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Effect of Boiling and Frying on the Total Carbohydrate, Vitamin C and Mineral Contents of Irish *(Solanun tuberosum)* and Sweet *(Ipomea batatas)* Potato Tubers

*Ikanone, C.E.O.[1] and Oyekan, P.O.[1]

ABSTRACT

In a study aimed at ascertaining whether boiling or frying best conserves nutrients; since the two methods are commonly adapted in Nigeria, the effect of boiling and frying on total carbohydrate, vitamin C and mineral contents of Irish *(Solanum tuberosum)* and sweet *(Ipomea batatas)* potato tubers were investigated. The determination of total carbohydrate was carried out using the phenol-sulphuric acid method and the spectrophotometric method was used to determine vitamin C content at 520 nm. The minerals evaluated are iron, zinc, magnesium, sodium, calcium and copper. These were determined by the atomic absorption spectrophotometric method. There was no significant difference ($p > 0.05$) in the total carbohydrate content of the boiled and fried sweet and Irish potatoes compared with their raw tubers. There was significant difference ($p < 0.05$) in the vitamin C content of the boiled and fried potato tubers. Boiling and frying of Irish potato resulted in a loss of 37.34 mg/100 ml (63.90%) and 30.44 mg/100 ml (53.90%) vitamin C respectively. Boiled sweet potato lost 51.16 mg/100 ml (72.37%) and fried lost 43.05 mg/100 ml (60.90%) of vitamin C. The mineral compositions of the boiled and fried Irish and sweet potatoes were significantly different ($p < 0.05$) from their raw tubers. Boiling retained more iron and copper while frying retained more zinc, magnesium, sodium and calcium in both Irish and sweet potato tubers. Boiling retained more carbohydrate while frying retained more vitamin C and minerals.

Keywords: Cooking, frying, total carbohydrate, vitamin C, mineral content, potato.

Introduction

Potato is a tuberous dicotyledonous crop grown all over the world because of the special role that it plays in human diet. It is a source of raw material for the cook, can be eaten as vegetable and is cheap and nutritious. Potatoes are sensitive to heavy frosts, which damage them in the ground. Even cold weather makes them more susceptible to bruising and possibly later rotting which can quickly ruin a large stored crop (Alison, 2008). Irish potato *(Solanum tuberosum)*, named after the Irish who were among the first to accept the potato, proved to be a source of protein, carbohydrates, minerals and vitamins *(*Hamilton *et al.*, 2004*)*. Irish potato can also be referred to as 'white potato'. It is probably one of the most common and an abundant form of this popular tuber and it is a major source of starch worldwide. Most markets stock Irish potatoes along with an assortment of other potato varieties. Like other tubers, the Irish potato keeps well when it is stored in cool, dry conditions, and as a result it is usually available all year round. When selecting Irish potatoes for eating, it is advisable to look for the tubers that do not have soft spots or slimy areas (Pawanexh, 2009).

[1] Crawford University, College of Natural and Applied Sciences, Department of Biological Sciences, Biochemistry Programme, P.M.B. 2001, Igbesa, Ogun State, Nigeria, West Africa.

* corresponding author: ceoikanone@gmail.com

Sweet potato *(Ipomea batatas)* belongs to the family *Convolvulaceae*. It is an irregularly shaped oblong tuber that has sweet taste (Purseglove, 1991; Woolfe, 1992). The young leaves and shoots are sometimes eaten as greens.

Potatoes are used to brew alcoholic beverages such as vodka, potcheen or akavavit. They are also used as food for domestic animals. Potato starch is used in the food industry as thickener and binder of soups and sauces, in the textile industry as adhesive and for the manufacturing of papers and boards (Abidin, 2004; Verrill, 1973). They can be boiled, fried or grilled, steamed, braised, baked and roasted (Hampson, 1957). These different cooking methods vary in different countries. Potatoes are good sources of nutrients, such as carbohydrate, lipids, protein, vitamins and minerals. They are also rich in enzymes and acids.

Two most common ways of consuming potato in Nigeria are boiling in water and frying in refined vegetable oil or palm oil. These methods of processing potatoes for consumption make them palatable but also have adverse effects on the nutrients. Cooking can be detrimental to micronutrient but beneficial to macronutrient contents of food (Chukwu *et al*., 2010). Cooking of foods leads to the improvement of microbiological and organoleptic qualities, destroys toxins and antinutritional factors, increases digestibility and nutrients bioavailability (Erdman and Schneider, 1994). Unfortunately, these procedures cause the loss of some of the micronutrients (Yang and Gadi, 2008). Macronutrient such as carbohydrate though not thermo-sensitive is important in providing the body with energy and spare protein so that they concentrate on building, repairing and maintaining body tissues instead of being used up as energy sources. It is the only source of energy for the brain. Some carbohydrates are high in fibre, which help to lower the risk of certain diseases such as cancer, heart diseases and diabetes (Gordon, 1999). Micronutrient such as vitamin C though thermo-sensitive, is required for the growth and repair of tissues in the body, necessary to form collagen, aid iron absorption and essential for healing of wounds and for repair and maintenance of cartilage (Sweetman, 2007). Vitamin C functions as anti-oxidant and anti-allergic molecule and is a crucial factor in the eye's ability to deal with oxidative stress, and can delay the progression of advance age-related macula degeneration (AMD) and vision loss. It is also important in the stimulation of the immune system. Mineral elements do not furnish energy but their presence is necessary for the maintenance of certain physiochemical conditions, which are essential for life. Minerals are not destroyed in food preparation; however, they are soluble in water so that some loss will occur if cooking liquids are discarded (Fafunso and Bassir, 1977).

In an attempt to determine whether boiling or frying best retains nutrients since these two methods of food processing are the most common in preparing Nigerian delicacies, and coupled with the fact that there is paucity of information concerning how cooking methods affect minerals in food and also in view of the importance of these nutrients to human health, this work was initiated to evaluate the effect of boiling in water and frying in refined vegetable oil on total carbohydrate, vitamin C and mineral contents present in Irish and sweet potato tubers.

Materials and Methods

Collection and processing of tubers

Potato tubers were freshly purchased from Lusada market in Igbesa, Ogun State, Nigeria. The local varieties of Irish potato *(Solanum tuberosum)* and sweet potato *(Ipomea batatas)* freshly harvested were used and identified by a plant taxonomist in the Department of Biological Sciences, Crawford University, Igbesa, Ogun-State. The potato tubers were washed with clean water and allowed to dry at room temperature for 3 h, cooled and finally weighed using a triple beam balance. Boiling and frying were done using the Nigerian household methods. Ten grams of the raw Irish and sweet potato tubers were manually peeled and weighed. They were chopped into pieces using a sterile knife and homogenized using a Warring mechanical blender (Model No: QBL-18L 40 China). 10 g of the potato tubers were boiled with 250 ml clean water at 100^{o}C in a metallic pot for 40 min. After boiling, the tubers were drained on absorbent paper and cooled for 20 min in desiccators before being homogenized. Ten grammes (10 g) of the tubers of potato were also peeled and chopped up into 2 mm slices and fried in 250 ml refined kings vegetable oil at 150^{o}C for 15 min in a metallic frying pan. The fried potatoes were drained on absorbent paper and cooled for 20 min in desiccators before homogenization. The raw, boiled and fried potato tubers were divided into three groups. The first group was used immediately for the evaluation for vitamin C content. The second group was dried in an oven at 45^{o}C until constant weight for the determination of total carbohydrate content. The third group was stored at -18^{o}C for subsequent analysis of the mineral contents.

Total Carbohydrate determination

The total carbohydrate content was determined according to the method of McCseady (1971) and Dubois *et al.* (1956).

An amount of 0.2 g of the sample (from each group) was accutately weighed into different test tubes in triplicates; 0.8 ml of distilled water was then added. 5% phenol (0.5 ml) was added to each test tube and mixed, and 2.5 ml of concentrated sulphuric acid added for colour development. The tubers were allowed to cool and the absorbance was measured using spectrophotometer (Spectumlab 22, USA) at 490 nm (McCseady, 1970; Dubois *et al.*, 1956).

For the standard curve, 100 mg/ml of glucose was prepared. Serial dilution of glucose was prepared and colour development monitored at 490 nm for the different glucose concentrations. One ml of distilled water was used as blank. A standard curve was plotted and used to calculate the total carbohydrate concentration in the samples.

Vitamin C determination

The vitamin C content in the sample was determined by spectrophotometric method as described by AOAC (2005) and Rahman *et al.*, (2007) using 2, 4-dinitrophenylhydrazine. 10 g of the potato tubers was homogenized with 50 ml of distilled water. 2 ml of each sample homogenate was pipetted into test tubes; 38 ml of 0.5% oxalic acid was added, mixed and incubated at 50^{o}C for an hour. The tubes were transferred to an ice-water bath for 5 min, 2.5 ml of 85% H_2SO_4 was added to the tubes in the ice-water bath drop-wise with mixing after each drop. The test tubes were removed from the ice-bath and left to cool at room temperature for 30 min. The absorbance was measured at 520 nm against the blank (2 ml of 4% TCA with 1 ml of 2,4-dinitrophenylhydrazine).

Concentration of Vitamin C (mg/100ml) =
Absorbance of sample × concentration of standard / Absorbance of standard

Mineral analysis

Atomic Absorption Spectrophotometer (AAS, Model Philips, PU9100x) was adopted to determine the mineral concentration in the samples. The technique makes use of absorption spectrometry to assess the concentration of an analyte in a sample. The liquid samples were aspirated, aerosolized, and mixed with combustible gases, such as acetylene and nitrous oxide. The mixture was then ignited in a flame whose temperature ranges from 2100 to 2800^{o}C. During combustion, atoms of the element of interest in the sample were reduced to free, unexcited ground state atoms, which absorb light at characteristic wavelengths. The characteristic wavelengths are element specific and accurate to 0.01 – 0.1nm. To provide element specific wavelengths, a light beam from a lamp whose cathode is made of the element to be determined was passed through the flame.

To ignite the flame, the acetylene was opened and set to 12 – 13 psi. The air compressor was turned on and also set to 50 – 60 psi. The fuel valve of the instrument was turned on and the flow was adjusted to 4 on the flow meter. The burner was lighted with a long handled striker after which the atomic absorption spectrophotometer was ready for running the samples. The calibration forms for each element were filled accordingly.

Starting with the stock solution, serial dilutions with the highest concentration of 5 ppm were prepared. The AAS machine was then calibrated using the stock solution. After calibration, the samples were aspirated and read automatically. The results of the samples were automatically recorded on the printer attached to the equipment.

Statistical analysis

All experiments and analyses were conducted in triplicates. Data obtained from the different parameters of the study were subjected to analysis of variance ($p < 0.05$). The data generated were expressed as means ± standard deviation. Statistical comparison were performed using SPSS version 13.

Results and Discussion

Results of the total carbohydrate content of the Irish and sweet potatoes are as presented in Table 1. The raw Irish and sweet potatoes contain 3.50 mg/100 ml and 3.70 mg/100 ml of total carbohydrate respectively. There was no significant difference ($p > 0.05$) in the total carbohydrate content of the boiled and fried Irish and sweet potatoes compared with the values of their raw tubers. Percentage loss of total carbohydrate in Irish and sweet potato were 2.00% and 3.00% after boiling against 2.70% and 5.95% after frying. This is in agreement with the results of Bahado-Singh *et al*. (2006). The flow of free sugar from food to water and oil during boiling and frying probably explained these losses (Guoado *et al*., 2011). Carbohydrates provide heat and energy for all forms of body activity. Deficiency can cause the body to divert proteins and body fat to produce needed energy, thus leading to depletion of body tissues (Gordon, 1999).

Results of vitamin C content of Irish and sweet potato tubers are as presented in Table 2. Raw Irish potato contains 56.47 mg/100 ml vitamin C. The highest loss of 37.34 mg/100 ml (68.90%) was observed when boiled while frying resulted to a loss of 30.44 mg/100 ml (53.90%). The vitamin C content obtained for Irish potato is in agreement with Babalola *et al*. (2010), who obtained losses of 63.43% and 54.60% respectively when the Irish potatoes were boiled and fried. The result presented in Table 2 for sweet potato also revealed the same trend of loss as that obtained for Irish potato. Raw sweet potato contained 70.69 mg/100 ml vitamin C. Boiling in water produced a loss of 51.16 mg/100 ml (72.37%) while frying produced a loss of 43.05 mg/100 ml (60.90%). Babalola *et al.* (2010), failed to evaluate how boiling and frying best retained minerals. They also obtained losses of 63.43% and 54.60% respectively, when sweet potatoes were boiled and fried. The values obtained for sweet potato is higher when compared

Table 1: Total carbohydrate content of Irish and sweet potato tubers

Processing method	Total carbohydrate content (mg/100 ml) Irish potato tuber	Sweet potato tuber
Raw	3.50 ± 0.01^a	3.70 ± 0.00^a
Boiled	3.43 ± 0.01^a	3.60 ± 0.01^a
Fried	3.40 ± 0.00^a	3.48 ± 0.00^a

Values are expressed as Mean ± Standard deviation for three determinations.
Values with the same superscript in the same column are not significantly different ($p > 0.05$).

with the values reported by Sinder *et al.* (1973), who obtained losses of 65% and 57% respectively when the potatoes were boiled and fried. Aidoo (1966), also obtained losses of 58% and 50% respectively when Irish potatoes were subjected to the same processing method as above, and losses of 93% and 85% respectively were encountered when yam was subjected to the same treatment as potatoes. These losses were higher than those obtained for Irish and sweet potatoes. The vitamin C loss in Irish and sweet potatoes could be due to the effect of heating as well as leaching into the boiling water. Duke (1983), and Gernah and Ajir (2007) reported that heating (especially boiling in open pots) can cause huge losses of vitamin C.

The results of the mineral compositions of Irish and sweet potatoes are as presented in Table 3. There is limited literature concerning how food processing methods best conserve minerals in staple foods. The mineral compositions of the boiled and fried Irish and sweet potatoes were significantly different ($p < 0.05$) from their raw tubers. This is in conformity with Fafunso and Bassir (1977), who reported that food preparation do not destroy minerals but some are lost during food processing. These authors also failed to quantify the extent of mineral lost during food preparation and which cooking method best retains more minerals.

Raw Irish potato tuber contains 17.00 ppm and 1.49 ppm of iron and copper respectively. Boiling retained more iron and copper with 3.67 ppm (21.59%) and 1.18 ppm (79.19%), while frying lost iron and copper with 14.67 ppm (44.90%) and 0.33 ppm (33%) respectively, when compared

Table 2: Vitamin C content of Irish and sweet potato tubers

Processing method	Irish potato		Sweet potato	
	Vitamin C mg/100 ml	% loss of vitamin C	Vitamin C mg/100 ml	% loss of vitamin C
Raw	56.47 ± 0.01[a]	-	70.69 ± 0.01[a]	-
Boiled	20.34 ± 0.02[b]	63.90[a]	19.53 ± 0.01[b]	72.37[a]
Fried	36.03 ± 0.02[c]	53.90[b]	27.64 ± 0.01[c]	60.90[b]

Values are expressed as mean ± standard deviation for three determinations.
Values with different superscript in the same column are significantly different ($p < 0.05$).

Table 3: Mineral contents of Irish and sweet potato tubers

Mineral content (ppm)	Irish potato tuber			Sweet potato tuber		
	Processing method			Processing method		
	Raw sample	Boiled sample	Fried Sample	Raw sample	Boiled sample	Fried sample
Iron (Fe^{2+})	17.00 ± 1.41[a]	20.67± 2.83[b]	18.50± 6.84[a]	32.67 ± 0.94[c]	17.00 ± 2.83[d]	18.00 ± 2.83[e]
Zinc (Zn^{2+})	35.17 ± 0.71[a]	19.17± 0.23[b]	24.80± 0.71[c]	43.17 ± 1.63[d]	8.33 ± 0.00[e]	29.33 ± 1.41[f]
Magnesium (Mg^{2+})	93.00 ± 0.71[a]	97.17± 0.71[a]	108.34 ±2.36[b]	107.67 ±1.89[c]	105.67 ±1.89[c]	102.67 ± 0.47[d]
Sodium (Na^{+})	1.67 ± 0.00[a]	1.67 ± 0.00[a]	2.33 ±0.23[b]	2.00 ± 0.28[c]	2.33 ± 0.23[c]	2.67 ± 0.13[d]
Calcium (Ca^{2+})	5.67 ± 0.48[a]	4.00 ± 0.00[b]	7.67 ± 0.21[c]	28.67 ± 0.65[d]	24.67 ± 0.92[e]	26.67 ± 2.36[f]
Copper (Cu^{2+})	1.49 ± 0.23[a]	2.67 ±0.00[b]	0.83 ± 0.71[c]	1.00 ± 0.00[d]	1.00 ± 0.95[d]	0.67 ± 0.47[e]

Values are expressed as Mean ± Standard deviation for three determinations.
Values with different superscript in the same row are significantly different ($p < 0.05$).

with their raw values. The raw tuber of Irish potato also contains 35.17 ppm zinc, 93.00 ppm magnesium, 1.67 ppm sodium and 5.67 ppm calcium. Frying retained more zinc, magnesium, sodium and calcium with 10.37 ppm (29.49%), 15.34 ppm (16.49%), 0.66 ppm (39.52%) and 2.00 ppm (35.27%) respectively, while boiling lost zinc, magnesium, sodium and calcium with 34.84 ppm (80.70%), 2.67 ppm (2.48%), 0.33 ppm (14.16%) and 4.67 ppm (16.29%) respectively.

Raw sweet potato tuber contains 32.67 ppm and 1.00 ppm of iron and copper respectively. Boiling lost iron with 15.67 ppm (47.96%) and do not affect copper, while frying lost iron and copper with 44.67 ppm (44.90%) and 0.33 ppm (33%) respectively when compared with their raw values. The raw tuber of sweet potato also contained 43.17 ppm zinc, 107.67 ppm magnesium, 2.00 ppm sodium and 28.67 ppm calcium. Boiling retained more iron and copper than frying. Frying retained more zinc, magnesium, sodium and calcium with 13.84 ppm (32.06%), 5.67 ppm (5.27%), 0.67 ppm (33.50%) and 2.67 ppm (9.31%) respectively, while boiling lost more zinc, magnesium, sodium and calcium with 34.84 ppm (80.70%), 2.67 ppm (2.48%), 0.33 ppm (14.16%) and 4.67 ppm (16.29%) respectively when compared with their raw values. Sweet potato is richer in mineral compositions than Irish potato even after being processed. These minerals are involved in diverse metabolic functions. For instance, iron is essential for haemoglobin formation (Cook *et al.*, 1997), zinc stimulates the activity of over one hundred enzymes, needed in the biosynthesis of DNA and wound healing, supports normal growth and development during pregnancy as well as in childhood and adolescence (Mckenna *et al.*, 1997). Magnesium is for muscle contraction and sodium for osmotic balance (Champe and Harvey, 1994). Calcium is involved in bone and teeth formation, and copper plays a role in iron absorption and mobilization of stored iron as well as being a component of many enzymes (Turnlund *et al.*, 1997).

Conclusion

The present study highlights the effect of boiling and frying on the total carbohydrate, vitamin C and mineral contents of Irish and sweet potatoes. Potato tubers are good sources of nutrients. Sweet potato contains more carbohydrate, vitamin C and minerals than Irish potato. In the food processing methods employed, it was observed that boiling retains more carbohydrate than frying while frying retains more vitamin C and minerals than boiling. It is therefore recommended that other food processing methods should be explored to ascertain which ones best retain minerals. It is concluded from this study that potatoes should be eaten fried. For optimum intake of vitamins and minerals, raw fruits and vegetables should be combined in the diet or as supplements in order to ensure adequate intake of micronutrients which are essential for life.

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