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Investigating the Effects of Processing Methods on The Nutritional Profile of Sweet Potato (*Ipomoea batatas*)

Oke Boluwatife E*, Oyedele Joel and Awolola Gbonjubola V

Department of Industrial Chemistry, University of Ilorin, PMB 1515, Ilorin, Kwara State, Nigeria

***Corresponding author:** Oke Boluwatife E, Department of Industrial Chemistry, University of Ilorin, PMB 1515, Ilorin, Kwara State, Nigeria, Tel: 08141187422, E-mail: oke_boluwatife@yahoo.com

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Abstract

The study investigated how different processing methods (boiling and frying) affects the proximate composition and mineral contents of *Ipomoea batatas* (sweet potato) which is commonly consumed in Nigeria. The samples were designated Raw Sweet Potato (RSP), Boiled Sweet Potato (BSP) and Fried Sweet Potato (FSP). The proximate analysis for RSP, FSP and BSP samples ranged from 32.41% to 53.82% for moisture content while the carbohydrate content ranged from 29.97% to 43.49%. Boiling reduced the ash and fibre contents and frying increased the crude fat, crude fibre and crude ash contents. The RSP recorded the highest crude protein content. The beta-carotene and ascorbic acid content reduced with processing but the reduction was more pronounced in the BSP sample. A high potassium mineral content was obtained from all the samples but there was a reduction upon processing. Magnesium and sodium was also present to a reasonable extent. These results showed that boiling and frying methods has effects on both the proximate composition and mineral contents of direct potato samples.

Keywords: Sweet Potato; Proximate; Anti-nutrients; BSP; FSP; RSP

Introduction

Sweet potato (*Ipomoea batatas*) which belongs to the botanical family Convolvulacae is a root and tuber crop which is the fifth most important food crop on a fresh weight basis in developing countries after rice, wheat, maize and cassava and cultivated in over 100 developing countries and considered as a staple food in many developing countries[1,2]. It is amongst the world's most important, versatile and underexploited food crops with more than 133 million tons in annual production. Sweet potatoes are tuberous rooted perennial mainly grown as annual. The roots are adventitious, mostly located within the top 15cm of the soil. Some of the roots produce elongated starchy tubers. It has over a 100 species in which only a few are cultivated for food, vegetable and medicine [3]. Flesh colours may be white or various shade of cream, yellow, orange or even purple [4-7]. According to National Population Commission [8]; Nigeria is witnessing an increase in population growth which was estimated to be 200,963,599. This major increase in population without an equivalent increase in food production and availability to the society resulted to household food insecurity. This issue poses serious nutritional problem in Nigeria, particularly among children and mothers of child bearing age. The resultant effect has an uncontrolled rapid increase in malnutrition which affects growth and development of the children and low productivity among the mothers [9]. Sweet potato is reported to have good sensory acceptability due to its eye pleasing colours and sweet taste. This acceptability of some varieties is suitable in malnutrition management and facilitating food security in under developed nations [10]. Been a traditional tuber crop with good productivity in short durations, its wide and balanced composition, it's adaptability to wide ecological range of high yield potential even on infertile soil the idea of sweet potato was easily acceptable [11]. The sweet potato tuberous roots contain an addition to high starch content, abundant vitamins, significant amount of minerals, proteins and carotenoid and dietary fibre [12]. The orange fleshed varieties are rich in beta-carotene [13]. Like many other foods, sweet potato is rarely eaten raw. They normally undergo some form of processing and cooking before consumption. The process of cooking vary from simple boiling to baking, frying, roasting, steaming, microwaving, sun-drying or any other preferred choice by the consumer [14]. The basic purpose is to make the sweet potato more palatable and digestible. Also the methods are done to make the sweet potato safe for human consumption, extend shelf life and provide variety of products, which are more convenient to prepare, cook and consume than the raw sweet potato [15]. This research was carried out to investigate how several processing methods (boiling and frying) affects that nutritional profile such as carbohydrate content, protein content, crude fibre, crude ash, crude fate, vitamin C content, beta-carotene content etc. determine the proximate and mineral composition.

Experimental

Materials and Methods

Material collection and preparation

Raw sweet potato tuber samples with average weight of 4kg firm, undamaged by any cracks, soft spots or bruises were purchased from Tanke market in Ilorin, Kwara State on 12th March, 2017. The sweet potato tuber samples were wrapped in grease-free paper packed into carton and transported to the Industrial Chemistry of University of Ilorin. The tubers were unwrapped and placed on a clean bench in an open and well ventilated environment devoid of direct sunlight (FAO, 1986). The samples are cleaned by washing in a clean running tap water to remove sand and debris after draining, the sweet potato samples were cut into thin slices.

Sample Treatment

Raw samples: Sampled roots were peeled, cut into equal parts and thoroughly mixed. The sample was then oven dried for 2days until a constant weight was achieved and designed Raw Sweet Potato (RSP). The RSP slices were homogenized into fine powder with pestle and mortar. The powder was stored in sterilized dry amber bottle with screw top prior to analysis.

Boiling method: The second part of the sliced sweet potato sample were diced and then placed in a stainless steel saucepan with lid and boiled in distilled water for 13mins at 100 °C. By the use of a fork, the sweet potato was judged as cooked when the core became soft. Cooked slices were drained, wrapped with aluminium foil and designated Boiled Sweet Potato (BSP). It was then kept in an oven at 100 °C to remove the moisture content.

Frying method: The third part of the sliced sweet potato sample was diced into smaller bits in open air and then fried in a stainless steel saucepan in preheated vegetable oil at about 140 °C for 15mins. After frying it was designated Fried Sweet Potato (FSP) and left to cool to room temperature. The FSP sample was dried in an oven at 100 °C.

All the processed samples were homogenized into fine powder with mortar and pestle and stored into a sterilized dry amber bottle with screw top prior to analysis.

Each individual cooking method (boiling and frying) and its raw (control) sample were done in triplicates.

Nutritional Analysis

The (AOAC, 2005) method was used to determine the moisture, crude fat, protein, crude fibre and total ash content of each sample. (AOAC, 2005) method was used to determine the total carbohydrate content. The ascorbic acid (Vitamin C), beta-carotene and lycopene content were also determined. Moisture content was determined by heating 5-10g of each sample to a constant weight in a crucible placed in an oven maintained at 105 °C. The dry matter was used in the determination of the other parameters. Crude protein (% total nitrogen X 6.25) was determined by the Kjeldahl method, using 2g samples. Crude fat was obtained by exhaustively extracting 5-10g of each sample in a soxhlet apparatus using n-hexane (boiling range of 40-60 °C) as the extractant. Ash was determined by incineration of 2g samples placed in a muffle furnace maintained at 600 °C for about 4hours. Crude fibre was obtained by digestion of 2g of sample with H2SO4 and NaOH and incinerating the residue in a muffle furnace maintained at 550 °C for 30minutes. Total carbohydrate was obtained by difference % total carbohydrate= 100- [% moisture+ %protein+ %lipids + %ash] [16].

Mineral content

The mineral contents of each sample were determined by Atomic Absorption Spectrometry (AAS) after dry ashing of the samples. The technique makes use of absorption spectrometry to assess the concentration of an analyte in a sample. This method is based on the absorption of UV-Visible radiation by free atoms in the gaseous state. The food sample is ashed. Each ash sample was transferred quantitatively into a conical flask and dissolved in 10ml of 3(N) HCl aqueous solution. The mixture is then placed on a hot plate and it is heated to vaporize and atomize the minerals. A beam of radiation is then passed through the atomized sample and the absorption of radiation is measured at specific wavelengths corresponding to the minerals of interest. The solution was then filtered into 100ml volumetric flask and made up to the mark with distilled water. The mineral contents (K, Zn, Mg, Fe, Mn, Na) were determined.

Beta-carotene and Lycopene determination

Beta-carotene and lycopene were determined using the method of (Nagata and Yamashita, 1992). 2g of the sample was weighed and dissolved in acetone-n-hexane in the ratio (4:6) ml and then filtered using Whatman No 4 filter paper, the filtrate was then taken to the UV spectrophotometer and the absorbance was recorded at wavelengths of 463, 505, 645 and 663 (nm). The β-carotene and lycopene content were then calculated using the formulae:

$$\text{B-carotene (mg/100ml)} = 0.216A_{663} - 1.22A_{645} - 0.304A_{505} + 0.452A_{453}$$
$$\text{Lycopene (mg/100ml)} = -0.048A_{663} + 0.204A_{645} + 0.372A_{505} - 0.0806A_{453}$$

Determination of ascorbic acid

The ascorbic acid content was determined using the Iodine Clock Reaction Method [17]. This reaction method is important because the iodine undergoes the sudden concentration change. When the iodine concentration increases, it reacts with the starch in the solution to form a complex, turning it to deep blue-black colour. On addition of the ascorbic acid, the deep blue-black colour becomes colourless. This is because the ascorbic acid acts as a reducing agent and reduces the iodine to iodide ions (colourless in solution).

$Na_2S_2O_3$ was standardized using 5cm^3 of 0.01M KIO_3 against 2ml of 10% KI and acidified with 10ml of 0.5M H2SO4 until the colour changes to pale yellow and 10 drops of starch indicator was added. Titration continued until a colourless solution appears. 5g of dry samples were dissolved with 50ml of H2O in a conical flask and then filtered. 25ml was measured from the filtrate and put into a 250ml standard flask and then made up to the mark with distilled water. 25ml of the solution was then pipetted into a conical flask, 25ml of 0.01M KIO3 was added and then 2ml of 10% KI and finally 40ml of 0.5M H_2SO_4. The solution was then titrated against 0.1M $Na_2S_2O_3$ in the burette until the solution turns colourless.

To calculate: From the mass of the KI and the end point volume of each of the titrations, calculate three values of the $Na_2S_2O_4$ solution. The molarity concentration results are then used to determine the number of moles that reacts with iodine and then subsequently the number of moles that reacts with the ascorbic acid.

Statistical Analysis

In all cases, the results are the mean ± Standard deviation of at least three individual experimental data; each in triplicate.

RSP= Raw Sweet Potato
BSP= Boiled Sweet Potato
FSP= Fried Sweet Potato

Table 1 shows the results of the proximate composition of sweet potato in %

Table 2 shows the mineral content of certain elements present in sweet potato in (mg/100g)

Table 3 shows the results of the ascorbic acid content in (mg/100g), beta-carotene and lycopene (mg/100ml) in each sweet potato sample

Results

The proximate composition of the raw and processed sweet potato samples (RSP, BSP and FSP) were presented in Table 1. The samples showed a significant difference in the values of the moisture, protein, fibre, ash and crude fat. The highest value for moisture content was 53.82% in boiled sweet potato followed by 47.64% in raw sweet potato and least of 32.41% in fried sample. Protein was highest in raw sweet potato with 2.79% and least in fried sweet potato sample. The ash contents were low in all the samples. The crude fibre contents of the samples were generally low in all the samples. The carbohydrate contents in all the samples were generally high except for the boiled sample. The highest values were in raw sweet potato. Table 2 gave the idea of the elements present in sweet potato samples as consumed. The iron contents in all the samples were generally low and even absent in the raw sweet potato sample. The zinc content of all the samples ranged from 0.01mg/100g to 0.04mg/100g in sweet potato samples. The potassium content was high in all the samples with BSP as the highest with composition of 290mg/100g. Carotenoids of sweet potato are presented in Table 3. B-carotene revealed a generally low level and the values ranges from 0.0213 in FSP to 0.0512 in BSP and 0.0655 in RSP. The lycopene values were also generally low as fried show a negative value which indicates the absence of lycopene in FSP.

Proximate Composition

Sample	Moisture	Crude Fibre	Crude Fat	Protein	Ash	Carbohydrate
RSP	47.64±1.30	0.02±0.01	3.36±0.27	2.79±0.03	2.71±3.03	43.47±1.21
BSP	53.82±0.08	0.02±0.004	12.82±0.13	2.69±0.71	0.68±1.75	29.97±0.80
FSP	32.41±0.50	0.03±0.01	26.79±0.09	2.34±0.33	2.84±0.14	35.60±0.30

All values are means± standard deviations of triplicate determinations

Table 1: Proximate Composition of the tuber of *Ipomoea batatas* in (%)

SAMPLE	ZINC (Zn)	POTASSIUM (K)	IRON (Fe)	MANGANESE (Mn)	MAGNESIUM (Mg)	SODIUM (Na)
RSP	0.01	34	N.D	0.02	3.1	3.1
BSP	0.04	290	0.04	0.01	8.1	10.4
FSP	0.03	5.4	0.01	0.02	0.3	10.4

All values are means of triplicate determinations. N.D= Not Detected

Table 2: Mineral Content (mg/100g) of *Ipomoea batatas*

SAMPLE	ASCORBIC ACID (mg/5g)	BETA-CAROTENE (mg/100ml)	LYCOPENE (mg/100ml)
RSP	36714.6	0.0655	0.0253
BSP	29963.0	0.0512	0.00062
FSP	30908.4	0.0213	N.D

Table 3: Vitamins of *Ipomoea batatas*

Discussion

From the results of the proximate analysis, it can be seen that sweet potato samples are generally low in protein contents. It is also noted that FSP has low moisture content this therefore reduces the microbial load and enhances long shelf life of the food sample. This is supported by the work of Temple *et al.* 1996 [18]. The present study revealed a low fat content in the RSP which is in agreement of Velmurugu, *et al.* 1995 [19] which was between the ranges of 3% ± 0.57 which can be seen to be relatively close to the values obtained. Moreso, the fat in the sweet potato sample is in line with values reported by Hiroshi, *et al.* (2000), Ojeniyi and Tewe (2001), Anita *et al.* (2006) [20-22] which are all within the range of 2-30%. Lipids are very important in food substances since they are vital to the biological function and structure of cells and significantly they contribute to the energy value of foods [23]. FSP showed a very high fat content of 26.79 ± 0.09since the oil used in frying provides essential fatty acids. Fat function in the increase of palatability of food by absorbing and retaining flavours (Anita *et al.* 2006) these most likely accounts for why FSP is mostly consumed more than other processed ones in the society by both children and adults. Due to the high fat content excessive consumption of FSP should be prevented by people with obesity and cardiovascular diseases. The crude fibre content of sweet potato samples were low which is in accordance with [24] which is 0.1 ± 0.03 in RSP and 0.05 ± 0.0023 in FSP. According to [25] dietary fibres are important in preventing cardiovascular diseases, reducing cholesterol levels and diabetes mellitus. They are also efficient in reducing the incidence of certain cancer types (colorectal, small intestine, larynx and breast) and also help with certain digestive diseases [26]. The study also revealed that carbohydrate constitutes the highest nutrient in the sample and in line with previous reports. [27,28] which is within the range of 25-55%. The authors agreed that if sweet potato is freely available for consumption, it will reduce the rate of energy malnutrition in the society. The mineral analysis revealed a low level of minerals present with the exception of potassium. The high potassium found in the sweet potato samples further justifies the fact that sweet potato can be eaten to maintain blood pressure, normalize H2O balance of the body, reduce muscle contractions, aid digestion and even maintain the pH of the body. It should be noted that many Nigerians consume more of the plant food sources for mineral and vitamins due to their economic level. Although zinc in this present study is low in the samples but its consumption should be encouraged because of its benefits to the body system. Beneficial effects of zinc are an increase in growth velocity hence prevents diarrhoea and pneumonia [29]. It is shown to be very useful to infants and children, adolescents, pregnant and lactating women [30]. In addition, it must be mentioned that quite a number of antinutrients exist in sweet potato. Such antinutrients determined in this work include β-carotene and lycopene. β-carotene is the most prominent and efficient provitamin A in carotenoid rich foods [31]. [32] stated that carotenoid rich foods have been food to have angiogenic activity that helps to halt the process of developing new blood vessels which is often seen in cancerous humans including prostate and lung cancer. The results obtained revealed a low level of β-carotene and lycopene in BSP and FSP is due to processing methods (boiling and frying) the foods were subjected to when compared to RSP sample. Sweet potato is seen to be rich in ascorbic acid (vitamin C). RSP is seen to have high amount of ascorbic acid and a reduction in FSP and further decline in BSP upon boiling. This can be justified with the fact that ascorbic acid (Vitamin C) is a H_2O soluble vitamin and can easily dissolve in H2O. Hence the FSP retains more ascorbic acid than the BSP. Ascorbic acid (Vitamin C) is taken to improve eye-sight, prevent scurvy in mouth gums, decrease the duration of common colds and also improve the skin health of the body [33-36].

Conclusion

The study reveals that sweet potato contains several nutritional constituents and if easily made available will reduce malnutrition, other nutritional related diseases and even the mortality rate in the society. Processing methods (boiling and frying) has been seen to have a considerable effect on the sweet potato samples. This can be increasing or decreasing the proximate composition or its mineral contents.

Recommendations

This research carried out is just a stepping stone to further discoveries which could be obtained if a lot of time, energy, money and if the equipment is made available. Sweet potato is a food crop which is high rich in a lot of vitamins and anti-oxidants. It would be a major benefit to the society as it could contain several components which could be a cure to several of the major diseases like cancer. Therefore encouraging the consumption of this well-liked, affordable and nutrient dense food crop may be an effective and economical way to increase consumption of potassium and dietary fibre intake in the society.

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