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EFFECT OF PRE-TREATMENTS ON THE PHYSICO-CHEMICAL PROPERTIES AND TOTAL CAROTENOID CONTENT OF ORANGE FLESHED SWEET POTATO FLOUR

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Abstract

Orange fleshed sweet potato (OFSP) roots are rich in β-carotene. Due to the possible denaturation of the carotene during processing, efforts are being made to identify processing methods which will help preserve and retain the carotenoid content of the product, even after processing. OFSP flour was processed from peeled and sliced UMUSPO1 variety using pre-treatment methods of boiling, blanching and treating with 0.5% metabisulphite solution for 10min, while the last sample was without any pre-treatment. The samples were oven dried and packaged for analysis. Effect of the different pre-treatment methods on their physico-chemical properties and total carotenoid contents were evaluated. Results show significant differences ($p<0.05$) in the proximate, functional and total carotenoid contents of the flour samples. Moisture content ranged from 8.23-8.68%, carbohydrate (78.45-79.89%), crude fibre (2.57-3.65%), crude protein (6.5-7.18%), fat (1.00-1.17%) and ash (1.81-1.93%). There were also significant differences ($p<0.05$) in the functional properties of the samples as a result of the pre-treatment method applied. Swelling power ranged from 13.64-15.42%, OAC (1.73-3.06%), WAC (2.65-3.05%), Gelatinization temperature (76.55- 77.54°C) and bulk density (0.61-0.68%). The blanched flour sample gave the highest amount of post processing total carotenoid content of 7.63mg/100g, followed by the untreated sample (7.60 mg/100g). Treatment with metabisulphite and boiling gave values of 6.87(mg/100g) and 6.92 (mg100/g) respectively. Processors of sweet potatoes are therefore encouraged to apply blanching method to reduce loss of carotenoids associated with processing.

Keywords: Sweet potato, processing, flour, physico-chemical properties, and carotenoid content

Introduction

Sweet potato (*Ipomea batatas*) is a unique staple crop in Southern and Eastern parts of the African continent (Tumwegamire *et al.,* 2007). It is cultivated and propagated by vegetative method and important because they are drought resistant. The tuberous root and the leaves are also eaten (Bovell-Benjamin, 2007). These characteristics and qualities make OFSP a dependable crop for food security. It requires less labour to maintain once it is established, and can be stored over a broad range of time in the soil without considerable loss if not harvested immediately at maturity (Woolfe, 1992). HarvestPlus has been promoting conventionally bred pro-vitamin A bio-fortified sweet potato varieties in Africa (Andrade *et al.,* 2013). OFSP are bio-fortified and contain high amount of beta-carotene. These varieties are used in many developing countries to combat blindness and vitamin A deficiency because of its rich beta carotenoid content. There are different colours and varieties of sweet potatoes, however, OFSP contain beta carotene which is responsible for its orange colour. Sweet potatoes are abundant at harvest season but have short shelf life because they are highly perishable, hence the need to process it into a more stable form as flour. Efforts have been made to preserve these crops after harvest in order to make it more available through the process of moisture removal using different methods of drying and pre-treatments. Processing sweet potato into dry form helps to minimize the moisture content and convert the roots into a product that is more stable and easy to move (FAO, 1990). Physico-chemical properties and carotenoid content of sweet potato are affected by different pre-treatments and processing methods such as parboiling and blanching as indicated by Osundahunsi *et al*., (2003) and Van Hal, (2000). Losses in vital nutrients such as beta-carotene are observed during processing and efforts are being made to evaluate pre-treatment methods which are suitable to reduce nutrient loss associated with processing, hence the objective of this study.

Materials and Methods

Fresh UMUSPO 1 OFSP variety (6kg) was harvested from the National Root Crops Research Institute

(NRCRI) experimental farm. These roots were washed, peeled, diced (2.5mm) and divided into four portions for processing into flour (without light exclusion) using three pre-treatment methods: blanching (5mins at 80^0C), boiling (till tender) and soaking with 0.5% sodium metabisulphite solution for 10mins. However, the fourth portion was untreated and was used as the control sample. They were oven dried, milled into flour (Fig 1) and then packaged for further analysis. The effect of the pre-treatments on the physicochemical properties and total carotenoid content of the flour samples were evaluated. The flour samples were packaged in transparent polyethylene bags and stored at ambient temperature (30± 2ºC) without light exclusion (Ukpabi *et al*., 2014) and were taken for further analysis.

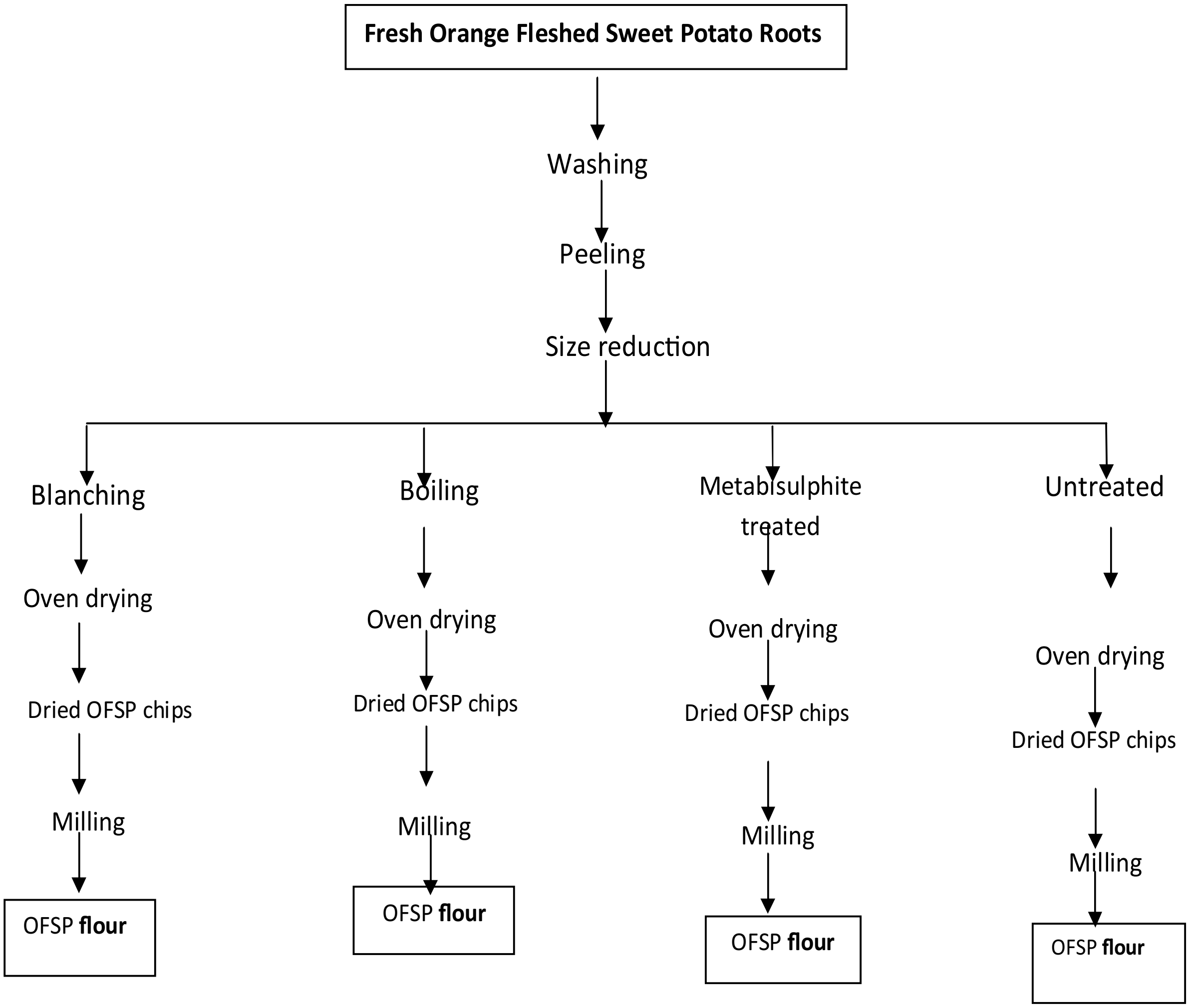

Fig. 1: Processing flow chart for OFSP

Proximate and functional properties determination

Moisture content, crude fibre, fat and ash content were determined using the method described by Onwuka (2005), while carbohydrate and crude protein content were determined by the method described by James (1995). Bulk density was determined using procedure by Okaka and Potter (1979), gelatinization temperature, water and oil absorption capacity according to Onwuka (2005) and Swelling power by Li and Yeh (2001) method.

Total Carotenoid Content Determination

Total carotenoid determination was determined according to the AOAC (1984) and Rodriguez-Amaya and Kimura (2004) methods as described by Mustapha *et al.,* (2009). Spectrophotometer (model 22UV/VIS), which was used to measure the absorbance, was set at 436nm wavelength and the absorbance of the extract taken. The Spectrophotometer was calibrated to zero point using a 1cm cuvette with petroleum-ether as blank. Samples of the extract were added into the cuvette. The readings of the samples were taken immediately the figure displayed on the spectrophotometer window was steady. The total carotenoid concentration was calculated using Beer-Lamberts Law, which states that the absorbance (A) is proportional to the concentration(C) of the pigment. The formula used for calculation is expressed thus.

$$\text{Total carotenoid content}\left(\frac{\mu g}{g}\right) = \frac{A \times V(ml) \times 10^4}{2592 \times P(g)}$$

Where
A=Absorbance
V=Total extract volume

P = Sample weight
2592 = A_{1cm}, beta- carotene Extinction Co-efficient in petroleum ether

Statistical Analysis

All data obtained from the analysis was subjected to analysis of variance (ANOVA) using SPSS software package version 20. Means were separated using Duncan Multiple Range test to determine the significant difference at 5% level of probability.

Results and Discussion

The composition of the OFSP in fresh weight basis is presented in Table 1, and the values in parentheses represent the composition in dry weight. There were significant differences ($p<0.05$) in the values of the proximate composition and total carotenoid content of the fresh OFSP obtained for fresh weight and dry weight. Moisture content in fresh weight basis is 66.66g/100g with dry matter content of 33.34 g/100g, while crude fiber and protein values are 1.72 g/100g and 2.23 g/100g with dry weight values 5.16 g/100g and 6.69 g/100g respectively. Fat content of the sample in fresh weight basis is 0.55 g/100g, while the ash content and carbohydrate content are 1.23 g/100g and 27.61 g/100g respectively. The total carotenoid content of the fresh sample is 7.66mg/100g, while the total carotenoid content of the sample in dry matter basis is 22.97mg/100g. According to Ukpabi *et al.,* (2012), total carotenoid content of OFSP contains about 95% pro-vitamin A rich beta-carotene.

The proximate composition of the OFSP flour samples which include; moisture content, carbohydrates, protein, crude fibre, fat and ash were evaluated. The results of the analysis are shown in Table 2. Results obtained showed that Pre-treatment method had significant difference ($p<0.05$) on the proximate composition of the flour samples. The moisture content of the samples ranged from 8.23-8.68%, and the untreated sample with the highest moisture content, while the boiled sample had the least. The carbohydrate content of the flour samples were high and ranged from 78.45 – 79.89%, and boiled samples with the highest and untreated sample the lowest. Crude fiber, protein and fat content of the samples ranged from 2.57-3.65%, 6.64 – 7.18% and 1.00- 1.17% respectively, and the untreated sample with the highest values, and boiled sample the lowest. The ash content of the flour samples ranged from 1.81 – 1.93%, and the blanched sample with the highest, and boiled sample the lowest. Pre-treatments involving leaching, such as boiling and blanching, led to losses in crude fiber, protein, ash, fat, water soluble vitamins and mineral contents of sweet potato flours according to Osundahunsi *et al.,* (2003) and Jangchud *et al.,* (2003), hence the comparative low nutrients observed in the boiled and blanched samples. Moisture is an important parameter considering flour storage as this may enhance or discourage the growth of microbes, depending on its bioavailability in foods (Fana *et al*., 2015). Moisture content at 10% has been recommended by Van Hal (2000) for long term storage, however, the result obtained were lower indicating that the flour samples have potential for storability. In OFSP flour, carbohydrate determines the bulk and serves as a rich source of energy (Woolfe, 1992) when compared to taro and yam which are tubers (Tortoe *et al.,* 2017). Protein is important for growth in human diets; however, sweet potatoes are low in protein but can also serve as protein source for the low income populace in developing African countries (Van Hal, 2000). Generally, increased proximate parameters could be because of corresponding concentration of nutrients due to reduction in moisture content during drying (Falade and Solademi, 2010).

Effect of pre-treatment on the functional properties of flour samples are presented in Table 3 and the values for swelling power (SP), oil absorption capacity (OAC), water absorption capacity (WAC), gelatinization temperature and bulk density ranged from 13.64-15.42g/ml,1.73-3.06ml/g, 2.65-3.05%, 76.55-77.54^{0}C and 0.62-0.68g/ml respectively. The result showed significant differences ($p<0.05$) in the pre-treatment methods across the samples. The untreated sample recorded the highest swelling power, OAC, WAC, gelatinization temperature and bulk density, but no significant difference ($p>0.05$) with the swelling power of the metabisulphite treated sample. The Boiled sample had the lowest swelling power, OAC, WAC, gelatinization temperature and bulk density, however, only the bulk density of the untreated sample was significantly different ($p>0.05$). Swelling power measures the extent of hydration of the starch molecules as it is used to describe the binding force existing among the starch granules of the food materials (Yemesrach *et al.,* 2018). The values (13.64-15.42g/ml) obtained in this study for swelling power is higher than 4.6 - 5.9glml as reported by Tortoe *et al.,* (2017). The difference in values could be because of different processing methods and varietal differences (Chandra and Smasher, 2013). Untreated sample, absorbed more oil and water compared to the other samples. This shows that it has the ability to achieve smooth consistency during processing as this criterion is important in making different kinds of gravies and baked foods (Nide *et al.,* 2001). The values obtained for OAC are higher than the range of 0.55-1.03ml/g and 1.28-2.20ml/g reported by Fana *et al.,* (2015) and Kolawole *et al.,* (2016) respectively. Only the bulk density of untreated sample was significantly different ($p<0.05$) among the pre-treatment methods applied as there was no significant difference ($p=0.05$) in the bulk density of the metabisulphite treated, blanched and boiled samples.

The results of effect of pre-treatment on the total carotenoid content of the flour samples are presented in Table 4. Results show that pre-treatment had significant effect on total carotenoid content of the samples. The total carotenoid content (TCC) of the OFSP flour samples ranged from 6.92- 7.63mg/100g. The blanched sample gave the highest TCC of 7.63mg/100g, while the boiled sample had the lowest of 6.92mg/100g. The total carotenoid content obtained from this study when compared with that of the fresh sample showed that pre-treatment caused a reduction in the total carotenoid content of the samples. Blanching helps to reduce losses in carotenoids as this is supported by the finding of Vimala *et al.,* (2011) and also Bechoff (2010), who indicated that the degradation of carotenoid can be limited by blanching. Despite the metabisulphite pre-treatment applied to the samples to retain its orange colour, it however did not reduce the loss of total carotenoids in the sample treated with it, as it recorded the lowest TCC. Further analysis on loss of TCC due to light induced carotenoid denaturation is important. Ukpabi *et al.,* (2014), reported positive effect of light exclusion on TTC loss during cassava flour production with carotenoid rich yellow cassava roots

Conclusion

The study analyzed the effect of pre-treatments on the physico-chemical properties and total carotenoid content of OFSP flour. Application of Pre-treatment methods during processing showed significant effect on the physicochemical properties and total carotenoid content of the flour processed from OFSP variety. Blanching of fresh OFSP before drying caused a reduction in TTC losses, however, further studies is required in the area of storage and microbial stability of the processed flour. Processors of sweet potatoes are therefore encouraged to apply this method to reduce loss of carotenoids associated with processing.

Table 1: Proximate composition and total carotenoid content of fresh OFSP

Proximate composition	Values
Moisture content	66.66g/100g
Dry matter content	33.34g/100g
Crude fiber	1.72 g/100g [5.16g/100g]
Crude protein	2.23 g/100g [6.69 g/100g]
Fat	0.55 g/100g [1.65 g/100g]
Ash	1.23 g/100g [3.69 g/100g]
Carbohydrate	27.61g/100g [82.81 g/100g]
Total carotenoid content	7.66mg/100g [22.97mg/100g]

Values in bracket = Dry weight basis

Table 2: Effect of pre-treatment on the percentage proximate composition of OFSP flour

Sample	Moisture content	Carbohydrate	Crude Fiber	Crude Protein	Fat	Ash
Untreated	8.68 ± 0.04^{a}	78.45 ± 0.00^{d}	3.65 ± 0.01^{a}	7.18 ± 0.01^{a}	1.17 ± 0.01^{a}	1.87 ± 0.01^{b}
Metabisulphite treated	8.40 ± 0.04^{b}	78.79 ± 0.00^{c}	2.64 ± 0.00^{b}	7.17 ± 0.05^{a}	1.15 ± 0.01^{a}	1.8 ± 0.01^{b}
Blanched	8.29 ± 0.03^{c}	79.38 ± 0.00^{b}	2.64 ± 0.02^{b}	6.64 ± 0.00^{c}	1.12 ± 0.00^{b}	1.93 ± 0.01^{a}
Boiled	8.23 ± 0.01^{d}	79.89 ± 0.00^{a}	2.57 ± 0.01^{c}	6.50 ± 0.01^{d}	1.00 ± 0.03^{b}	1.81 ± 0.01^{c}
Mean	8.42 ± 0.18	79.14 ± 0.58	2.63 ± 0.36	6.80 ± 0.26	1.12 ± 0.08	1.86 ± 0.05

The values are means ± Standard Deviation for three determinations. Means on the same column with different superscripts are significantly different ($p<0.05$)

Table 3: Effect of pre-treatment methods on the functional properties of OFSP flour

Sample	Swelling power (g/ml)	OAC*(ml/g)	WAC* (%)	Gelatinization Temp(^{0}C)	Bulk Density(g/ml)
Untreated	15.42 ± 0.01^{a}	3.06 ± 0.00^{a}	3.05 ± 0.02^{a}	77.54 ± 0.00^{a}	0.68 ± 0.01^{a}
Metabisulphite treated	15.42 ± 0.02^{a}	2.70 ± 0.00^{b}	2.93 ± 0.00^{b}	77.00 ± 0.00^{b}	0.61 ± 0.01^{b}
Blanched	14.28 ± 0.04^{b}	1.91 ± 0.00^{c}	2.74 ± 0.10^{b}	76.55 ± 0.00^{c}	0.62 ± 0.03^{b}
Boiled	13.64 ± 0.00^{c}	1.73 ± 0.00^{c}	2.65 ± 0.00^{b}	76.61 ± 0.00^{c}	0.63 ± 0.00^{b}
Mean	14.69 ± 0.84	2.35 ± 0.58	2.85 ± 0.17	76.90 ± 0.42	0.638 ± 0.04

The values are means ± Standard Deviation for three determinations. Means in the same column with different superscripts are significantly different ($p<0.05$)

: WAC=water absorption capacity, OAC= oil absorption capacity

Table 4: Effect of pre-treatment on the total carotenoid content of OFSP flour

Sample	Total Carotenoid content (mg/100g)
Untreated	7.60 ± 0.08^{b}
Metabisulphite treated	6.87 ± 0.02^{d}
Blanched	7.63 ± 0.01^{a}
Boiled	6.92 ± 0.08^{c}

The values are means ± Standard Deviation for three determinations. Values in the same column with the different superscripts are significantly different ($p<0.05$)

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