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Effect of Fermentation on the Nutrient, Anti-nutrient and Phytochmical Composition of Orange Flesh Sweet Potato

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Abstract

This study was carried out to assess the nutrient, anti-nutrient and phytochemical composition of raw and fermented orange-flesh sweet potato. The sample was divided into five portions. One was analysed raw and the other four portions were fermented by soaking in water for 24, 48, 72 and 96 hours respectively. Both the raw and the fermented samples were subjected to nutrient, phytochemical and anti-nutrient analysis using standard procedures. Results showed that apart from moisture, proximate values decreased with increase in fermentation period. The vitamins, mineral, phytochemical and anti-nutrient content also decreased as the fermentation period increased. The anti-nutrients which include oxalate and phytated decreased from 16.80 to 3.36 and 87.5 to 12.5mg respectively. Fermentation did not have a positive effect on nutrients and phytochemical composition of orange-flesh sweet potato. Other processing methods that can eliminate the anti-nutrients and at the same time preserve the nutrients and phytochemical composition of orange-flesh sweet potato should be explored.

Key words: Nutrients, anti-nutrients, phytochemicals, fermentation, Orange-flesh sweet-potato

Introduction

Sweet potato (*Ipomoea batatas*) belongs to the *Convolvulaceae* family. It is one of the world's important food crops and is a major food crop in developing countries. It ranks as the world's seventh most important food crop after wheat, rice, maize, potato, barley, and cassava (International Potato Center, 2000). According to FAO (2011), sweet potato is one of the seven crops in the world producing over 105 hundred million metric tonnes of edible food products in the world annually. With the report of an annual production of about 933,500 tonnes, Nigeria is one of the major producers of sweet potatoes in Sub Saharan Africa (FAO, 2012). Sweet potato is mainly produced in marginal soil

systems of developing countries where it is a major food crop and it is consumed in low-input subsistence families in large quantities. It is an important staple food crop in Rwanda. It is quickly becoming an important supplementary staple in Eastern and Southern part of the African continent (Tumwegamire, 2004).

Sweet potato (*Ipomoea batatas*) is the second most important root tuber and the seventh most important food crop of the world. Although categorized as "poor man's food" or "famine crop," it has tremendous potential to contribute to a food based approach to promote food security, to alleviate poverty and to supplement as an alternative staple food for the resource poor farmers. This is because of its diverse range of positive attributes like high yield with limited inputs, short duration, high nutritional value and tolerance to various production stress (Mitra, 2012). Idowu *et al*., (2013) have observed that sweet potatoes are vegetable crops which have been grossly underutilized in Nigeria and therefore efforts at promoting their utilization should be encouraged.

Sweet potato is a staple food source for many indigenous populations in China, Central and South Americas, Ryukyu Islands and Africa. It serves as an important protein source for many world populations (Bovell-Benjamin, 2007) and is an important source of starch and other carbohydrates. In Comparism with other tubers, sweet potato contains an average amount of proteins and carbohydrates mainly starch. They also contain some free sugars which gives the tuber its sweet taste (Ingabire and Hilda, 2011).The energy value of sweet potato exceeds that of cassava and other known tubers (Janssens, 2001). Sweet potato contains various micro-nutrients, Substantial quantity of vitamin C, moderate quantities of thiamin (vitamin B_1), riboflavin (vitamin B_2) and naicin (vitamin B_3). It also contains some quantities of pantothenic acid (vitamin B_5), pyridoxine (vitamin B_6), folic acid and satisfactory quantities of vitamin E. It also contains some essential minerals and trace elements having especially high quantity of iron. Two other important minerals present are potassium and calcium (Woolfe, 1992). Moderate quantity of zinc, sodium, magnesium and manganese are also present (Antia *et al.,* 2006; Suda, Yoshimoto and Yamakawa, 1999). According to Oke and Workneh (2013), the nutritional quality of sweet potatoes can be enhanced by developing new varieties from available germ plasm. Orange-fleshed sweet potato is now emerging as an important member of the tropical tuber crops having great possibility of being adopted as regular diet of the consumer food chain to tackle the problem of vitamin A deficiency. Apart from cheap source of energy, the tubers are rich in starch, sugars, minerals and vitamin A in the form of β-carotene. Thus, the poor people having only limited access to the expensive vitamin A rich animal foods

like fish oil, egg, milk and butter, can meet the daily requirement of vitamin A along with some other essential nutrients through increased consumption of these tubers (Mitra, 2012). The major contribution which sweet potato makes to human nutrition is the beta-carotene present in orange-fleshed varieties. Beta-carotene is converted to vitamin A in the human body. Dark-orange varieties can contain up to 20 000µg beta-carotene per 100g fresh storage root weight (Woolfe, 1992; Bovell-Benjamin, 2007). Other crops such as maize, rice and wheat contain very little beta-carotene. Orange-fleshed sweet potato is used in food diversification programs for the alleviation of vitamin A deficiency (VAD). It has an advantage over most vegetables in that it can supply significant amounts of vitamin A and energy simultaneously thus helping toddlers that have VAD and under nutrition (Teow *et al.*, 2007). Studies have shown that daily intake of 100g of orange flesh sweet potato prevent vitamin A deficiency in children and lactating mothers (Anbuselvi and Balamurugana, 2012)

Orange-flesh sweet potato is an example of a bio-fortified crop in which the micronutrient status of staple foods is enhanced through plant breeding to the point where impact on micronutrient status can be achieved (Buzz, 2013). Since the poorest households typically obtain over 60% of their energy needs from food staples, this strategy is particularly suited to poor rural households that cannot access or purchase fortified food products but could grow orange flesh sweet potato. The intensity of the orange color reflects the amount of beta-carotene present in the sweet potato. White-fleshed varieties dominate and contain no beta-carotene, light orange varieties contain at least 250RAE/100gms (30µg/g), medium-intensity varieties at least 458RAE/100gms (55µg/g) and dark-orange-varieties at least 833RAE/100gms (100µg/g).

Fermentation is one of the oldest technologies used for food preservation. Over the centuries it has evolved and has been refined and diversified. Today a large variety of foods are derived from this technology which is used in household small scale food industries and the large commercial enterprises (Omoruyi, Dilworth and Asemota, 2007). Fermentation is the process by which complex organic compounds such as glucose are broken down by the action of enzymes into simpler compounds without the use of oxygen. Fermentation results in the production of energy in the form of two Adenosine triphosphate (ATP) molecules and produces less energy than the aerobic process of cellular respiration. Fermentation is the process of preserving food. Leaving the food on the counter gives more time for the activity to increase which in turn lowers pH and prevents spoilage. Aerobically (with oxygen), the yeast in the ferment can be oxidized to form acetic acid (vinegar) (Kristen 2012). Fermentation also

allows residual hydrocyanic acid to diffuse out, making the product safer for human consumption. The International Potato Centre (2000) suggests that optimal hydrocyanic acid reduction can be achieved through a combination of fifteen minutes soaking and two minutes blanching. Fermentation of orange-flesh sweet potato can add value to its products. However information on the chemical composition of fermented orange flesh sweet potato is lacking, hence the need for this study.

Objective of the study

The general purpose of the study was to investigate the effect of fermentation on the nutrient, anti-nutrient and phytochemical composition of orange-flesh sweet potato. Specifically, the study determined;

1. proximate, mineral and vitamin composition of raw samples of orange-flesh sweet potato and samples fermented for 24, 48, 72, and 96 hours respectively.
2. phytochemicals composition of raw samples of orange-flesh sweet potato and samples fermented for 24,48,72 and 96 hours respectively.
3. anti-nutrient composition of raw samples of orange flesh-sweet potato and samples fermented for 24, 48, 72 and 96 hours respectively.

Materials and methods

Sample procurement and preparation: The orange-flesh sweet potatoes used in this study were purchased from Ogige market in Nsukka local Government area of Enugu State. The sample was washed, peeled and rewashed. The cleaned samples were quartered, homogenized and divided into five equal portions. One portion was analyzed raw (fresh) while the remaining four portions were soaked in water separately and allowed to ferment for 24, 48, 72, and 96 hours respectively. Both the fermented and raw samples were sent to the analytical laboratory in the Department of Home Science, Nutrition and Dietetics, University of Nigeria Nsukka for chemical analysis.

Chemical analysis

***Nutrients*:** The proximate values of the samples were determined using standard procedure. Moisture content of the samples was determined by hot air oven method of Pearson (1976). The sample was dried at 100^{o}c and the dry weight was subtracted from the sample's initial weight.

Fat was determined using the soxholet extraction method as described by Association of Analytical Chemists, (1995). Crude protein content was determined using the Micro-kjedahl method of AOAC, (1995). This involved digestion, distillation and titration. The acid hydrolysis method of AOAC (1995) was used for crude fibre determination. Ashing was also done in a hot air oven at 100^{o}c as described by AOAC (1995). The dish plus the sample was place in a cool muffle furnace and the temperature of the furnace was maintained until its content (residue) appeared grayish

white. This was cooled and weighed. The percentage total ash content of the sample was then calculated. Carbohydrate was determined by difference that is 100-(a+b+c+b+d+e). Where a = % moisture, b= % fat, c=% protein, d= % fibre and e = % ash.

For the vitamins and mineral content determination, the samples were prepared using the method described by Pearson (1976). After the preparation, the exact wave length for each sample was used to measure absorbance in a spectrophotometer. β-carotene, vitamin C, iron, calcium, and zinc absorbance, were measured at 328m, 420nm, 500nm, 425nm and 420nm respectively

***Anti-nutrients*:** Oxalate and phytate were determined by photometric method of Pearson (1976) and Lata and Eskin (1980) respectively. Readings were then taken in a spectrophotometer at 490nm for Oxalate and 500nm for phytate.

***Photochemicals*:** For alkaloid determination, Harborne, (2000) method was used. Five grams of the sample was weighed and 10% oxalate in ethanol was added. It was filtered and concentrated. Ammonium hydroxide was added drop wise until precipitation was complete. The precipitate was collected washed and the residue filtered.

The method used for saponin determination was described by Obadoni and Ochuko (2001`). Twenty grams of the sample was weighed and heated at 55^0c. The mixture was filtered and the residue extracted. About 20ml of diethyl ether was added to the concentrate and shaken vigorously. The aqueous layer was recovered and n-butanol added. It was then washed and heated. After evaporation, the sample was dried in the oven to a constant weight.

The total flavonoid content was determined using the method of Pearson, (1976). The sample was diluted, mixed with reagents and allowed to incubate at room temperature for 30 minutes. Absorbance of the mixture was measured at 415nm in a spectrophotometer.

Results

Table 1: Proximate composition of raw and fermented orange-flesh sweet potato in grams

Hours	Moisture	Ash	Fat	Protein	Fibre	CHO.
0hr/Raw	51.15±38.09^a	0.50±0.00^d	0.44±0.01^b	4.93±0.01^e	0.67±0.01^d	42.3±0.10
24hrs	77.85±0.22^b	0.50±0.01^d	0.10±0.00^a	4.13±0.01^d	0.38±0.03^c	17.04±001
48hrs	80.85±0.05^c	0.34±0.01^c	0.11±0.01^a	4.04±0.10^c	0.36±0.02^c	14.3±0.01
72hrs	81.15±0.01^d	0.31±0.01^b	0.10±0.01^b	0.25±0.01^b	0.25±0.01^b	14.32±00l
96hrs	84.07±0.02^c	0.15±0.01^a	0.11±0.01^a	3.02±0.10^a	0.20±0.01^a	12.64±0.01

Means ± S. D of triplicate Mean with different superscript on the same column are significantly different ($P < 0.05$).

Table 1 shows the proximate composition of raw and fermented orange flesh sweet potato samples in grams. It can be seen that the moisture content varied from 51.15 - 84.07g. The sample fermented for 96 hours had the highest value (84.07g) while the fresh sample had the least moisture content (51.15g). The ash content varied from 0.15 - 0.50g. The raw sample and the sample fermented for 24 hours had the same value (0.50g) and this was the highest. The sample fermented for 96 hours had the least ash value (0.15g). The fat content ranged from 0.10 - 0.44. The fresh sample had the highest value (0.44g) and the sample fermented for 24hours and 72 hours had the least value (0.10g). The samples fermented for 48 and 96hours had the same fat value (0.11g) which was higher than the one fermented for 24 and 72 hours respectively. The protein content ranged from 0.25 - 4.93g. The raw sample had the highest value (4.93g) while the ones fermented for 72 hours had the least value (0.25g).The fibre content ranged from 0.20 – 0.67g.The raw sample had the highest value (0.67g) while the one fermented for 96 hours had the least value (0.20g).The carbohydrate content ranged from 12.64 - 42.3g. The raw sample had the highest value (42.3g), the one fermented for 96 hours had the lowest value (12.64g) while the sample fermented for 24 hours was higher than the one fermented for 48 and 72 hours respectively.

Table 2: Mineral composition of raw and fermented orange flesh sweet potato in milligrams

Hours	Magnesium	Iron	Calcium	Zinc
0 hrs/Raw	0.04 ± 0.06^{b}	0.52 ± 0.67^{a}	4.02 ± 0.02^{c}	4.00 ± 10.0^{d}
24 hrs	0.01 ± 0.06^{a}	0.09 ± 0.00^{a}	3.20 ± 0.03^{d}	3.01 ± 0.15^{c}
48 hrs	0.02 ± 0.01^{a}	0.05 ± 0.01^{a}	2.31 ± 0.08^{b}	3.00±0.31
72 hrs	0.02 ± 0.04^{a}	0.05 ± 0.01^{a}	2.38 ± 0.02^{c}	2.01±0.31
96 hrs	0.02 ± 0.04^{a}	0.05 ± 0.20^{a}	0.78±0.03	1.04 ± 5.78^{a}

Means ± S.D of triplicate. Mean with different superscript on the same column are significantly different ($P<0.05$).

Table 2 shows the mineral composition of raw and fermented orange-flesh sweet potato in milligram. The magnesium content varied from 0.01-0.04mg. The raw sample had the highest value (0.04mg) while the sample fermented for 24 hours has the least value (0.01mg). The samples fermented for 48, 72 and 96 hours had the same value (0.02mg). Iron content varied from 0.05-0.52mg. The raw sample had the highest value (0.52mg) while the ones fermented for 48, 72 and 96 hours respectively had the same and the least value (0.05mg). Calcium content varied from (0-78-4.02mg). The raw sample had the highest value (4.02mg) while the sample fermented for 96 hours had the least value (0.78mg).

Table 3: Vitamin composition of raw and fermented orange-flesh sweet potato in milligrams

Hour	Beta-carotene	Vitamin C
0 hrs/Raw	28.35±0.01^{d}	137±0.1
24 hrs	23.63± 0.01^{c}	96±0.01^{c}
48 hrs	14.18±0.01^{b}	56±0.15^{b}
72 hrs	14.7±0.01^{b}	55±0.02^{b}
96 hrs	9.45± 0.01^{a}	42± 0.01^{a}

Means ± S.D of triplicate. Mean with different superscript on the same column are significantly different (P<0.05).

The sample fermented for 24 hours had a value (3.20mg) which was higher than those fermented for 48 and 72 hours respectively. Zinc content varied from (1.04- 4.00mg), the raw sample had the highest value (4.00mg) while the sample fermented for 96 hours had the least value (1.04mg).

Table 3 shows that the raw sample had the highest beta-carotene (28.35mg). The sample fermented for 96 hours had the least value (9.45mg) while the sample fermented for 24 hours (23.63mg) was higher than the ones fermented for 48 and 72 hours respectively. The table also showed that the raw sample had the highest vitamin C value (137mg) while the sample fermented for 96 hours had the least value (42mg).

Table 4: Phytochemical composition of raw and fermented orange-flesh sweet potato in grams

Hours	Alkaloid	Flavonoids	Saponin
O hrs/Raw	1.4±0.03^{a}	6.10±0.04^{a}	0.85±0.01^{a}
24 hrs	1.2±0.05^{a}	4.4±0.01^{a}	0.75±0.02^{a}
48 hrs	1±0.15^{b}	2.15±0.02^{a}	0.43±0.0^{a}
72 hrs	0.9±0.03	1.45±0.02^{a}	0.3±0.01^{a}
96 hrs	0.78±0.02^{a}	0.5±0.05^{a}	0.15±0.01^{a}

Means ± S.D of triplicate. Mean with different superscript on the same column are significantly different (P<0.05).

Table 4 shows that the alkaloid content varied from 0.78g – 1.4g. The raw sample had the highest value (1.4g) while the one fermented for 96 hours had the least value (0.78g). Flavonoid values varied from 0.5g – 6.10g .The raw sample had the highest value (6.10g) while the sample fermented for 96 hours had the least value (0.5g). Saponin values varied from 0.15 -0.85g. The raw sample had the highest value (0.85g) while the sample fermented for 96 hours had the least value (0.15).

Table 5: Anti-nutrient composition of raw and fermented orange-flesh sweet potato in miligrams

Hours	Oxalate	Phytate
O hrs/Raw	16.80	87
24 hrs	13.44	62
48 hrs	10.08	50
72 hrs	10.08	37
96 hrs	3.36	12

Means ± S.D of triplicate. Mean with different superscript on the same column are significantly different (P<0.05).

Table 4 shows that the oxalate content varied between 3.36 – 16.80mg. The raw sample had the highest value (16.8mg) while the sample fermented for 96 hours had the least value (3.36mg).The phytate content varied between 12 – 87mg. The raw sample had the highest value (87mg) while the sample fermented for 96 hours had the least value (12mg).

Discussion

The result revealed that the moisture content was higher in fermented orange flesh sweet potato than in raw sample from (73.15-84.07). This could be attributed to the absorption of water by the tuber during fermentation. This finding is in line with Treche and Agbor-Egbe, (1995) who observed that in 72 hours of fermentation the moisture content tends to increase. There was reduction in the ash content of fermented orange flesh sweet potato, compared with the raw samples. It is believed that the process of fermentation might have contributed to the reduction in the ash content. This result agrees with the work of Talaro, (2002) who found out that the ash content of sweet potato decreased from (2.52 – 1.78) after 72 hours of fermentation. It is possible that some available mineral are utilized by the fermenting organism in the sweet potato mesh. According to Oyewole and Odunfa (1990), the reduction is due to combination of leaching into the soaking water and microbial utilization. The more the minerals are leached into the water the more the reduction in the ash value. The crude fiber content of orange flesh sweet potato decreased with increase in fermentation period from (0.65-0.20) this is in line with other studies. According to (Oluwole *et al*., 2012) 72 hours of sweet potato fermentation resulted in the reduction of crude fiber from (0.73 – 0.06). The result of this study indicate that increase in hours of fermentation appear to have effect on the crude protein content. The crude protein decreased with increase in fermentation period from (4.93-0.25g). Appiah, Oduro and Elis (2011) however observed a marginal increase in crude protein from (3.80-4.43%) after 24 hours of fermentation. The differences observed in these studies could be attributed to different fermenting medium and or analytical

errors. The carbohydrate content of raw orange flesh sweet potato was higher than the fermented samples. This agrees with the work of Achimba (2010) that fermentation reduced the carbohydrate content of tubers. However, Ogunjobi, Adebayo and Adenike, (2005) posit that the low carbohydrate in sweet potato is an advantage for it is medically recommended for diabetic patients. This study revealed that the crude fat content of orange flesh sweet potato decreased with increase in fermentation period from (0.45-0.10), this agrees with the work of (Oluwole *et a*l., 2012). In his study 72 hours of fermentation decreased the crude fat from (0.59 – 0.21) as the hours increased.

The mineral content of orange flesh sweet potato, which includes zinc, magnesium and calcium decreased with increase in fermentation period. This could be as a result of decrease in the ash content. According to Odunfa, (1999) the reduction could be due to leaching into the soaking water and microbial utilization .Talaro, (2002) have also reported that some available minerals are utilized by the fermentation organism in the potato mesh. According to Oyarekua, (2013) the minerals decreased with increase in fermentation period due to utilization of these minerals by the various microbes in the sample.

The vitamin C and beta-carotene content of orange flesh sweet potato became lower as the fermentation period increased from (137.5 to 41.2) and (85.106-28.365) respectively. According to Hacineza *et al*., (2010) fermentation of sweet potato for 72 hours, decreased vitamin C content from (50.17 – 47.9). It could be that some of the vitamin C, being water soluble, might have dissolved into the fermenting liquid. Hacineza *et al*., (2010) also attributed the reduction of beta- carotene in the fermented samples to oxidative effect of oxygen and light on beta-carotene.

The phytochemicals comprising of flavonoid, alkalnoids and saponin decreased as the fermentation period decreased ranging from (6.10-0.50), (1.40-0.78) and (0.85-0.15) respectively. This finding is in line with existing literatures since several researchers have found out that fermentation and processing lead to reduction in phytochemicals of root crops (Zielinski Mishalska, Amigo-Benavent, Dei Castillo and Piskula, 2009; Makins and Rossiter, 2011).

Raw samples of orange flesh sweet potato had the highest level of phytate but decreased as fermentation period increased. This reduction could be due to phytase activity, which is known to be affected by a wide range of microflora. This study agreed with other studies which have revealed that phytate can be reduced by natural fermentation (Bishnoi *et al.,* 1994 ; Sharma and Kapoor, 1996).There was reduction in oxalate content of orange flesh sweet potato as the fermentation period increased from (16.80-3.6). This agreed with the studies of Bolarinwa (2012) which stated that the decrease of oxalate during fermentation could

be attributed to the effect of enzyme/acid hydrolysis or the starch granule during fermentation. According to Iwuoha (1995), the reduction could be due to effect of leaching and enzyme/acid hydrolysis of starch granule during fermentation.

Conclusion

This study revealed that fermentation had a positive effect on the anti-nutrient as the anti-nutrient content of the samples were decreasing as the fermentation progressed. For the nutrients and phytochemical composition of orange flesh sweet potato, negative effect was observed (as the hours of fermentation increased, there were continuous decrease in the nutrients and phytochemimcal content of the samples). This implies that fermentation though an age long acceptable food processing technique should not be recommended for orange flesh sweet potato since it results to appreciable nutrients and phytochemical losses. Twenty four (24) hours fermentation could however be permitted because it led to marginal nutrients and phtytochemical losses and appreciable losses of anti-nutrients which hinder nutrient absorption.

Recommendation

Based on the finding, the following recommendations are made.

1. Orange flesh sweet potato should not be fermented beyond 24 hours so as to minimize nutrient and phytochemical losses as much as possible.
2. Fermentation as a food processing method should be employed in anti- nutrient reduction of orange flesh sweet potato.
3. Other processing methods that can reduce or totally eliminate the anti-nutrients while preserving the nutrients and phytochemicals should be explored.

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