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INFLUENCE OF PROCESSING METHODS ON THE QUALITY ATTRIBUTES OF BIO-FORTIFIED SWEET POTATO PRODUCTS

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ABSTRACT

Bio-fortified sweet potato (BSP) is one of the crops that can be used to address the problems of vitamin A deficiency in the Sub-Saharan Africa but it's currently being underutilized. This study seeks to evaluate the effects of different heat processing methods on the quality of products made from BSP in order to increase its utilization. Freshly harvested tubers were purchased from a Research Farm in Federal University of Agriculture, Abeokuta (FUNAAB), Nigeria and brought to the Processing Centre, Nigerian Stored Products Research Institute (NSPRI), Ilorin. The sample was taken through some standard pre-processing operations of sorting, peeling, washing, slicing (2.11 mm), and deep frying (3 minutes) while some portions were boiled immediately after sorting with or without skin for 10–15 minutes. Each treated sample was analysed for sensory, proximate, vitamins and mineral compositions following standard methods. Results showed that fried sample had highest acceptability for aroma (7.25) and crispiness (7.00) while sample boiled without skin (15 min) was rated with least scores in colour (5.30), appearance (5.40), texture (4.95), crispiness (4.65) and overall acceptability (5.70). Protein, vitamin C, phenolics, flavonoids and reducing sugar contents were 6.53–18.52%, 10.89–76.69 mg/100 g, 0.57–3.15 mg/L, 94.64–383.91 mg/L and 43.05–237.12 g/100 g respectively while some minerals such as Na, K and Zn ranged from 8.42–17.45, 5.12–9.30 and 0.03–0.09 mg/L respectively. Different heat processing at different durations affected the sensory attributes, nutritional and mineral compositions of BSP.

Key words: Post-harvest, food security, potato, heat treatment, quality

INTRODUCTION

Vitamin A deficiency is rampant in Sub-Saharan Africa, affecting 43 million children who are under the age of five (5), and contributing to high rates of blindness, disease, and premature death in children and pregnant women (UNICEF, 2019). The deficiency of vitamin A impedes children's growth, increases their vulnerability to disease, and contributes to poor immune function and maternal mortality. Bio-fortified sweet potato (BSP) commonly known as Orange-Fleshed due to the flesh colour is an improved breed of sweet potato (*Ipomea batatas* L.) grown in equatorial and sub-equatorial parts of the world as sources of calorie and income for non-urban inhabitants (Mitra, 2012; Adebisi, *et al.,* 2015). It can be propagated by vegetative method, and its partly drought resistant in nature after establishment with brief period for matureness. To this extent, bio-fortified sweet potato is a good food security crop in sub-equatorial parts of Africa which consist majorly underdeveloped nations (Satheesh and Workneh, 2019).

According to a report by the International Potato Centre (2019), BSP is a crucial source of beta-carotene, the pre-cursor to vitamin A. Sweet potatoes especially BSP are bred as a tool for the global fight against vitamin A deficiency in areas that lack vitamin A rich food material (Kolawole *et al*., 2020). It has been reported that BSP increases vitamin A consumption and blood retinol in children (Ajanaku *et al*., 2013). It can also contribute to colour, flavour and dietary fibre of processed food products such as bread, pasta products, and in other food preparations (Kolawole *et al*., 2020). The development of new products from this sweet potato variety will therefore play a major role in raising awareness on the potential of the crop and encourage production. Thereby increasing its utilization, serves as a source of nutrients such as carbohydrates, vitamins A, B6 and C, some minerals like Ca, P, Fe, K, Mg and Zn (Olubunmi *et al*., 2017).

Bio-fortified sweet potatoes are underutilized particularly in Nigeria despite their richness in nutrients quality. On the other hand, sweet potato has a very short shelf-life; hence, it must be processed almost immediately after harvest in order to reduce spoilage. Therefore, the objective of this study was to process BSP into different food products and to evaluate the influence of processing on the physicochemical and nutrients compositions including the consumers' acceptability.

MATERIALS AND METHODS

Sample collection and preparation

Bio-fortified Sweet Potato tubers were procured from the Federal University of Agriculture, Abeokuta, Nigeria. The sample was taken to the Processing Centre, NSPRI, Ilorin where it was taken through some standard pre-processing operations of sorting into uniform average sizes (5 cm), then peeling, washing, slicing (2.11 mm) and deep fried (3 minutes). Some portions were boiled immediately after sorting with or without skin for 10–15 minutes. Each treated sample was analysed for sensory attributes, nutritional and mineral compositions and compared to the raw sample.

METHODS

Sensory Evaluation

Samples were presented to 20 semi-trained panellist members to award scores on 9-point hedonic scale where 9 represents like extremely and 1 represents dislike extremely (Olatunde *et al*.,2016; Babayeju *et al*., 2017).

Nutritional Analysis

Proximate compositions (moisture, ash, crude fats, crude fibre, crude protein) were determined as described by Sanoussi *et al*. (2016), carbohydrate was subtracted by difference [100 – (moisture + ash + crude rats + crude fibre + protein)] and recorded as percentage (Oyeyinka *et al*., 2019). Dry matter was also estimated by subtraction (dry matter=100 – moisture content). The 2, 6-dichlorophenol indophenol titration method previously described by Akande *et al*. (2018) was followed in the determination of ascorbic acid content. Lycopene and β-carotene contents were determined according to the methods reported by Lawal *et al*. (2019). Total phenol in the potato products was determined using spectrophotometric method described by Vijay and Rajendra (2014). Flavonoids content of sweet potato was determined following the methods described by Talari *et al*. (2012) while the reducing sugar was determined by using the Megazim kit.

Vitamin A (retinol) Determination

Estimation of vitamin A from pro-vitamin components (beta-carotene) of the food was done following the methods described by Aremu and Nweze (2017). According to them, the concept of Retinol Equivalent (RE) was used to express the vitamin A activity of carotenoids in diet on a common basis (retinol) as follow;

1 µg retinol = 1 Retinol Equivalent (RE)

1 µg beta-carotene = 0.167 µg RE

Determination of Mineral Compositions

The digestion process and mineral analysis was conducted as described by Akande *et al*. (2015). The alkali metals (Na and K) were measured with flame photometer (PFP7/C) while other elements such as Ca, Fe, Zn, Mg, Mn, Cu and some heavy metals such as; Al, Cd, Cr, and Pb were analysed with Atomic Absorption Spectrophotometer (Buck Scientific VGP 210).

Statistical Analysis

Data obtained were subjected to analysis of variance (ANOVA) and tested for significance difference among treatments by Student Newman Kuel (SNK) Test at (p=0.05) using SPSS software package version 20.0.0 (IBM Statistics).

RESULTS AND DISCUSSION

Effect of Different Heat Processing on the Sensory Attributes of Bio-fortified Sweet Potato (BSP)

Effect of heat processing on the sensory attributes of BSP was presented in Table 1. Fried sample was significantly high (p=0.05) in aroma, crispiness and overall acceptability. These scores were expected especially in aroma and crispiness because the sample was deep fried with vegetable oil. Peeled sample boiled for 15 minutes (BWOS 2) had significantly lower (p=0.05) score in colour, appearance, texture, crispiness and overall acceptability when compared with other samples. This indicated that boiling of peeled Bio-fortified sweet potato for 15 minutes affected the colour and appearance and made it less appealing to panellist members.

Table 1: Effect of different heat treatments on the sensory attributes of BSP products

Sample	Colour	Appearance	Aroma	Texture	Crispiness	Overall Acceptability
Raw	7.10^{b}	6.55^{b}	6.10^{ab}	6.20^{bc}	5.60^{b}	6.95^{b}
Fried	7.20^{b}	7.20^{b}	7.25^{c}	7.00^{c}	7.00^{c}	7.45^{c}
BWTS1	7.25^{b}	7.15^{b}	6.45^{b}	5.70^{b}	5.45^{b}	6.70^{b}
BWTS2	6.95^{b}	7.15^{b}	5.90^{ab}	6.45^{bc}	5.35^{b}	6.90^{b}
BWOS1	6.70^{b}	6.55^{b}	6.15^{ab}	6.35^{bc}	5.40^{b}	6.80^{b}
BWOS2	5.30^{a}	5.40^{a}	5.70^{ab}	4.95^{a}	4.65^{a}	5.70^{a}

Results show mean of 20 scores on 9-point hedonic scale where 9 represent like extremely. Means with different superscripts along the same column are significantly different (p=0.05). Raw=unprocessed control, BWTS 1=boiled with skin for 10 minutes, BWST 2=boiled with skin for 15 minutes, BWOS 1=boiled without skin for 10 minutes, BWOS 2=boiled without skin for 15 minutes, fried=deep fried with vegetable oil

Effect of Different Heat Processing on the Nutritional Compositions of Bio-fortified Sweet Potato (BSP)

The influence of processing methods on the proximate composition of bio-fortified sweet potato was as presented in Table 2. The results indicated that ash, fat, crude fibre, protein, carbohydrates and dry matter contents were 3.22–7.21%, 5.50–37.28%, 1.93–15.60%, 6.53–18.52%, 37.37–74.52% and

16.58–80.10% respectively. Also, the values obtained for vitamin C, lycopene, beta-carotene, phenolics, flavonoids and reducing sugars ranged from 10.89–76.69 mg/100 g, 1.13–2.46 mg/100g, 2.48–10.05 mg/100g, 0.57–3.15 mg/L, 94.64–383.91 mg/L and 43.05–237.12 mg/100 g respectively. Fried sample had significant high (p=0.05) values in fats (ether extracts), crude fibre and dry matter contents. The result is expected to be so since the sample was deep fried in vegetable oil. Skin bearing sample boiled for 15 minutes (BWTS 2) had significant high (p=0.05) ash, protein and reducing sugar contents. Nevertheless, no statistical difference was recorded in the ash content and that of peeled sample boiled for 10 minutes (BWOS 1). There was no significantly difference (p=0.05) in the vitamin C content of skin bearing sample boiled for 10 minutes (BWTS 1) and that of control. This might have indicated that boiling with the peel help to limit vitamin C losses due to indirect contact with the boiling water. The facts that vitamin C reduced significantly (p=0.05) due to further boiling for 5 minutes showed that this vitamin is a heat labile vitamin and must not be subjected to prolonged heating. Similar observations of vitamin C losses due to effect of heating have been reported for different vegetables (Igwemmar *et al*. 2013; Abubakar and Obirinakem, 2015; Kaleem *et al*. 2016; Seema and Yadaval, 2017). Peeled sample boiled for 15 minutes (BWOS 2) had significant high (p=0.05) phenolics and flavonoids contents.

Table 2: Effect of different heat treatments on the nutritional composition of Orange Flesh Sweet Potato (dry matter basis)

	Raw	Fried	BWTS 1	BWTS 2	BWOS 1	BWOS 2
Ash (%)	$4.15^{ab} \pm 0.29$	$3.22^{a} \pm 0.14$	$5.84^{c} \pm 0.34$	$7.21^{d} \pm 0.47$	$6.47^{cd} \pm 0.41$	$4.83^{b} \pm 0.15$
Fats (%)	$7.59^{b} \pm 0.41$	$37.28^{f} \pm 0.07$	$33.74^{e} \pm 0.65$	$29.05^{d} \pm 0.48$	$14.66^{c} \pm 0.48$	$5.50^{a} \pm 0.45$
Fibre (%)	$1.93^{a} \pm 0.14$	$15.60^{f} \pm 0.12$	$9.61^{e} \pm 0.23$	$7.63^{d} \pm 0.02$	$3.56^{b} \pm 0.24$	$4.78^{c} \pm 0.15$
Protein (%)	$9.71^{c} \pm 0.31$	$6.53^{a} \pm 0.17$	$12.23^{e} \pm 0.99$	$18.52^{f} \pm 0.40$	$7.43^{b} \pm 0.93$	$10.52^{d} \pm 0.15$
Carbohydrates (%)	$74.06^{c} \pm 1.94$	$37.37^{a} \pm 0.26$	$38.59^{a} \pm 2.07$	$37.39^{a} \pm 1.05$	$67.62^{b} \pm 1.09$	$74.52^{c} \pm 0.15$
Dry matter (%)	$22.68^{d} \pm 0.26$	$80.10^{e} \pm 0.29$	$18.91^{b} \pm 0.35$	$16.68^{a} \pm 0.90$	$16.68^{a} \pm 0.18$	$19.97^{c} \pm 0.23$
Vitamin C (mg/100 g)	$67.34^{d} \pm 11.22$	$33.03^{bc} \pm 3.79$	$76.69^{d} \pm 4.93$	$43.98^{c} \pm 7.51$	$23.65^{ab} \pm 2.63$	$10.89^{a} \pm 2.15$
Lycopene (mg/100g)	$2.46^{d} \pm 0.04$	$2.24^{c} \pm 0.01$	$1.13^{a} \pm 0.08$	$1.96^{b} \pm 0.04$	$2.39^{cd} \pm 0.06$	$1.96^{b} \pm 0.05$
Beta-Carotene (mg/100g)	$7.76^{c} \pm 0.05$	$10.05^{d} \pm 0.01$	$2.48^{a} \pm 0.28$	$8.05^{c} \pm 0.01$	$7.59^{c} \pm 0.59$	$6.57^{b} \pm 0.08$
Phenolics (mg/L)	$1.45^{c} \pm 0.01$	$0.77^{b} \pm 0.00$	$0.57^{a} \pm 0.07$	$1.63^{d} \pm 0.00$	$2.87^{e} \pm 0.00$	$3.15^{f} \pm 0.02$
Flavonoids (mg/L)	$339.52^{c} \pm 4.42$	$94.64^{a} \pm 4.98$	$276.71^{b} \pm 5.33$	$356.05^{d} \pm 11.88$	$373.24^{cde} \pm 37.32$	$383.91^{e} \pm 0.32$
Reducing Sugar (mg/100 g)	$140.00^{b} \pm 0.86$	$43.05^{a} \pm 0.00$	$49.66^{a} \pm 1.33$	$237.12^{c} \pm 0.49$	$164.12^{b} \pm 1.21$	$43.05^{a} \pm 0.00$

Results show Mean ± SE of triplicates determinations (n=3). Means with different superscripts across the same row were statistically different. Raw=unprocessed control, BWTS 1=boiled with skin for 10 minutes, BWST 2=boiled with skin for 15 minutes, BWOS 1=boiled without skin for 10 minutes, BWOS 2=boiled without skin for 15 minutes, Fried=deep fried with vegetable oil

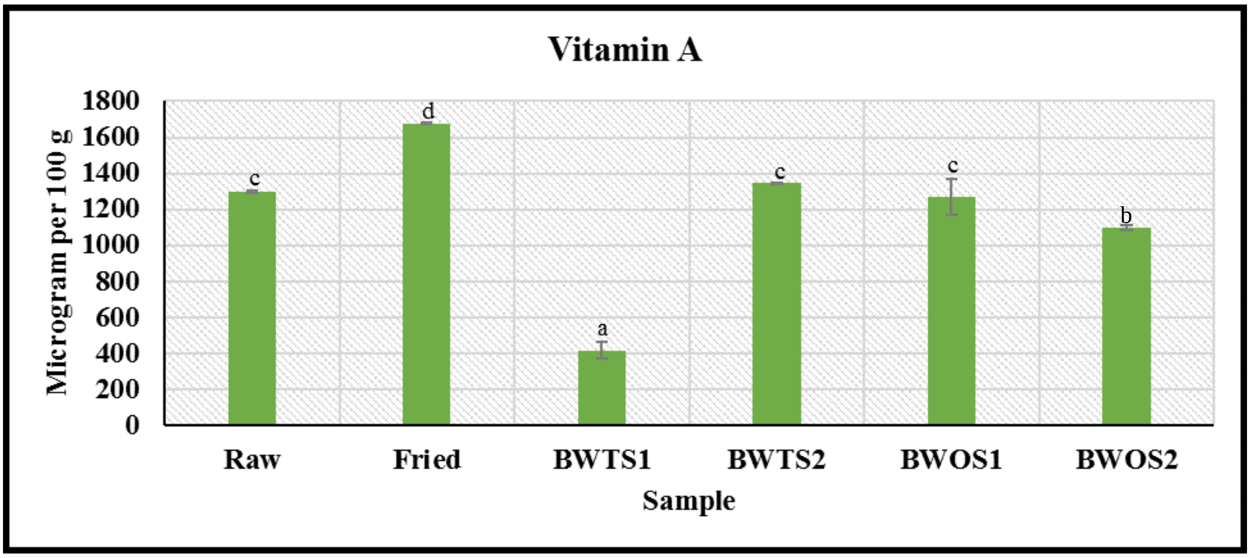

Figure 1: Effect of different heat processing methods on the vitamin content of bio-fortified sweet potato. Each bar represents the mean of duplicate determinations; error bar represents the standard error (SE) of the mean. Bars with the same alphabet are not significantly different (p=0.05). Raw=unprocessed control, BWTS 1=boiled with skin for 10 minutes, BWST 2=boiled with skin for 15 minutes, BWOS 1=boiled without skin for 10 minutes, BWOS 2=boiled without skin for 15 minutes, Fried=deep fried with vegetable oil

Effect of Different Heat Processing Methods on the Vitamin A (retinol) Content of Bio-fortified Sweet Potato (BSP)

The effect of different heat processing methods on the vitamin A content of bio-fortified sweet potato was as presented (Figure 1). The vitamin A content of different heat processed sweet potato varied from 414.98–1677.93 µg per 100 g. Higher vitamin A content (1677.93 µg per 100 g) was recorded in fried sweet potato sample, the reason for increase in vitamin A content in this particular sample might be due to the facts that it was fried with vegetable oil which could have contributed to the increase. There was no significant difference (p=0.05) in the vitamin A contents of raw, BWTS2 and BWOS1 while the value recorded for vitamin A content in the BWTS1 was significantly low (p=0.05) compared to all the other samples.

Effect of Different Heat Processing on the Mineral Compositions Bio-fortified Sweet Potato (BSP)

The effect of different heat treatments on the mineral compositions of orange flesh sweet potato is as shown (Table 3). The mineral profiles of heat treated BSP indicated that Na, K, Fe, Zn, Ca, Mg and Mn were 8.42–17.45, 5.12–

9.30, 2.09–2.32, 0.03–0.09, 8.07–9.24, 2.07–2.78 and 0.06–0.13 mg/L respectively while Al, Cr, Cd and Pb were not detected in both raw and heat-treated samples. Heat treatment caused increase in the compositions of Na and K with significant high (p=0.05) values in skin bearing sample boiled for 15 min (BWTS 2) and peeled sample boiled for 10 min (BWOS 1) respectively. The results showed that sodium and magnesium were significantly high (p=0.05) in BWTS 2. There was no significant change (p=0.05) in Iron and manganese contents of raw and processed samples. This might Indicates the fact that heat treatment had no influence on these minerals.

Table 3: Influence of processing methods on the mineral compositions of bio-fortified sweet potato

Mineral (mg/L)	Raw	Fried	BWTS 1	BWTS 2	BWOS 1	BWOS 2
Na	$8.42^{a}\pm0.02$	$9.18^{b}\pm0.03$	$9.76^{c}\pm0.01$	$17.45^{f}\pm0.07$	$10.30^{d}\pm0.14$	$12.45^{e}\pm0.21$
K	$5.12^{a}\pm0.02$	$5.63^{b}\pm0.01$	$8.05^{c}\pm0.06$	$8.96^{e}\pm0.04$	$9.30^{f}\pm0.08$	$8.75^{d}\pm0.08$
Fe	$2.16^{a}\pm0.06$	$2.32^{a}\pm0.12$	$2.09^{a}\pm0.05$	$2.22^{a}\pm0.09$	$2.12^{a}\pm0.02$	$2.22^{a}\pm0.03$
Zn	$0.09^{c}\pm0.00$	$0.08^{c}\pm0.01$	$0.09^{c}\pm0.01$	$0.03^{a}\pm0.00$	$0.09^{c}\pm0.01$	$0.07^{b}\pm0.03$
Ca	$8.80^{b}\pm0.01$	$9.23^{c}\pm0.06$	$8.07^{a}\pm0.08$	$8.89^{b}\pm0.08$	$9.24^{c}\pm0.16$	$8.69^{b}\pm0.01$
Mg	$2.30^{bc}\pm0.56$	$2.19^{ab}\pm0.06$	$2.33^{bc}\pm0.11$	$2.78^{d}\pm0.06$	$2.53^{c}\pm0.04$	$2.07^{a}\pm0.07$
Mn	$0.06^{a}\pm0.03$	$0.09^{a}\pm0.00$	$0.10^{a}\pm0.00$	$0.11^{a}\pm0.00$	$0.12^{a}\pm0.00$	$0.13^{a}\pm0.00$
Al	-	-	-	-	-	-
Cr	-	-	-	-	-	-
Cd	-	-	-	-	-	-
Pb	-	-	-	-	-	-

Results indicate Mean ± SE of duplicate determinations (n=2). Means with different superscripts across each row statistically different (p=0.05). Raw=unprocessed control, BWTS 1=boiled with skin for 10 minutes, BWST 2=boiled with skin for 15 minutes, BWOS 1=boiled without skin for 10 minutes, BWOS 2=boiled without skin for 15 minutes, Fried=deep fried with vegetable oil (3 minutes).

CONCLUSION

The study has shown that heat treatments in form of frying, boiling at different temperatures and durations had notable influences on the sensory, nutritional and mineral compositions of bio-fortified sweet potato (BSP). Frying increased the aroma, crispiness and vitamin A content of BSP. Boiling with peel (15 min) increased the protein, reducing sugars, sodium and magnesium contents, while peeling before boiling (15 min) reduced acceptability of colour, appearance, texture, crispiness and overall acceptability of BSP but increased phenolics and flavonoids contents.

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