

Importance of β -carotene rich weaning food prepared through enrichment of maize meal with potatoes (*Ipomea batatas*) also known as Orange Flesh Sweet Potatoes (OFSP)

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ABSTRACT

Background: Vitamin A deficiency (VAD) and xerophthalmia is prevalent and contribute to morbidity and mortality especially in young children in developing countries. Vitamin A deficiency contributes up to 23% lives lost in children aged 6 to 59 months. Thanks to huge requirements in children aged less than 59 months, vitamin A supplementation has been adopted by countries with support from UNICEF and other development partners. Without vitamin A supplementation a typical child in a developing country is not able to attain and maintain the minimally adequate liver retinol stores [Children are vitamin A deficient with liver retinol stores $<20 \mu\text{g/dL}$ ($<0.693 \mu\text{mol/L}$)]. However, vitamin A supplementation has faced a number of challenges which creates an avenue for other intervention strategies. Dietary diversity is important. Beta carotene is converted to retinol on a function of 1:2, therefore children would have to eat tenfold increase in portion sizes of fruits and vegetables. Food fortification and enrichment of a specific meal that provides the necessary dietary recommendations of the child in less than three food servings that would provide the necessary nutritional requirements at a low cost therefore making it valuable in developing countries. This study aimed to wean food (maize and OFSP) and calculate the β -carotene nutrient retention.

Methods: Four OFSP varieties were procured from Embu in Kenya. The weaning food consisted of 20% maize (white) meal and 100% OFSP. Analysis was done on the composite flour and maize meal for pro-vitamin A. OFSP composite flour samples were analyzed for pro vitamin A and compared with recommended dietary allowance for children 6 to 59 months.

Results: two OFSP varieties had the highest pro vitamin A carotenoid content: Taugaing (57.10 mg/kg) and Haspot (51.70 mg/kg). Addition of white maize meal was important to improve gelatinization during preparation. One kilogram of maize meal enriched with Taugaing variety of sweet potatoes is estimated to contain 50.88 mg/kg pro vitamin A carotenoid.

Conclusion: white maize meal enriched with 80% OFSP is estimated to increase pro vitamin A carotenoid intake in children aged 6 to 59 months, contributing to a reduction in vitamin A deficiency in rural households.

Keywords: *Xerophthalmia*; retinol; RDA; Pro-vitamin A carotenoid, weaning food.

INTRODUCTION

The nutrition quality of food can be improved through two ways: fortification and enrichment. Food enrichment is the action of improving the quality of food using another. Foods low in certain nutrients can be improved using portion of foods rich in that/those particular nutrients. For instance, iron and zinc content can be improved using amaranth seed flour while vitamin A might be used using orange fleshed products such as cassava or sweet potatoes [1]. After exclusive breastfeeding infants require high amounts of nutrients, including vitamin A. Because residents of developing countries rely heavily on plant-based diets, β carotene a pro vitamin A is important [2,34]. Weaning foods should therefore have a high amounts of pro vitamin A [5,6]. Vitamin A is a fat-soluble vitamin important for normal vision, the immune system and functioning of the organs. In Kenya, white maize, which is widely used for complementary feeding and is seldom fortified at the household level, whose populations are associated with the high prevalence of vitamin A deficiency among infants in low-income countries [7,8].

Vitamin A deficiency is estimated identified as a problem of severe public health significance in developing and least developed countries [8,9]. Vitamin A deficiency is among major health problems worldwide that leads to blindness, retarded growth and death, particularly in developing countries. In these countries, vitamin A deficiency largely affects pre-school children, pregnant and lactating mothers, and the rural poor [10]. To supplement vitamin A supplementation, governments in Africa have focused on orange fleshed cassava, yellow maize and orange fleshed sweet potatoes to improve the vitamin A status of children 6-59 months [11,12]. Consumption of sweet potatoes is prevalent in parts of the sub-Saharan African (SSA). To improve the vitamin A content of this product governments in partnership with international potato center (CIP) have conducted research on this product which has ended with a sweet potato orange in color, also known as orange fleshed sweet potatoes (OFSP). Sweet potato is a low-priced crop, which is part of staple foods that can be a year-round source of vitamin A. Therefore, by using orange-fleshed sweet potato, it is possible to improve vitamin A status, increase the bio-availability of different micro-nutrients such as Fe, Zn, Ca and Mg, reduce vitamin A deficiency and hence reduce child mortality rates by 23 to 30% [13]. Evidence exists that beta carotene, in combination with other nutrients: vitamin C and E plays a critical role as anti-oxidants in lung function, with a direct correlation between lung function and retinol in children [14,15]. Carotenoids and vitamins A, among other natural antioxidants remove harmful free radicals which are produced (naturally) through cellular activity and other stressors (environmental), thus maintains the structural integrity of cells' immunity [16,17]. Nature has >600 carotenoids, including β -carotene. An estimated 50 of these are carotenoids, also known as provitamin A carotenoids which produce vitamin A. The most abundant and sufficient carotenoid in foods is β -carotene. β -carotene's anti-oxidant properties are important

in acting on free radicals and reactive nitrogen species (RON) formed during the body's normal immune function or through externally (such as pollution or smoking). Free radicals, which are not scavenged by the body are linked to development of cancer and other degenerative diseases. The main source of retinal (dietary) is beta carotene with red and orange food products having particularly high amounts [18]. Roughly one million children have clinical signs and symptoms of vitamin A deficiency, and over 0.9 million children under 6 years of age suffer from a certain degree of *xerophthalmia*; with an estimated 30,000 children becoming blind every year due to severe vitamin A deficiency. The biochemical and nutritional composition of the sweet potato with emphasis on its β -carotene highlights the potential of it as value added product. Also, the high concentration of the beta-carotene makes it a healthier alternative to synthetic coloring agents [14].

METHODS

Production of sweet potato composite meal [5].

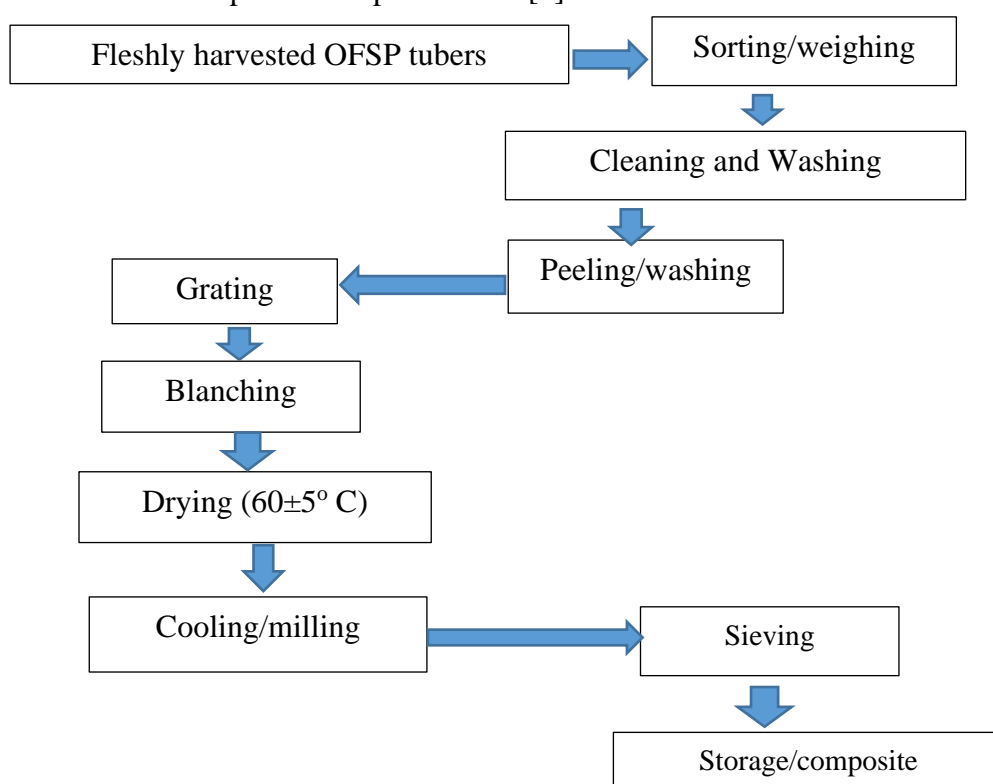


Figure 1. procedure for production of composite flour which will be used for weaning foods. Freshly harvested tubers are sorted, cleaned and peeled. Blanching is done after grating followed by sieving. The product is dried at $60\pm 5^\circ\text{C}$

Cleaning, washing and taking the weight of sweet potatoes was the first stage. Peeling of the skin was done by mechanical removal using a knife. Grating of the sweet potatoes was done to increase the surface area for drying. Blanching for 10 seconds was done to deactivate polyphenol preventing enzymatic discoloration of the sweet potatoes. Drying of the pieces was done in stainless steel trays in an oven to prevent discoloration due to ferrous material in the sweet potatoes; oven drying was done as it is a faster means of drying therefore efficient and effective preventing contamination in comparison to sun drying; the temperature of 60°C is suitable as it prevents browning due to *maillard* reaction. The drying was done for 6 hours.

Milling of the sweet potatoes was done by use of a blender to make fine flour. Sieving was then done to remove the fiber found in the flour. The sweet potato flour was then stored in a cool dry condition (temperatures needed to preserve its usefulness).

Analysis of β -carotene

β -carotene was analyzed using the HPLC. Four OFSP were selected for analysis in order to determine the specific variety that has the best suitable beta carotene for maize meal enrichment [15].

5mg of the sample was weighed and then placed into a conical flask. Followed by the addition of 40ml of acetone and 60ml/L of petroleum ether. The objective was to effect the extraction of the beta carotene from the sample. 0.1g of Magnesium Carbonate was then added to prevent the escape of volatile compounds. The solution was then allowed to dissolve and stand for 5 minutes. The sample solution was then decanted leaving the insoluble solids. The sample was then evaporated to dryness by the use of a vacuum dryer. The sample was then reconstituted using acetone. The volume was then made up to 5ml/L and then eluted into the HPLC machine. The β carotene was quantified by use of the detectors. The detector uses fluorescence detecting with detection wavelength at 450nm. The rate of flow was 1.5ml/min. For efficient results the procedure was done in triplicates.

Calcium content

The mount of calcium in OFSP was done (in the two selected samples) by dry method using flame emission AAS.

Ashing

5g of sample were weighed into the crucible. The samples were burnt in muffle furnace at 550°C for six hours. Ash represents all minerals available in the OFSP.

AAS analysis

AAS analysis was done as follows: The samples digested by ashing were dissolved in 25ml/L of Hydrochloric acid. Calcium was then determined in its ionic state by reaching the absorbance at 480nm in the spectrophotometer [15].

RESULTS

Tauing variety had the highest amount of beta carotene while Kensport 3 had the lowest amount. Marginal amounts of beta carotene were found in maize meal (Table 1).

Table 1: *beta* carotene content and calcium in Orange Fleshed Sweet Potatoes (OFSP) and maize meal

<i>OFSP Samples</i>	<i>Beta- carotene ($\mu\text{g/g}$)</i>	<i>RAE¹ ($\mu\text{g/g}$)</i>	<i>Calcium ($(\mu\text{g/g})^2$)</i>
Kenspot 3	1.96±0.02a	0.54	-
Kenspot 4	2.00±0.04a	0.54	-
Haspot	5.17±0.03b	1.41	22.00a
Tauing	5.71±0.06b	1.54	28.70b
Maize meal	1.30±0.20	0.36	27.00b
Weaning food	5.09±0.12b	1.38	-
P- level	***	***	-

¹Retinyl Activity Equivalent. Conversion ratio is 1:3.7 (Rodriguez-Amaya DB 2002)

***P≤0.001, Means with the same letters on the same column are not significantly different at p≤0.05

²Calcium content was done in products with the highest beta-carotene content.

Equally, Tauing and Haspot were more nutritionally satisfying (RAE) compared to the other varieties. Weaning food made with a combination of OFSP and cereal flours is likely to have good stability if combined with fats and oils (Table 2). Calcium content was also higher in Tauing and Maize meal in comparison to Haspot variety.

Table 2: Vitamin A fortificants and their suitability as fortificants for specific food vehicles Source [18]

<i>Food vehicle</i>	<i>Form of vitamin A</i>	<i>Stability</i>
Cereal flours	Retinyl acetate or retinyl palmitate (dry stabilized forms)	Fair
Fats and oils	Beta-carotene and retinyl acetate or retinyl palmitate (oil-soluble)	Good
Sugar	Retinyl palmitate (water dispersible forms)	Fair
Milk powder	Retinyl acetate or palmitate (dry water dispersible forms)	Good
Liquid milk	Retinyl acetate (preferred) or palmitate (oily form, emulsified)	Good/fair depending on packaging
Infant formula	Retinyl palmitate (water dispersible beadlets)	Good
Spreads	Retinyl acetate or palmitate (oily form)	Good

DISCUSSION

Weaning flour made using OFSP and maize flour had sufficient amount of *beta* carotene to satisfy RDAs for children and pregnant and lactating women [1,5]. The recommended dietary allowance for vitamin A intake for children is 250 to 400 retinol activity equivalents (RAE), 575 to 725 RAE for adolescents, and 750 RAE for adults. RDA for men and women is 900 and 700 μg respectively RAE/day. Conversion efficiency of dietary β -carotene to retinol in humans ranges 3.6–28:1 by body weight. This is in line with children's dietary requirements where they have what WHO and health ministries considers as "normal" body weight. Obese or overweight children are likely to have a problem. Increased consumption of OFSP "rich" diets will increase the amount of beta carotene which ends up in the body [18]. Increased consumption beta carotene rich products has led to reduction in vitamin A deficiency in human populations [19,20]. Additionally, consumption of orange fleshed sweet potatoes has been associated with increases in serum beta carotene without sufficient serum retinol in South Africa and Bangladesh [14,16,22]. Increase in consumption of beta carotene does not necessarily result in increased improvements in vitamin A status, perhaps due to bio conversion reasons. however, increases in serum beta carotene content can serve therapeutic effects besides modest improvement in vitamin A status. β -Carotene also forms stable radicals, and may have beneficial effects in preventing the development of some forms of cancer [21, 18].

A kilogram of white maize meal, *Kenspot 3* and *Kenspot 4* varieties are not sufficient to achieve RDAs for children (250 to 400 $\mu\text{g}/\text{day}$). However, *Tauing* and *Haspot* varieties are able

to achieve this objective. Preparation of a composite flour of maize meal (20%) and *Tauing* OFSP variety reduced the RAE to 1.38 µg per gram. This is sufficient for a child prepared as thin porridge. Cumulative effect of RAE from OFSP composite flour can help reduce vitamin A deficiency in children as is the case in Zimbabwe with orange maize.

Using the IITA [6] standard, the RAE/ 100 g (calculated as the percentage of the REA divided by 3.7) of the 80% composite weaning flour (5,087 RAE/ 3.7) was inadequate for children. The implication is that maize meal can be enriched with *Tauing* OFSP on ratios of 1:4 so as to address vitamin A status to a certain extent in children living in poor resource settings [24].

Consumption of sweet potato flour is common in some countries. For example, roots tubers are often processed into flour which is then used to prepare food products in West African countries. Consumption of root relishes is prevalent in Nigeria. In this country, meal from sweet potato varieties is used in a local porridge call *amala* [19, 20, 23].

CONCLUSION

Weaning food made from a combination of *Tauing* OFSP and white maize meal (1:4) may contribute to addressing vitamin A status if consumed in combination of other foods rich in beta carotene such as fruits and leafy vegetables in children aged less than 59 months in addition to vitamin A supplementation and consumption of fortified foods. Evidently, consumption of OFSP is likely to reduce vitamin A deficiency in SSA rural areas. Consumption of OFSP will lead to a reduction in cancer incidence in children and other members of population.

List of abbreviations: OFSP: Orange Fleshed Sweet Potatoes; µg/g: micro grams per gram; CIP: International Potato Center; SSA: Sub-Saharan Africa; RDA: Recommended Dietary Allowances; AAS: Atomic Absorption Spectrophotometer; HPLC: High Liquid Performance Chromatography; RAE: Retinol Activity Equivalent; IITA: International Institute of Tropical Agriculture

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