which OFSP was incorporated (168,175 and 254). Crude ash value (as %) was observed to be 1.77 for the control and 3.21, 3.40 and 3.72 for 25, 30, 35% OFSP incorporated flat bread, respectively. This difference in ash value was significant ($p < 0.05$), the control sample being the lowest value (1.77%) and highest value (3.72%) was obtained for sample 254 (35% OFSP). Both the crude fat and ash values of all OFSP incorporated samples were significantly different ($p < 0.05$) from each other.

Table 5. Proximate composition of OFSP incorporated and traditional maize -based flat breads on dry weight basis (Mean ±SD)

Composition	Control (120)	168	175	254
Moisture	7.50 ± 0.02^{d}	8.28 ± 0.02^{C}	8.65 ± 0.01^{b}	9.03 ± 0.28^{a}
Crude protein	6.00 ± 0.15^{a}	5.30 ± 0.05^{b}	5.18 ± 0.03^{c}	5.12 ± 0.46^{d}
Crude fat	6.92 ± 0.03^{a}	5.12 ± 0.02^{c}	4.80 ± 0.03^{d}	5.76 ± 0.03^{b}
Crude fiber	1.91 ± 0.19^{b}	2.90 ± 0.13^{a}	3.18 ± 0.04^{a}	3.12 ± 0.33^{a}
Crude Ash	1.77 ± 0.01^{d}	3.21 ± 0.02^{c}	3.40 ± 0.02^{b}	3.72 ± 0.00^{a}
Total carbohydrate	77.81 ± 0.09^{b}	78.09 ± 0.19^{a}	74.97 ± 0.0^{d}	76.37 ± 0.41^{c}
Total energy Kcal	397.52 ± 0.00^{a}	379.64 ± 1.16^{b}	375.8 ± 0.03^{d}	377.8 ± 0.05^{c}

Control (120) = Maize: OFSP (100%:0%)
Sample 168 = Maize: OFSP (75%: 25%)
Sample 175 = Maize: OFSP (70%: 30%)
Sample 254 = Maize: OFSP (65%: 35%)
Values with different superscripts in the same row are significantly different at $p < 0.05$

3.1.2.4. Mean Value of Vitamin A (µg RAE per 100gm) of OFSP Incorporated and Traditional Maize Based Flat Breads

The result on mean value of vitamin A (µg RAE per 1 00gm) of OFSP incorporated and traditional maize based flat breads as served is shown in Table 6. The mean moisture contents (% wet bases) for the observed values of vitamin A were 34.05, 38.00, 39.76 and 41.60 for flat bread samples coded 120 (control), 168, 175 and 254, respectively. The value of the vitamin A content of the control bread was observed to be 0. The three OFSP incorporated flat bread samples (168,175,254) were observed to have significantly ($p<0.05$) different values for vitamin A content. The vitamin A content of formulated flat breads increased as proportion of OFSP incorporated to maize flour increased.

Table 6. Mean value of vitamin A (µg RAE per 100 gm) of OFSP incorporated and traditional maize based flat breads

Treatment	Vitamin A content (µg RAE per 100gm)
120	0
168	175.8
175	197.22
254	269.63

RAE *- Retinol Activity Equivalent
13 µg β- carotene: 1 µg RAE [10].
Control (120) = Maize: OFSP (100%:0%)
Sample 168 = Maize: OFSP (75%: 25%)
Sample 175 = Maize: OFSP (70%: 30%)
Sample 254 = Maize: OFSP (65%: 35%)

4. Discussions

4.1. Sensory Evaluation by Panellists and Lactating Mothers

In general, the results on sensory evaluation (Tables 2 and 3) revealed that all the formulated flat bread samples were acceptable both by panellists and lactating mothers. A similar finding was observed on a bread sample which was made of orange flesh sweet potato and locally available wheat flours on northern part of Ethiopia [11]. Out of 47(42%) consumer who had purchased golden bread (OFSP flour incorporated wheat based bread) found the colour (98%) and taste (85%) of the golden bread superior to that of the white bread. Seventy eight percent preferred heavier textured breads such as golden bread to lighter breads [13].

The present study, in addition, indicated that substituting 25-35% of maize flour by OFSP flour for preparing flat bread was acceptable. Our result was in agreement with a study done on a bread sample which was made of orange flesh sweet potato and locally available wheat flours [11]. The result of another study also showed feasibility to substitute wheat flour with 30% sweet potato flour in fried and baked snack products [12]. In contrast to the present study, a study showed up to 20% substitution of wheat flour with sweet potato flour was acceptable. This was true especially if the sweet potato is well processed and is of high quality and substitution beyond 20% proportion was not acceptable [14]. Similarly another study indicated no significant difference ($p<0.05$) in terms of overall acceptability at 10% substitution of sweet potato on wheat bread compared to the 100% wheat based bread (control). This study, however, revealed that 20 and 30% substitution levels of sweet potato bread samples were significantly different in some of the attributes tested (colour, taste and texture) from the wheat bread with wheat bread being preferred by the panellists. It was noted from the above mentioned two studies substituting 10-20% of wheat by sweet potato flour is acceptable [15]. Compared to these studies, it was observed by the present study that a higher level of substitution (up to35%) of OFSP for maize-based flat bread preparation was acceptable. This variation could be attributed to several factors. Some possible explanations for this could be the ingredient used for the present study being maize flour and the difference in dietary and socio-cultural aspects of study subjects. The previously mentioned study done in Kampala, for instance, mentioned a change in the taste of sweetness as a reason for the poorer acceptability of bread in which sweet potato-flour was incorporated compared to the one usually bought from local markets [14]. In that the popular bread in Kampala is very sweet but sweet potato flour introduction in bread-processing seemed to reduce the sugary taste.

Sensory evaluation done at community level in the current study showed that the colour of the control (sample 120) flat bread was most preferred by mothers over the rest of the samples and this was significant at 5% level of significance. This could be explained for the reason that there exists a higher preference for white colour is in most of the cases as revealed by studies. Similarly a study revealed that rural communities in Africa are thought to be cautious about accepting foods substantially different in colour and taste from those they are used to [16].

4.2. Nutrient Analysis

4.2.1. Proximate Composition

The crude fat, crude fiber, crude ash, total carbohydrate and energy value of maize flour observed in the current study (Table 4) were in agreement with the values in the Ethiopian food composition table. However, the protein value was found to be higher than the Ethiopian food composition table [17]. The crude fiber value of OFSP flour was high (4.91%). Similarly the result of a study done in India showed that sweet potato flour had high fiber content and this high fiber increases the utility of sweet potato flour in various food products [18]. It was also observed that the crude fiber content of the control flat bread was lower than other flat bread samples in which OFSP was incorporated (Table 5). A similar study also indicated that the ash and fiber contents of bread increased with increasing levels of sweet potato flours [24]. The improvement in crude fiber content in the formulated flat bread could be attributed to the inclusion of OFSP, which was shown in the flour result

of the present study (Table 4).

The protein content of OFSP flat bread samples in dry weight bases range from 4.99-5.42. A research on macroscopic properties of bread supplemented with 50%, 55%, 60% and 65% sweet-potato flour revealed that the protein value was highest for the bread supplemented with the lowest proportion (50%) of sweet potato [19].Another study also showed that the protein contents of the bread that is made from a composite flour of Wheat, Maize and Orange Fleshed decreased significantly with increasing levels of sweet potato flours [25]. A similar result was observed by the present study.

4.2.2. Value of Vitamin A (µg RAE per 100gm)

The value of vitamin A (µg RAE per 100 gm) of maize flour was observed to be zero. This value was similar with the values in the Ethiopian food composition table [17].

A study showed that, the amount of total β-carotene in OFSP was high even though there is loss during boiling, storage and drying [26]. This indicated that, flour from OFSP has potential as a significant source of VA The vitamin A content of OFSP flour in the present study (Table 6) was lower than the previous study (< 1,500 µg RAE per 100 gm.) [20]. This difference might be due to the difference in the drying method and OFSP varity used.

In the present study the value of the vitamin A (µg RAE per 100gm) of the control bread as it is served was observed to be 0. A similar finding was observed by [17]. The vitamin A content (RAE per 100 gm) of formulated flat breads was highest in the bread supplemented with highest proportion (35%) of OFSP. This finding was in agreement with another study [21].

5. Conclusions

Maize-based flat breads in which OFSP flour was incorporated at the proportions of 25%, 30% and 35% were acceptable at the laboratory and community level. Therefore, it can be concluded that OFSP incorporated maize based flat bread has the potential to be readily accepted and used by lactating mothers in the study area. The addition of OFSP flour improved the vitamin A content (µg RAE) of traditional maize based flat bread. Therefore, the formulated flat breads can be used as potential food sources of vitamin A for lactating mothers living in the study area

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