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Utilization of Orange-fleshed Sweetpotatoes to Enhance the ß-Carotene Content of Locally Consumed Food Products

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Abstract

A food-based approach can be a more sustainable and cost-effective means of addressing vitamin A deficiency. Incorporating orange-fleshed sweetpotatoes (OFSP) in commonly consumed food products could be one strategy to enhance intake for ß-carotene. This study determined the ß-carotene composition, sensory qualities, and acceptability of developed OFSP enriched food products compared to the locally consumed food products. The *Inmitlog* variety which can provide a high yield and contains 4,463ug/100g of ß-carotene, was used to enrich *pandesal*, hopia, and candies. This commonly consumed *pandesal*, hopia, tamarind, and coconut-candied products have nil to trace amounts of ß-carotene. OFSP-enriched pandesal, hopia, and candies, on the other hand, contain considerable amounts of ß-carotene, which can be an additional source of the recommended daily vitamin A intake for consumers. Sensory evaluation showed that wheat flour substitution with OFSP in pandesal had improved the textural moistness relative to the local pandesal. The sensory shelflife of pandesal and hopia is four days. The OFSP- tamarind candy has a shelflife of seven months, while the OFSP–coconut candy has a shelflife of four months. This study had shown that incorporating OFSP in commonly consumed food items can be a possible intervention to increase the ß-carotene intake of consumers.

KEYWORDS

Orange-fleshed sweetpotato
sweet-potato enriched food
product development
ß-carotene
shelflife

Introduction

The 2013 Food and Nutrition Research Institute (FNRI) survey reported that the main sources of vitamin A are from meat and its products (25.4%) and poultry (23.4%), whereas vegetables provide only 14.8%. It has also been reported that as wealth status increases, the estimated average requirement for green and leafy and yellow vegetables decreases. These findings imply that vitamin A intake is more of the pre-formed vitamin A, mainly supplied by animal sources, and less of the pro-vitamin A (β- carotene), mostly from orange-colored fruits and vegetables. Researches have shown that safe and appropriate intake of vitamin A can only be attained by consuming these two components (Weber &

Tilman, 2012). ß-carotene is a safe source of vitamin A and its pro-vitamin A function contributes to vitamin A intake (Tilman et al., 2010).

ß-carotene, the main component of carotenoids, is a precursor of vitamin A and has the highest vitamin A activity of all carotenoids (Burri, 2011). Once absorbed in the body, only a portion is transformed into vitamin A while a larger portion is stored in the liver. Children who consumed 125g boiled OFSP (1031 ret equivalent) had greater improvement in vitamin A liver stores than those given white-fleshed sweetpotatoes (Jaarsveld et al., 2005). Vitamin A is beneficial for maintaining the integrity of epithelial tissue growth and proper functioning of the retina and immune system (Nzamwita et al., 2017). In one in vivo experiment, ß- carotene was also reported to work as an antioxidant by acting as a lipid radical scavenger and as a singlet oxygen quencher (Tilman et al., 2010).

However, the consumption of sweetpotatoes is limited to traditional food items such as *turon* and camote cue. Although researches have shown that sweetpotato can be used to partially substitute wheat flour in the preparation of bread, cookies, and biscuits, these products are rarely found in the market.

Strategies to promote OFSP as one tool to help attain food and nutrition security include recipe development, nutrition education, and an income-generating crop to farmers (Kurabachew, 2015). Besides disseminating developed recipes, the nutritional information and its potential benefits should be included as one element of the nutrition education and technology commercialization package. However, there's limited information available on the ß-carotene content of OFSP developed recipes. The ß-carotene information could be useful to consumers who opt for healthier food products available in the market. This paper provides information on the ß-carotene composition of developed OFSP food products compared to the locally consumed food products. It also includes information on the sensory qualities, shelflife, production costs, and acceptability of OFSP-based food products.

Materials and Methods

Market Survey of Existing Local Food Products

Prior to vitamin A enrichment, an informal market survey was done to assess the nutritional information and the vitamin A content of existing local food products. Sources of nutritional information included the product labels (if available). The Food Composition Table (1997) of the Food and Nutrition Research Institute of the Department of Science and Technology (FNRI-DOST) also shows the nutritional information for other locally consumed food products.

Preparation of OFSP-Enriched Food Products

Preparation of OFSP Enriched Loaf Bread

The variety *Inmitlog*, which has potentials for adoption by commercial sweetpotato growers was used to enrich the *pandesal*. This variety has a dry matter content of 29–32% at three months after planting with 4,463 ug/100 of ß-carotene (Table 1). Among the OFSP varieties, this variety produced the highest average yield of 18t/ha under farmers' production systems.

Table 1

The Yield, Dry Matter and ß-carotene of the OFSP's Grown in Pidigan, Abra, Philippines, 2017- 2018

Variety	Marketable (t/ha)	Dry matter content (%)	ß-carotene content (ug/100g)
Inmitlog	18.40^{a}	29.8^{ab}	4463^{b}
SP 30	13.1^{b}	27.1^{ab}	874^{c}
Taiwan	13.6^{b}	22.5^{c}	7407^{a}

Source: Quindara, H. (2017)

Standardization of product formulation. Biscuits, pancakes have shown that the optimum wheat flour substitution ranges from 20-30% (Bonsi et al., 2014; Edun et al., 2019; Srivastava et al., 2012). For this study, boiled and mashed OFSP was used because it has higher all-trans ß-carotene than flour (Muzhingi, 2016). Four substitution ratios (kg OFSP: kg bread flour) were considered, namely: 0.75:2.5; 1:2.5; 1.25:2.5; and 1.5:2.5. These formulations were compared to the control, which is 100% bread flour. The optimum formulations were identified using the hedonic rating scale of 1 to 7 involving 40 panelists.

Preparation of Hopia Filled with OFSP Paste

Boiled and mashed dark OFSP (*Taiwan* variety) was mixed with sugar, margarine, and buttermilk. The mixture was cooked until thick and used as filling for hopia production. Cooled sweetpotato paste were filled into a flaky dough then baked at 180-200^{o}C.

Preparation of OFSP-enriched Candies

Of all the varieties, *Taiwan* contains the highest ß-carotene of 7,407ug/100g sample and lowest dry matter content of 22% (Table 1). This variety was used in the preparation of candied products. Preparation of candied product does not require specific dry matter for standard culinary operation such as dough handling.

Tamarind candy available in the market is prepared by cooking ripe tamarind and sugar until thick, cooling, shaping into balls, and rolling in sugar. Candied coconut, locally termed as bukayo is also made from grated fresh coconut and sugar, which was cooked until a chewy texture is reached. The mixture consisting of the fruits, sweetpotatoes, sugar, margarine, and a little flour was cooked with constant stirring until a chewy consistency was also attained.

Standardization of Product Formulation. Three fruit: OFSP ratio were considered in this study, namely: 1:0.5 w/w; 0.5:1 w/w; and 1:1 w/w. These formulations were compared with the control, which is 100% fruit. The overall acceptability of the different samples was evaluated by 30 panelists using the hedonic rating scale of 1 (dislike very much) – 7 (like very much). The responses to describe the qualities of the different formulations were also gathered.

Nutritional and Data Analysis

Based on sensory evaluation results, OFSP *pandesal* produced from 1kg sweetpotato: 2.5kg wheat flour, and candied products made from 1:1 fruit to sweetpotato ratio obtained the highest sensory acceptability ratings. These products were then submitted to the Industrial Technology and Development Institute of the Department of Science & Technology (ITDI- DOST) for proximate and ß-carotene analysis. Since the nutritional analysis of locally consumed products such as *pandesal*, hopia, tamarind, and coconut was already done by the Food and Nutrition Research Institute of the Department of Science & Technology (FNRI–DOST), no re-analysis was done in the study.

The ß-carotene contribution OFSP-enriched food products were compared with the commonly consumed food products. Vitamin A derived from the ß-carotene content of OFSP products was estimated. One RE is equivalent to 6ug ß-carotene (FNRI, 1997). The proximate ß-carotene and vitamin A content were taken from the FNRI Philippine Food Composition Table (1997) for commonly consumed food products.

Sensory data were statistically analyzed using the Analysis of Variance (ANOVA). The means were compared using the least significance difference (LSD) test. Significant differences between means were evaluated involving the Duncan's Multiple Range Test (DMRT) at 95% confidence levels ($P \leq 0.05$).

Shelflife Evaluation

Shelflife is an objective means of determining the time a product can be stored without appreciable change in qualities and acceptability. The shelflife of the developed products was evaluated using the 7-point hedonic rating scale involving 20 panelists. This method of sensory shelflife evaluation was also used in chocolate and carrot cupcakes (Montes & Trindade, 2010) and minimally processed kiwi fruit (Mastromatteo et al., 2011). Packed samples were stored under ambient conditions, and samples were withdrawn at a specific period for sensory evaluation. In the study, the sensory shelflife was determined as the average number of days required for the acceptability rating to reach an acceptability rating score of 5.5 (like slightly). Sensory evaluation for

OFSP pandesal and hopia were done daily. For candied OFSP, sensory evaluation was done at weekly intervals.

Estimation of Production Cost

Preliminary product costing was done on the different food products. The cost of raw materials and supplies, labor, rentals, and other costs such as fuel, water, and electricity were estimated using the prevailing market price. The production costs were based on the packing size of the OFSP products.

Results

Proximate Composition and ß-carotene of OFSP-Enriched Food Products

OFSP-Enriched Bread Products

Table 2 compares the proximate composition and ß-carotene content of enriched and unenriched bread. For every 100g sample, the OFSP-enriched *pandesal* contains 32g moisture content, 290kcal of energy, 3.2g of fat, 56.6g of total carbohydrates, and 8.8g of protein. The 100% wheat *pandesal* contains 21.6g moisture, 330g kcal energy, 4.2g total fat, 62.9g total carbohydrates, and 10.1g protein. No ß- carotene was detected on *pandesal* made from pure wheat flour, while the OFSP-enriched pandesal contain about 1,038ug/100g analyte. This ß-carotene content has a vitamin A retinol equivalent (RE) of 173ug/100g. On the other hand, the local Spanish bread filled with yellow-fleshed sweetpotato contains 85ug/100g of ß-carotene with RE of 14.17ug/100g sample (FNRI, 1997).

Hopia filled with OFSP paste contains higher energy (398kcal/100g) and carbohydrates (65.4g/100g) with lower total fat (10g/100) and protein content compared to mungbean-filled hopia (5.2g/100). This product also has high ß-carotene content of 1,873ug/100g sample with an estimated total vitamin A RE of 312ug/100g. On the other hand, the hopia filled with mungbean paste, which contains 5ug/100g sample of ß-carotene can provide only 0.83ug/ 100g RE.

Candied Products

The different candies differ mainly on the ß-carotene, fat, ash, and protein content (Table 3). The 100% tamarind and coconut candies had zero ß-carotene content. The OFSP-enriched tamarind candy has lower ß-carotene content of 1,655ug/100g analyte with an estimated RE of 276ug/100g. The OFSP-enriched coconut candy contains 2,557ug/100g sample of ß-carotene with a RE of 426ug/100g.

OFSP-added coconut candy contains higher fat content (6.7g/100g analyte) than pure coconut candy with a fat content of 2.1g/100g analyte. The ash content of OFSP-coconut candy is 2.3g/100g sample while the 100% coconut candy contains 1.3g/100g sample. The addition of OFSP in coconut candy increased the moisture content from

Table 2

The Proximate Composition and ß-carotene of OFSP Bread as Compared to the Locally Available Bread

Analyte/100g	OFSP Pandesal	Pandesal	Spanish bread with yellow camote	Hopia OFSP Paste	Hopia Mungbean Paste
Moisture, g	32.00	21.60	21.60	24.10	23.50
Ash, g	1.40	1.20	1.20	1.20	1.30
Energy, kcal	290.00	330.00	371.00	398.00	383.00
Total fat, g	3.20	4.20	12.40	10.00	12.00
Total CHO, g	56.60	62.90	55.50	65.40	62.30
Protein, g	8.80	10.10	9.30	5.20	6.50
ß- carotene, ug	1038.00	0	85.00	1873.00	5.00
RE (ß-carotene),ug	173.00	0	14.17	312.00	0.83

Table 3

The Proximate Composition and ß-carotene of OFSP-Fruit Candied Products Compared with the Locally Available Fruit-based Candies

Analyte/100g	Candied Products			
	OFSP-tamarind	100% Tamarind	100% Coconut	OFSP-coconut
Moisture, g	14.10	16.70	1.60	2.80
Ash, g	1.20	0.50	1.30	2.30
Energy, kcal	400.00	355.00	377.00	399.00
Total fat, g	1.10	0.70	2.10	6.70
Total CHO, g	96.50	81.70	77.30	96.60
Protein, g	1.60	0.40	1.80	1.60
ß- carotene, ug	1655.00	0	0	2557.00
RE (ß-carotene),ug	276.00	0	0	426.00

1.6g/100g (100% coconut) to 2.8g/100g sample.

The protein content (1.6g/100g) of OFSP with tamarind candy is higher than the pure tamarind candy (0.4g/100g sample). For the ash, energy, fat, and carbohydrate content, 100g of OFSP-tamarind contain 1.2g, 400 kcal, 1.1g and 96.5g, respectively. On the other hand, the 100% tamarind candy contains 0.5g of ash, 355kcal of energy, 0.7g of fat, and 81.7g of carbohydrates.

Acceptability of OFSP-enriched Food Products

Acceptability of OFSP-enriched Bread Products

Pandesal. *Pandesal* substituted with OFSP (Figure 1) received higher acceptability ratings for sweetness and color than the pandesal made from 100% wheat flour (Table 4). The combination of wheat flour and OFSP in a ratio of 2.5:1 (by weight) had the highest acceptability rating for texture (6.5) and general acceptability rating (6.8). Pandesal from pure wheat flour had a general acceptability rating of 5.2. The formulation that consisted of 0.75kg OFSP and 2.5kg of wheat flour had an acceptability rating of 6.5. When the substitution level was increased to 1.25 and 1.5kg OFSP for every 2.5kg of wheat flour, the general acceptability rating decreased to 4.7 and 4 (neither like nor dislike), respectively. The low acceptability ratings can be attributed to the observed compact and moist textural characteristics of the product.

Figure 1

Dough with Boiled and Mashed OFSP (left); OFSP-enriched Pandesal (right)

Table 4

The Acceptability of Sweetpotato Bread Using Different Levels of Substitution

Substitution level OFSP: Bread flour (kg)	Mean Acceptability/Responses				
	Sweetness	Texture	Color	General Acceptability	Remarks
Control (Pure bread flour)	6.0^{ns}	4.2^{b}	4.5^{a}	5.2^{b}	Dry texture
0.75 : 2.5	6.4	5.8^{ab}	5.1^{ab}	6.5^{a}	Slightly moist texture
1: 2.5	6.5	6.5^{a}	6.1^{ab}	6.8^{a}	Slightly moist texture, light orange color
1.25: 2.5	6.8	5.3^{a}	6.7^{a}	4.7^{bc}	Moderately moist, compact, light orange color
1.5 : 2.5	6.7	4.1^{a}	6.7^{a}	4.0^{c}	Compact, moist

Number of panelists: 40 *ns- not significant*
Means with the same letter in a column are not significantly different at P ≤ 0.05

Acceptability of Sweetpotato-Based Candies Using Different Levels of OFSP

The optimum fruit to sweetpotato ratio is 1:1, as shown by the high sensory acceptability rating (6.5 to 6.7) in Table 5. The OFSP-tamarind candy branded "camarind candy" (Figure2) produced using the combination of 1kg tamarind and 0.5kg sweetpotato was evaluated as very sour. On the other hand, the formulation that contains 0.5kg of tamarind with 1kg sweetpotato lacks the characteristic sour taste preferred by the panelists.

For OFSP-enriched coconut candy, the formulation that consist of 1kg coconut and 0.5kg sweetpotato and the formulation that contains 0.5kg coconut and 1kg sweetpotato had lower sensory acceptability ratings. The candy that contains a 1:1 w/w ratio of sweetpotato and coconut had the highest general acceptability rating of 6.7.

Acceptability of OFSP Paste-Filled Hopia

Table 6 shows the comparative acceptability

Table 5

The Acceptability of Camarind Candy Using Different Levels of OFSP

Fruit: OFSP Ratio	Acceptability/Responses	
	General Acceptability	Remarks
Tamarind		
1:0.5 w/w	5.4^{b}	Very sour
0.5:1 w/w	5.6^{b}	Lacks sourness
1:1 w/w	6.5^{a}	Sourness & sweetness just right, good blend, taste good
Coconut		
1:0.5 w/w	5.1^{b}	Oily
0.5:1 w/w	4.6^{bc}	Not so good, more of sweetpotato
1:1 w/w	6.7^{a}	Good flavor, yummy, taste good

Note: Number of panelists = 30
Acceptability rating scores: 7 – like very much, 6 – like moderately, 5 – like slightly, 4 – neither like nor dislike, 3 – dislike slightly, 2 – dislike moderately, 1 – dislike very much
Means followed by common letters in a column are not significantly different at P ≤ 0.05.

Figure 2

Camarind Candy (Mixture of OFSP and Tamarind) (left); OFSP-Coconut Candy (Marketed as Molido) (right)

of hopia filled with paste from different varieties of sweetpotatoes. No significant differences in appearance, color, texture, flavor, sweetness and general acceptability were observed among the sweetpotato varieties used. The products (Figure 3) had sensory scores ranging from 6 (like moderately) to 7 (like very much). These results indicate that any sweetpotato variety could be processed as paste that can be used as filling for hopia production.

Figure 3

OFSP-Filled Hopia

Shelflife and Production Costs of OFSP Products

Table 7 shows the sensory shelflife of different food products. The ambient storage temperature ranges from 14-19°C. Daily sensory testing of OFSP *pandesal* and hopia showed that on the 4th and 5th day, respectively, the average general

Table 6

The Acceptability of Camarind Candy Using Different Levels of OFSP

Parameters	Sweetpotato Varieties		
	JO6 30-3 (yellow-fleshed)	Inmitlog (orange-fleshed)	Haponita (violet-fleshed)
Appearance	6^{ns}	6^{ns}	6^{ns}
Color	6	6	6
Texture	6	6	6
Flavor	7	7	7
Sweetness	7	7	7
General acceptability	7	6	6

ns – not significant

Table 7

Production Costs and Shelflife of the Different OFSP Products

Product	Shelflife	Production Cost (Php)
Hopia	5 days	7.66 /pc
OFSP pandesal	4 days	32.00 /pack
Coconut- OFSP candy	4 mos	25.00 /100 g
Tamarind – OFSP candy	7 mos	26.77 /100 g

acceptability rating score was 5.6. Using this value as cut-off point, the sensory shelflife is four days, indicating that the product has been liked slightly. Of the two candies, OFSP-coconut has a shorter sensory shelflife of 4 months than OFSP-tamarind, which can be stored for 7 months.

At the time of the experiment, the market retail prices of the main ingredients wheat flour and sweetpotato were Php30.00/kg and Php20.00/kg, respectively. The formulation of 1kg OFSP per 2.5kg of wheat flour can produce 113 pieces of *pandesal* (40g/piece). Adding the costs of the other ingredients, such as sugar, butter, yeast, labor, depreciation, and others, it requires Php32.00 to produce a pack of pandesal containing 15 pieces. For hopia, filling 2kg OFSP paste into the dough can produce 72 pieces (45g/pc); the estimated product cost was Php7.66/pc.

Fruit-flavored OFSP candied products were packed at 100g/pack. The market price of coconut and tamarind were Php60.00/kg and Php40.00/kg, respectively. The formulation consisting of 1kg OFSP and 1kg tamarind can produce 32 packs at 100g/pack with a production cost of Php26.77/pack. Following the same ratio of 1:1 of coconut and OFSP, the production cost is Php25.00/100g.

Discussion

The study shows that the optimum ratio for pandesal consists of 1kg boiled and mashed sweetpotato and 2.5kg wheat flour. This formulation had a higher acceptability rating than 100% wheat *pandesal*, which could be attributed to the slightly moist textural characteristic of the OFSP-enriched bread observed by the panelists. The higher moisture content of OFSP *pandesal* (32g/100g) compared to 100% wheat *pandesal* (21.6g/100g) implies that the addition of sweetpotato had increased the moisture content which provided moister textural qualities. These findings are similar to the results of Low & Jaarsveld (2008) and Bonsi et al. (2016) that consumers strongly preferred the golden bread bun (OFSP-enriched) than the pure wheat flour because of its heavier texture and attractive appearance.

Incorporating 30% of OFSP in *pandesal* production can provide consumers an additional source of pro-vitamin A in the diet. The ß-carotene not available in wheat flour can be supplied by the OFSP (var. *Inmitlog*), which contains 4,463ug/100g. Similarly, Afework et al. (2016) reported that 30% substitution of OFSP flour to wheat flour in biscuits had significantly higher ß-carotene content than biscuits prepared from pure wheat flour. The higher ß-carotene detected on hopia compared to *pandesal* can be attributed to the amount of filling where 35g of OFSP paste is filled into the flaky dough before baking.

The reduced carbohydrate, energy, and protein content observed in OFSP in *pandesal* can be attributed to the dilution effect of sweetpotato, which contains a lower amount of carbohydrate and protein. FNRI Food Composition table (1997) shows that wheat flour contains 75.2g/100 carbohydrate and 12.6g protein. On the other hand, sweetpotato contains 29-31g/100 of carbohydrates and 0.5g of protein. OFSP paste-filled hopia also had lower energy, fat, and protein but had higher carbohydrates than mungbean-filled hopia. These nutrient differences were also attributed to differences in protein and carbohydrate composition, where mungbean has higher protein content than sweetpotato.

The deep OFSP variety (*Taiwan*) incorporated with tamarind and coconut enhanced the ß-carotene content of the candied products. However, it has been observed that the ß- carotene of OFSP-tamarind candy was lower by 30% as compared with OFSP-coconut candy. The two candies follow a similar fruit:sweetpotato ratio of 1:1. Therefore, these findings indicate that ß-carotene can be degraded when cooked together with acidic fruits such as tamarind. This result is similar to the findings of Qian et al. (2012) that ß-carotene degradation increases with decreasing ph. Another experiment on carrot juice showed that adjusting the ph to neutral and slightly acidic conditions reduced the total carotenoids (26%) while adjusting the ph from 3 to 6 increased the total carotenoids from 18 to 22% (Bell et al., 2016). This result requires further study to elucidate the effect of ph on the stability of ß- carotene. However, despite the nutrient loss encountered, the ß-carotene level is still considerable because of the high ß-carotene content of the dark OFSP variety. On the other hand, combining grated coconut or margarine in the OFSP candied products is beneficial to the bio-availability of ß-carotene. Cooking ß-carotene-rich food with oil is recommended (Burri, 2011) because consuming ß-carotene with oil is important in the absorption of this nutrient in the body (Faila et al., 2009).

Boiled and mashed OFSP was used to prepare bread and candied products because this type of preparation retains 70-80% of the ß-carotene content (Jaarsveld, 2006). However, despite these losses, the ß-carotene is still substantial because this nutrient is highly available in the OFSP. The 173 RE ug/100g ß-carotene obtained from OFSP-enriched pandesal is higher than bread enriched with yellow-fleshed sweetpotato flour with ß-carotene content of 0.1656-0.4715ug/g (Nogueira et al., 2018). These results imply that food products enriched with OFSP are more efficient vitamin A sources than yellow-fleshed sweetpotatoes. In the Philippines, the recommended daily intakes for vitamin A are 500ug RE for children, 400-600ug RE for adults, 500-800ug RE for pregnant mothers, and 900ug RE for lactating mothers (Barba & Cabrera, 2002). The ß-carotene of pandesal 173ug/100g RE can provide 43%, 29%, 22%, and 19% on the recommended daily vitamin A intake for children, adults, pregnant and lactating mothers, respectively. This estimated contribution to Recommended Dietary Allowance (RDA) for vitamin A is lower than the report of Nzamwita et al. (2017), where sweetpotato flour incorporated in bread at 20-30% provided 29 and 89.2% on the RDA for vitamin A in children aged 3–10 years old. In addition to this report, pregnant and lactating women who consume 100g of OFSP bread can provide nearly half of the RDA for vitamin A.

Hopia filled with OFSP paste, which contains 312ug RE/ 100g, can contribute 78%, 52%, 39%, and 35% to the recommended daily intake for vitamin A of children, adults, pregnant and lactating mothers, respectively. The potential contribution of hopia to the RDA for vitamin A is higher than OFSP-*pandesal* because the deep OFSP variety ('Taiwan'), which contains 7,407ug/100g sample, was used in the filling production.

The OFSP-candied products could be considered a good source of vitamin A. The ß-carotene content of OFSP-coconut candy is 2557ug/100g equivalent to 426ug RE/100g of vitamin A, while the OFSP-tamarind candy contains 1,655ug/100g of ß-carotene. These products are potential sources of vitamin A because, according to Low & Jaarsveld (2008), processed products that contain at least 15ug/g of trans- ß-carotene are good sources of vitamin A.

The sensory shelflife of OFSP *pandesal* and hopia is 4 days, which indicates that the products attained a sensory hedonic rating scale of like slightly. In contrast, Wanjuu et al. (2018) found that bread substituted with OFSP puree had a shelflife of 6 days, while white bread had a shelflife of 4 days. The occurrence of microbial spoilage was used as the basis in determining the shelflife. According to the report, the longer shelflife was attributed to the increased water holding capacity that can reduce water activity. The study did not consider microbial load determination. Thus, a further study is needed to evaluate the physio-chemical and microbial changes that influence the sensory qualities and ratings.

Wheat flour substitution with OFSP can provide economic benefit to processors. When the price of sweetpotato is lower than wheat flour, the production cost can be reduced. This preliminary product costing, however, needs to be validated on a larger scale. Thus, pilot testing before commercialization is recommended to evaluate the developed products' applicability and profitability under a semi-commercial production system.

Conclusions

The study had shown that incorporation of OFSP in the production of commonly consumed bread, hopia, and candied products could be considered a source of ß-carotene to augment the daily required vitamin A intake. In addition to their nutritional benefits, wheat flour substitution with sweetpotatoes has the potential to reduce production cost and dependence on imported wheat flour. Hence, promoting the nutritional advantage accompanied by commercial adoption of the processing of these food products can help spread the nutritional benefits to a wider population.

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