An assessment of wholesomeness of imported Tiger nut *Cyperus esculentus* used as snack food in Umuahia, Nigeria

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ABSTRACT

There is little or no information on the wholesomeness of imported tiger nut consumed as an uncooked snack food in Umuahia, Nigeria. In addition to undertaking a sensory evaluation of uncooked dried and rehydrated tiger nut samples marketed in Umuahia, relevant chemical/biochemical and microbiological procedures were used to evaluate some intrinsic antioxidants and microbial flora. Results showed that while the dried tiger nut samples had mean values of 20.90% moisture, 49.50 mg/100g ascorbic acid and 9.17 µg/g β-carotene, the rehydrated tiger nut samples had 52.96% moisture, 47.00 mg/100g ascorbic acid and 2.20 µg/g β-carotene. Though there was no significant difference (P=0.05) in the mean score of the organoleptic assessors for the overall acceptability for the experimental dried and rehydrated tiger nut samples (using a Hedonic scale analysis), the assessors preferred the taste of the dried ones and the mouth feel of the rehydrated samples. It was found that washing with clean water reduced the microbial load of dried and rehydrated tiger nut samples. The bacterial load reductions (at 37°C, 24hrs) were 17.39% (to 13 x 10^3 cfu/g) and 46.15% (to 7 x 10^3 cfu/g) respectively for the dried and rehydrated samples while the fungal load reductions (at 25°C, 72hrs) were 40.00% (to 9 x 10^3 cfu/g) and 44.44% (to 5 x 10^3 cfu/g) respectively for the dried and rehydrated samples. Furthermore, the identified microorganisms did not include spore forming bacteria and fecal coliforms. Nevertheless, it is advisable for local consumers of the unpackaged experimental dried and rehydrated tiger nuts to physically wash them with clean water before consumption.

Keywords: *Cyperus esculentus*, Snack Food, Ascorbic acid, β-carotene, Microbial flora, Food Wholesomeness

1. INTRODUCTION

Tiger nut (*Cyperus esculentus* L.) belongs to the family Cyperaceae [1, 2]. Its common English names include: yellow nut sedge, earth almond and Chufa sedge. The Spanish name of the crop is Chufa [2, 3]. In Nigeria it is called Aya, Aki-awusa and Ofio in Hausa, Igbo and Yoruba languages, respectfully. This crop, with an underground nut-like tuber, is generally eaten as a snack food in many parts of Nigeria.

Though considered as a problematic weed by some farmers [1, 4], tiger nut with its nutty taste is generally regarded as a healthy food material [3]. This probiotic or health food status of the crop is probably due to its resistant starch and soluble fiber content, mono-saturated fatty acid content, anti-sickling effect (among sickle cell anemia patients) and its general health related antioxidant characteristics [3-6]. Its oil, which is similar to olive
oil, has the nutritional beneficial oleic and linoleic fatty acids and the fat soluble antioxidant vitamin E (α-tocopherol and β-tocopherol) [7]. Dried tiger nut generally has about 5-10% protein, 25-30% oil; 47-50% total carbohydrates, 29.5% starch and 15.4% sugar [2, 6, 8]. Like the major tuberous starchy staple foods of Nigeria (cassava, yam, Irish potato, cocoyam and sweet potato) that are sources of the water soluble antioxidant vitamin C or ascorbic acid[9,10,11,12,13,14], tiger nut is also known to possess appreciable quantity of vitamin C or ascorbic acid[15,16]. However, unlike the aforementioned staple food materials that are largely processed and/or cooked before being eaten as wholesome food by the country’s populace, tiger nut whole tubers are generally not known to be cooked before their consumption as snack food in Southeastern Nigeria.

In as much as tiger nut can be produced in the northern states of Nigeria [3,6, 17], the tiger nuts consumed in the humid Umuahia capital territory of Abia state, Southeastern Nigeria are largely imported as uncooked dehydrated (sun dried) tiger nuts from the dry southern region of neighboring Niger Republic. These imported tiger nuts are then rehydrated locally and marketed unpackaged (in basins and wheel barrows) as snack food either in the form of dry tiger nut or rehydrated tiger nut.

Presently, there is dearth of information on the wholesomeness of tiger nuts being marketed in Umuahia, Nigeria. Therefore, the aim of this investigation was to evaluate the wholesomeness and consumer acceptability of the uncooked snack-food forms (dried and rehydrated tubers) of tiger nut sold in Umuahia, Nigeria.

2. MATERIALS AND METHODS

2.1. Source of materials

The experimental tiger nut snack-foods (dried and rehydrated tubers) were randomly collected from male tiger nut hawkers or food vendors at the court yard of the Central Mosque (major tiger nut distribution center) of Umuahia Capital Territory of Abia State in South East Nigeria. The dehydrated tiger nuts were originally imported from Maradi Region of Southern Niger Republic through Katsina State in Northern Nigeria by male Muslim Hausa traders. These local traders usually soaked the dry tiger nuts for two to three days to obtain the rehydrated tiger nuts as shown in Figure 1. The analytical chemicals and reagents were manufactured by British Drug Houses (BDH), Poole, United Kingdom.

![Figure 1](image-url). Experimental dried tiger nuts (left) and rehydrated tiger nuts (right).

2.2. Chemical/Biochemical Analyses

The moisture content of the randomized experimental dried and rehydrated tiger nut samples was determined in quadruplicates by drying the broken up samples to constant weight in an electric oven (Gallenkamp BS Oven, England) at 70°C [18]. The percentage moisture content was calculated from the difference in weight. The ascorbic acid (vitamin C) content of the randomly collected dried and rehydrated tiger nut samples were also determined in quadruplicates using the titration method [19] that use 2,6-dichlorophenolindophenol (DCIP) as an indicator to get the titer values (at 15seconds persistent pinkish end point). Freshly prepared standard ascorbic acid solution was used to calculate equivalent to 1ml of the DCIP dye solution.

The β-carotene (pro-vitamin A) content of the replicated samples was determined using the HarvestPlus spectrophotometric method [20]. Acetone and petroleum ether were sequentially used as the extraction solvents (with light exclusion), while the readings with the spectrophotometer (Jenway 6406, England) was done at λ450 nm with 1 cm glass cuvette. The β-carotene content was calculated as follows:

\[
\text{Carotene content (µg/g)} = \frac{A \times V \times DF \times 10^4}{A_c \times \text{Sample weight (g)}}
\]

Where A= absorbance
V= Volume of extract
DF = Dilution factor
10^4 = constant
$A_c = \text{Absorption coefficient of } \beta\text{-carotene in petroleum ether (2592)}$

2.3. Sensory Evaluation

A seven point Hedonic scale (1-7) was used for an organoleptic or sensory evaluation of the randomly collected tiger nut snack food samples using 20 semi-trained sensory assessors and following the procedure as explained by Iwe [21] and Lawless and Heymann [22]. The assessors were trained to score for color, taste, texture (mouth feel) and overall acceptability independently and objectively (without bias) with a pre-trial scoring test. In the sensory analysis, with the 7-point Hedonic scale, 7 = like extremely, 6 = like highly, 5 = like, 4 = neither like nor dislike, 3 = dislike, 2 = dislike highly and 1 = dislike extremely.

2.4. Microbiological Analysis

The microbiological analyses of the randomly collected mixed samples of dried and rehydrated tiger nut were done with relevant standard methods [18, 23, 24]. Sterile diluent (0.1% peptone + 0.85% NaCl) was used for the 10-fold dilution series. Nutrient Agar and Potato Dextrose Agar were respectively used to evaluate for the bacterial and fungal flora in the samples. The bacteria plates were incubated at 37°C for 24hrs while the fungi plates were incubated at 26°C for 72hrs (in quadruplicates). Furthermore, relevant microbiological and biochemical tests were carried out to characterize the coded isolated bacteria [25], with color and microscopy employed in the identification of the coded isolated fungi at genus level [26]. A Zeiss Standard 25 microscope was also used to observe the morphology of the experimental micro-flora and to check for the presence of spores in the stained samples. Freshly purchased $H_2O_2$ was used for the Catalase test. The microbial load analyses (bacterial and fungal) of the experimental samples were further repeated after they had been physically hand washed with clean water in the laboratory.

2.5. Statistical Analysis

Statistics Analysis System (SAS)/PC software was used for mean separations of data. The system is properly identified as SAS (r) Proprietary Software Release 612 TS 020. The copyright belongs to SAS Institute Incorporated, Cary, North Carolina, U.S.A.

3. RESULTS AND DISCUSSION

Table 1 data show that the ascorbic acid (vitamin C) content of the tiger nut samples (47.00 – 49.5mg/100g) are relatively high, and are comparable or higher than the mean values obtained for the major tuberous crops in Nigeria. Infact, Degras [11] gave the vitamin C content of fresh sweet potato, cassava, Irish potato, Colocasia (taro cocoyam), yam and Xanthosoma (tannia cocoyam) as 24mg/100g, 20mg/100g, 30mg/100g, 15mg/100g, 20mg/100g and 14 mg/100g, respectively while Chukwu et al [15] gave the vitamin C content of tiger nut in a Nigerian market as 46-75mg/100g after postharvest handling. It might be interesting to undertake future research on postharvest ascorbic acid metabolism (anabolism and catabolism) of tiger nut varieties as Ukpabi et al. [27] tried to do for cassava tuberous roots. After noting that phenylalanine, thiocyanate and ascorbic acid are beneficial in ameliorating the symptoms of sickle cell anemia disease, Monoa and Uwakwe [5] used in-vitro sickle cell experimentation to show that alcohol and aqueous extracts of tiger nuts can ameliorate the gelation (polymerization) of hemoglobin-S (HbS) of sickle cell anemia patients. The antioxidant and anti-scurvy vitamin C is also known to play a role in the formation of human collagen [28].

The relatively low $\beta$-carotene (pro-vitamin A) content (2.20 – 9.17µg/g) of the tiger nut snack food samples on the other hand (Table 1) are higher than the values got for most of the white fleshed yam, cassava and sweet potato tubers [9, 11, 13, 20] and similar to the 2.10 µg/g vitamin A content obtained for Nigerian tiger nut flour by Ekeanyanwu and Ononogbu [17]. However, the obtained $\beta$-carotene values in this investigation are by far lower than the values obtained for orange fleshed sweet potatoes (developed to combat vitamin A deficiency) that have up to 60mg/100g on dry matter basis [11]. Therefore, the 6µg/g carotene content of yellow fleshed cassava tuberous roots [14] seems to be closer to those of the experimental tiger nuts. Carotenes are known to impart yellow-orange hues to the colors of some plant tissues [29]. In this study, it was easily observed visually that the creamy flesh of the rehydrated tiger nut tubers had spots with yellow hues. Nutritionally, $\beta$-carotene is both a precursor of vitamin A and an antioxidant. While Ezeh et al [7] in Europe documented 12mg/100g as the vitamin E (α-tocopherol and β-tocopherol) content of tiger nut, Ekeanyanwu and Ononogbu [17] in Nigeria got 0.74 mg/100g vitamin E content for tiger nut flour that had 11.70 moisture content.

The results of the sensory analysis of the experimental snack food samples are shown in Table 2. Though there was no significant difference (P=0.05) in the mean score of the organoleptic assessors for the overall acceptability for the -
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Table 1. Mean ascorbic acid and β-carotene contents* of the experimental dried and rehydrated tiger nuts

<table>
<thead>
<tr>
<th>Food form</th>
<th>Moisture (%)</th>
<th>Ascorbic acid (mg/100g)</th>
<th>β -carotenoid (µg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dried</td>
<td>20.90b</td>
<td>49.5a</td>
<td>9.17a</td>
</tr>
<tr>
<td>Rehydrated</td>
<td>52.96a</td>
<td>47.0a</td>
<td>2.20b</td>
</tr>
</tbody>
</table>

*Values in a column with the same letter are not significantly different (P=0.05)

Table 2. Mean sensory evaluation scores* of the experimental tiger nut snack-food forms**

<table>
<thead>
<tr>
<th>Sample form</th>
<th>Color</th>
<th>Taste</th>
<th>Texture (mouth feel)</th>
<th>Overall Acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dried</td>
<td>5.8b</td>
<td>6.5a</td>
<td>5.2b</td>
<td>5.4a</td>
</tr>
<tr>
<td>Rehydrated</td>
<td>6.4a</td>
<td>5.7b</td>
<td>5.7a</td>
<td>5.3a</td>
</tr>
</tbody>
</table>

*Values in a column with the same letter are not significantly different (P=0.05)

** Where 7 = like extremely, 6 = like highly, 5 = like, 4 = neither like nor dislike, 3 = dislike, 2 = dislike highly and 1 = dislike extremely

Table 3. Mean microbial loads* of the washed and unwashed experimental tiger nuts

<table>
<thead>
<tr>
<th>Sample</th>
<th>Bacteria (cfu/g x 10^3) at 37°C, 24hrs</th>
<th>Fungi (cfu/g x 10^3) at 26°C, 48hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dried (unwashed)</td>
<td>23a</td>
<td>15a</td>
</tr>
<tr>
<td>Dried (washed)</td>
<td>19b</td>
<td>9b</td>
</tr>
<tr>
<td>Rehydrated (unwashed)</td>
<td>13c</td>
<td>9b</td>
</tr>
<tr>
<td>Rehydrated (washed)</td>
<td>7.0d</td>
<td>5c</td>
</tr>
</tbody>
</table>

*Values in a column with the same letter are not significantly different (P=0.05)
Table 4. Microbial and biochemical tests of the isolated bacteria

<table>
<thead>
<tr>
<th>Sample code</th>
<th>Cultural characteristic</th>
<th>Gram reaction</th>
<th>Spore</th>
<th>Motility</th>
<th>Catalase</th>
<th>Coagulase</th>
<th>Indole</th>
<th>Methyl red</th>
<th>NO$_3$</th>
<th>H$_2$S</th>
<th>Urease</th>
<th>Gelatin</th>
<th>Glucose</th>
<th>Lactose</th>
<th>Sucrose</th>
<th>Mannitol</th>
<th>Manitol</th>
<th>Probable Bacteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>O$_p$</td>
<td>Swarming colonies</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>N</td>
<td>N</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>N</td>
<td>-</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>-</td>
<td>+</td>
<td>Proteus spp</td>
</tr>
<tr>
<td>O$_m$</td>
<td>Smooth, shinning and greenish colonies</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>N</td>
<td>-</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>+</td>
<td>N</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>Pseudomonas spp</td>
</tr>
<tr>
<td>O$_s$</td>
<td>Yellow colonies, smooth and shiny edges</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>+</td>
<td>+</td>
<td>N</td>
<td>+</td>
<td>N</td>
<td>+</td>
<td>+</td>
<td>Staphylococcus spp</td>
</tr>
</tbody>
</table>

Legend: + = positive; - = negative; N = Not determined

Table 5. Characteristics of the isolated fungal species

<table>
<thead>
<tr>
<th>Code</th>
<th>Colour</th>
<th>Microscopic description</th>
<th>Identified organism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y$_1$</td>
<td>Dark-brown</td>
<td>Fruiting heads bearing chains of conidia with long non-septate mycelia.</td>
<td>Aspergillus spp</td>
</tr>
<tr>
<td>Y$_2$</td>
<td>Green</td>
<td>Whorls, cluster of three or more sterigmata.</td>
<td>Penicillium spp</td>
</tr>
<tr>
<td>Y$_3$</td>
<td>White cottony</td>
<td>Sickled shaped, macroconidia, microconidia, and presence of conidiophore</td>
<td>Fusarium spp</td>
</tr>
</tbody>
</table>

experimental dried and rehydrated tiger nut samples, the assessors significantly (P=0.05) preferred the taste of the dried ones and the mouth feel of the rehydrated samples in the Hedonic scale analysis. This could be due to the fact that rehydration of dried tiger nut leads to increased tuber moisture content (that enhance sweet sugar dilution) and increased tuber sphericity [30] that give better smoothness when compared with the wrinkled dried tiger nut tubers (as depicted in Figure 1). Figure 1 also clearly shows the preferred and highly liked yellow color of the rehydrated tiger nut (Table 2) or yellow nut sedge.

Tables 3-5 show the microbial characteristics of the experimental tiger nut samples. From the results in Table 3, it could be inferred that the water soaking process of the local tiger nut traders that led to rehydration of the dried tiger nut also led to a decrease in both its bacterial and fungal loads. Hand washing of the tiger nut samples was also observed to have led to the bacterial load reductions at the mean rates of 17.39% for the dried samples and 46.15% for the rehydrated samples. For the fungal load reductions through hand washing with clean water, the obtained figures were 40.0% and 44.44% respectively, for the dried and rehydrated samples.
Fortunately, dangerous fecal coliforms, *Salmonella* and spore forming bacteria were not among the probable bacterial genera identified in the experimental tiger nuts (Table 4). The identified fungi genera (Table 5) also have species that are innocuous at appropriate microbial ecology for food materials [31]. Interestingly, Chukwu *et al.* [15] also identified *Aspergillus* and *Penicillium* species in marketed tiger nut tubers in Nigeria. In as much as the observed microbial levels in this study do not seem alarming [18], further specific classification of these microorganisms at an advanced laboratory, using relevant molecular analyses, would be helpful to adequately discuss the microbial health implication of the obtained results as they concern the uncooked experimental tiger nuts.

In addition to the local use of uncooked tiger nuts as snacks, there is the need to develop large scale functional foods with local West African tiger nuts, such as the industrially produced vegetable milk (known internationally as Horchata de Chufas) that is used by people that are intolerant to dietary lactose [3, 32]. Its Nigerian equivalent, known locally as Kunnu aya [6, 33] also needs to be popularized in Southeastern Nigeria after procedural standardization and mechanization that should involve healthy commercial sterilization.

**4. CONCLUSION**

The study showed that the investigated imported and commercially unsterilized tiger nut snack foods (dried and rehydrated) are sources of nutritional vitamin C and vitamin A. Though the local food consumers generally liked the experimental tiger nut snack-foods, there might be a necessity to adequately wash them physically in clean water (to lower their microbial loads) before consumption.

**Conflict of Interest**

The authors declare that they have no conflicts of interest.

**References**