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# Influence of Processing Techniques on the Nutrients and Antinutrients of Tigernut (*Cyperus esculentus* L.)

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**Abstract:** The effects of soaking and toasting on the nutrients and anti-nutrients of tigernut were investigated. Tigernut was soaked in water (1:10w/v) at ambient (27-30°C) temperature for 12h and at 60°C for 6h and 7h. Tigernut was also toasted in hot air oven at 120°C for 30min and in open pan for 10min and 30min. Raw tigernut contained 4.69% moisture, 4.27% crude protein, 27.44% crude fat, 13.35% crude fibre, 2.32% ash, 47.9% carbohydrate, 2.37% tannin,1.0% polyphenol, 21.42% phytate, 13.12% oxalate and 2.63% alkaloid. Soaking and toasting increased the crude protein and crude fat of tigernut but reduced the carbohydrate. Soaking reduced the tannin by 15-61%, polyphenol by 15-48%, phytate by 27-44%, oxalate by 37-58% and alkaloid by 3-13% while toasting reduced tannin by 36-71%, polyphenol by 25-65%, phytate by 22-40%, oxalate by 57-77% and alkaloid by 13-27%. Soaking at higher temperature (60°C) was more effective in reducing the anti-nutrients than ambient temperature soaking. Toasting in open pan for 30min also reduced the anti-nutrients more than toasting in open pan for 10min and toasting in the oven. Soaking at 60°C for 6h and toasting in an open pan for 30min are therefore the preferred methods for tigernut.

**Key words:** Tigernut · Anti-nutrients · Nutrients · Soaking · Toasting

## INTRODUCTION

To alleviate the problems of short food supply and malnutrition, the development and use of nutritious foods, conventional and non-conventional, have been advocated [1]. Much attention is now focused on plant foods such as peas and tubers. Non availability of nutritional information and presence of antinutritional factors in the foods are some of the factors limiting their use in food formulation. Processing technique such as soaking, roasting and germination are means of improving the nutritional value and protein digestibility of foods [2, 3].

Tigernut (*Cyperus esculentus*), a non-conventional and under-utilized tuber belong to the family Cyperaceae and is native to Mediterranean and tropical regions. Its tubers can be eaten unprepared, roasted with sugar, soaked in water or be processed into starch [4] and flour [5]. It can be processed into a milky beverage called "Horchata de chufa" in Spain [6] or "Atadwe" milk in Ghana. Tigernut milk can be used, in conjunction with other foods, to fight cardiovascular diseases [7]. In Nigeria, tigernut is well grown and available in semi-dried form in Nigerian markets where it is sold locally and consumed uncooked. They are underutilised due to lack of information on their nutritional potentials [8].

In processing tigernut into a milky beverage, soaking is a major unit operation. The tubers are soaked in water, wet milled, sieved, sweetened and flavoured. Soaking is a method of food processing which involves inserting food materials in a liquid for a time until it becomes completely wet [9]. It can be used to reduce soluble anti-nutrients (e.g. tannins and polyphenols) which can be eliminated with the discarding soaking solution. Soaking of tigernut can be achieved at different temperatures and time, ranging from ambient (25-30°C) to 100°C for 5h to 12h depending on the processor. Traditionally, tigernut is soaked at ambient temperature for 12h while it is soaked industrially at a higher temperature for a varied period of time. Djomdi and Ndjouenkeu [7] reported 60°C and 6h as the best soaking temperature and time for high yield and high quality tigernut milk. Toasting, on the other hand,

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apart from aiding flavour development, improves minerals and protein content of foods and removes heat labile anti-nutrients [10]. Although studies have been carried out on the behavior of the tuber during soaking with respect to kinetics of water uptake and characteristics of volatile component in roasted tigernut [7, 11], there is dearth of information on the effects of these processing methods on the antinutritional factors of tigernut. This paper therefore studied the effects of soaking and toasting on the nutrients and antinutritional factors of tigernut tubers.

## MATERIALS AND METHODS

**Sample Preparation:** Tigernut (*Cyperus esculentus* L) tubers obtained from a local market in New Bussa, Nigeria were sorted to remove stones, pebbles, dirt materials, rotten stems and broken tubers before cleaning in water to remove the adhering soil. The cleaned tubers were dried in the oven at 60°C for five hours before they were divided into eight parts. Washed and dried tigernut without further treatment served as the control (RTGN). The second part of the washed and dried tigernut was soaked in distilled water (1:10 w/v) at room temperature (28±2°C) for 12h (TGSR); third part was soaked in distilled water at 60°C for 6h (TGS1) while the fourth part was soaked in distilled water at 60°C for 7h (TGS2). The fifth, sixth and seventh parts were toasted in the oven at 120°C for 30min (TGOV), in an open pan for 10min (TGP1) and 30min (TGP2) respectively. The processing methods used simulate the traditional methods for both soaking and toasting of tigernut. The soaked samples were drained and dried in the oven at 60°C for 12h before milling into flour that were used for analysis.

**Determination of Proximate Composition:** The crude protein, fat, ash, moisture and crude fibre were determined using standard methods of AOAC [12] while the carbohydrate content was calculated by difference. Crude protein was determined by percentage nitrogen x 6.25 using micro-kjeldhal distillation unit. Triplicate determination was carried out for each sample.

**Determination of Antinutritional Factors**

**Determination of Phytate:** The phytate content of the flours was determined by Maga [13] method. Two (2g) grams of each finely ground flour sample was soaked in 20ml of 0.2N HCl and filtered. After filtration, 0.5ml of the filtrate was mixed with 1ml ferric ammonium sulphate solution in a test tube, boiled for 30min in a water bath, cooled in ice for15min and centrifuged at 3000 x g for 15min. One milliliter of the supernatant was mixed with 1.5ml of 2,2-pyridine solution and the absorbance measured in a spectrophotometer at 519nm. The concentration of phytic acid was obtained by extrapolation from a standard curve using standard phytic acid solution.

**Determination of Tannin Content:** For tannin determination, 10ml 70% aqeous acetone was added to 200mg of finely ground sample in a bottle and properly covered. The bottle was put in an ice bath shaker for 2h at 30°C. The solution was then centrifuged and the supernatant stored in ice. From the supernatant, 0.2ml was pipetted into 0.8ml distilled water. Standard tannic acid solution was prepared. Folin reagent (0.5ml) was added to both sample and standard followed by 2.5ml 20% $Na_2CO_3$. The solutions were vortexed and allowed to incubate for 40min at room temperature after which the absorbance was read at 725nm. The concentration of tannin in the sample was estimated from the standard tannic acid curve [14].

**Determination of Oxalate:** The titration method described by Day and Underwood [15] was used to determine the oxalate content. One gram of the sample was weighed into 100ml conical flask where 75ml 3N $H_2SO_4$ was added and stirred intermittently with a magnetic stirrer for 1h. It was then filtered using Whatman No.1 filter paper. From the filtrate, 25ml was taken and titrated while hot (80-90°C) against 0.1N $KMnO_4$ solution until a faint pink colour persisted for at least 30 secs.

**Determination of Total Polyphenols:** The total polyphenols in the samples was determined using Purssion Blue spectrophotometric method [16]. A standard curve which expressed the result as tannic acid equivalent (mg/100g) and gave a colour intensity equivalent to that given by polyphenols after correction for blank was prepared.

**Determination of Alkaloids:** The gravimetric method of Harborne [17] described by Onwuka [18] was adopted. Five grams of each sample was dispersed in 50ml of 10% acetic acid solution in ethanol. The mixture was shaken and allowed to stand for 4h before it was filtered. The filtrate was evaporated to one quarter of its original volume. Concentrated $NH_4OH$ was added drop wise to precipitate the alkaloids. The precipitate was filtered off with weighed filter paper and washed with 1% $NH_4OH$ solution. The precipitate in the filter paper was dried in the oven at 60°C for 30min and reweighed. Alkaloid was expressed in percentage.

**Statistical Analysis:** The results obtained from the proximate analysis and antinutritional factors were subjected to one-way ANOVA and the means were separated by Duncan Multiple Range Test using SPSS-13.0 (Microsoft Inc., USA).

## RESULTS AND DISCUSSION

The proximate composition of the raw, soaked and toasted tigernut is as shown in Table 1. The values obtained for the raw tigernut fall within the range reported in literature [4, 5, 19]. Soaking increased the crude protein, crude fat and crude fibre but reduced the moisture content, ash and carbohydrate of tigernut. Increase in soaking temperature from ambient to 60°C increased the protein, fat and crude fibre from 4, 27 and 13% to 8, 31 and 26% for tigernut soaked at ambient temperature for 12h and 60°C for 6h and 7h respectively. Ahmed *et al.*, [20] reported an increase from 53 to 68% and 2.3 to 4.0% for protein and oil respectively for guar gum seeds soaked at 60°C. The increase could be attributed to leaching of some soluble constituents of the tuber into the soaking water. Constituents such as simple sugars and some anti-nutrients e.g. tannin and phytic acid are leached into soaking water especially at above ambient temperature through the swollen and ruptured cell walls which permeate water and soluble constituents. At 60°C, increase in soaking time from 6-7h did not affect the protein and fat but ash and crude fibre significantly (P=0.05). This agreed with the report of Djomdi and Ndjouenkeu [7] that the best quality tigernut milk can be processed from tigernut soaked at 60°C for 6h. The decrease in the ash content of the soaked tigernut could be due to leaching of some mineral elements into soaking water. Obizoba and Atii [21] have made a similar observation for sorghum soaked in water.

Toasting on the other hand increased only the crude protein and fat but reduced the carbohydrate contents of the tigernut. The increase could be attributed to the concentration of the constituents during roasting brought about by loss of moisture and reduction/ destruction of certain protease inhibitors and other anti-nutrients like phytic acid and tannins which form complexes with protein and make protein unavailable during hydrolysis. A similar increase in protein content has been reported for *Terminalia catappa* seeds roasted at a high temperature [22]. The decrease in carbohydrate content of the toasted tigernut could be due to Maillard reaction which occurred between amino acids, amines, aldehydes and carbonyl group of reducing sugars at high temperature to produce the toasted tigernut flavour. The major aromatic compounds like pyrazines, furans and pyrroles, formed during roasting of tigernut were associated with Maillard reaction [11]. The author also reported an increase in the number and concentration of the volatile compounds as the roasting time increased from 10 to 60min at 120°C. The proximate composition of tigernut was significantly (P=0.05) affected by toasting (Table 1). An increase in fat and crude fibre contents after toasting has been reported for cowpea [23] and pigeon pea [24]. Oven toasted tigernut had the highest protein and crude fibre contents but the lowest fat and carbohydrate contents. Increase in toasting time from 10 to 30min also increased the protein and carbohydrate contents from 6.40 and 44% to 7.22 and 49% respectively while it reduced the crude fat, crude fibre and ash from 33, 13 and 2.16% to 31, 8 and 1.8% respectively. This shows that toasting time has significant (P=0.05) effect on the nutrient composition of tigernut.

The effects of soaking and toasting on the anti-nutrients of tigernut are as shown in Table 2. Both soaking and toasting reduced tannin significantly (P=0.05). The concentration of tannins in the raw tigernut

Table 1: Proximate composition of raw, soaked and toasted tigernut*

| Sample | Moisture content (%) | Crude protein (%) | Crude fat (%) | Crude fibre (%) | Ash (%) | Carbohydrate(%) |
|---|---|---|---|---|---|---|
| RTGN | $4.69\pm0.01_{b}$ | $4.27\pm0.54_{e}$ | $27.44\pm0.4_{d}$ | $13.35\pm0.0_{e}$ | $2.32\pm0.00_{a}$ | $47.91\pm0.45_{c}$ |
| TGSR | $1.78\pm0.1_{d}$ | $7.24\pm0.22_{c}$ | $22.11\pm0.16_{e}$ | $14.20\pm0.01_{d}$ | $2.07\pm0.01_{c}$ | $52.58\pm0.13_{a}$ |
| TGS1 | $3.41\pm1.03_{c}$ | $8.50\pm0.19_{a}$ | $30.52\pm0.48_{bc}$ | $18.72\pm0.01_{c}$ | $1.94\pm0.01_{d}$ | $36.90\pm0.30_{e}$ |
| TGS2 | $5.54\pm0.01_{a}$ | $8.00\pm0.22_{ab}$ | $30.91\pm0.15_{b}$ | $25.94\pm0.05_{a}$ | $1.37\pm0.02_{f}$ | $28.22\pm0.36_{f}$ |
| TGOV | $1.77\pm0.01_{d}$ | $7.59\pm0.26_{c}$ | $29.99\pm0.03_{c}$ | $21.56\pm0.01_{b}$ | $2.06\pm0.01_{c}$ | $36.97\pm0.20_{e}$ |
| TGP1 | $1.48\pm0.01_{e}$ | $6.40\pm0.28_{d}$ | $32.78\pm0.57_{a}$ | $12.60\pm0.44_{f}$ | $2.16\pm0.01_{b}$ | $44.56\pm0.53_{d}$ |
| TGP2 | $3.02\pm0.01_{f}$ | $7.22\pm0.04_{c}$ | $31.04\pm0.11_{b}$ | $7.50\pm0.01_{g}$ | $1.80\pm0.01_{e}$ | $49.40\pm0.15_{b}$ |

*Values are means of triplicate determinations. RTGN-Raw tigernut; TGSR-Tigernut soaked in distilled water at room temperature for 12h; TGS1-Tigernut soaked in distilled water at 60°C for 6h; TGS2-Tigernut soaked in distilled water at 60°C for 7h; TGOV-Tigernut toasted in the oven at 120°C for 30min; TGP1-Tigernut toasted in an open pan for 10min; TGP2-Tigernut toasted in an open pan for 30min

Table 2: Anti-nutritional factors in raw, soaked and toasted tigernut in mg/100g

| Sample | Tannins | Polyphenols | Phytates | Oxalates | Alkaloids |
|---|---|---|---|---|---|
| RTGN | 2.37±0.20$_d$ | 1.00±0.07$_d$ | 21.42±0.67$_e$ | 13.12±0.10$_d$ | 2.63±0.04$_f$ |
| TGSR | 2.02±0.05 (15)$_{cd}$ | 0.85±0.10 (15)$_{cd}$ | 15.65±0.67 (27)$_{cd}$ | 8.28±0.15 (37)$_c$ | 2.55±0.04 (3)$_e$ |
| TGS1 | 1.65±0.08 (30)$_{bc}$ | 0.58±0.03 (42)$_b$ | 14.97±0.52 (30)$_{bc}$ | 7.90±0.15 (40)$_c$ | 2.48±0.03 (6)$_d$ |
| TGS2 | 0.93±0.07 (61)$_a$ | 0.52±0.07 (48)$_{ab}$ | 11.95±0.58 (44)$_a$ | 5.46±0.08 (58)$_b$ | 2.29±0.02 (13)$_c$ |
| TGOV | 1.10±0.19 (54)$_{ab}$ | 0.48±0.15 (52)$_{ab}$ | 16.75±0.38 (22)$_d$ | 5.55±0.43 (58)$_b$ | 1.93±0.04 (27)$_a$ |
| TGP1 | 1.51±0.17 (36)$_b$ | 0.75±0.05 (25)$_c$ | 12.90±0.38 (40)$_{ab}$ | 5.67±0.51 (57)$_b$ | 2.05±0.02 (22)$_b$ |
| TGP2 | 0.70±0.10 (71)$_a$ | 0.35±0.01 (65)$_a$ | 13.87±0.19 (35)$_b$ | 2.97±0.07 (77)$_a$ | 2.30±0.01 (13)$_c$ |

*Values are means of triplicate determinations. Values in parenthesis are reductions in percentage while the values followed by different alphabets in a column are significantly different (P=0.05). RTGN-Raw tigernut; TGSR-Tigernut soaked in distilled water at room temperature for 12h; TGS1-Tigernut soaked in distilled water at 60°C for 6h; TGS2-Tigernut soaked in distilled water at 60°C for 7h; TGOV-Tigernut toasted in the oven at 120°C for 30min; TGP1-Tigernut toasted in an open pan for 10min; TGP2-Tigernut toasted in an open pan for 30min

was 2.37%. The value was higher than 0.28% reported for *Mucuna pruriens* seeds [25], 1.3% and 1.9% reported for cashew nut and full-fat pumpkin seed flours [26]. Ahmed *et al.*, [20] reported 1.75% for Guar gum seeds, 0.15% and 0.07% were reported for soybean and brown millet [27]. Higher value (9.9%) was reported for Breadnut seeds flour [26]. The tannin concentration in the soaked tigernut ranged between 0.93 and 2.02% denoting reduction of 15-61%. Although, all the soaking processes reduced tannin, soaking at ambient temperature had the least reduction (15%) while tigernut soaked at 60°C for 7h had the highest reduction (61%). Increase in soaking temperature and time also reduced tannin concentration significantly (P=0.05). This is in agreement with the report of Onwuka [18] who reported a decrease in tannin content of pigeon pea (*Cajanus cajan*) and vegetable cowpea (*Vigna unguiculata*) with increase in soaking time. This could be attributed to the solubility of tannin in water which aids its leaching into soaking water. A similar result was also reported for different legumes when soaked in water [25, 28, 29]. Tannins inhibit the activities of some enzymes like trypsin, amylase and lipase by forming insoluble complexes with protein [30] and divalent ions such as $Fe^{2+}$ and $Zn^{2+}$ thereby reducing their absorption in the body [31]. Toasting reduced the tannin content of tigernut significantly (P=0.05) up to 71% which was higher than the value recorded for soaking. The tannin content of toasted tigernut ranged between 0.7-1.51% with reduction of 36-71%. A similar effect was reported for roasted breadnut [26] and *Mucuna flagellipes* [29]. The higher percentage reduction of tannin in toasted tigernut showed that tannin is heat labile, thereby destroyed during toasting.

From Table 2, the total polyphenols concentration was 1.0%, 0.52-0.85% and 0.35-0.75% for the raw, soaked and toasted tigernut respectively while the reduction was 15-48% and 25-65% for soaked and toasted tigernut respectively. Generally, there was a significant (P=0.05) decrease in polyphenols concentration of both soaked and toasted tigernut. The decrease could be attributed to the leaching of the soluble polyphenols in water at all temperatures. There was significant (P=0.05) reduction in polyphenols concentration as the soaking temperature increased but no significant decrease was observed when the soaking time was increased. A similar trend was reported by Kataria *et al.*, [28] and Vijayakumari *et al.*, [25]. Soaking at elevated temperature and longer period did not affect polyphenols concentration significantly (P=0.05). Toasting was more active in reducing polyphenols concentration than soaking. The reduction was highest (65%) in tigernut toasted in open pan for 30min and lowest (25%) in tigernut toasted in open pan for 10min. The percentage reduction was more in toasted tigernut than in soaked tigernut. This indicates that polyphenols are heat labile. Iyayi *et al.*, [3] reported a higher percent (67-70%) reduction in polyphenols of *Mucuna pruriens* and *Centrosema pubescens* toasted at 100°C for 1h.

The phytate value recorded for raw tigernut (21.42%) was higher relative to 8.25 and 4.25% reported for white sesame seed and black millet respectively [27] and 0.18% reported for locust bean [32]. Soaking reduced the phytate content significantly (P=0.05). It was reduced up to 44% in tigernut soaked in water at 60°C for 7h. A similar reduction was reported for *Mucuna pruriens* [25] and maize [33]. This could be attributed to the type of heat treatment and the moisture content of the samples. Khan *et al.*, [33] stated that the higher the moisture content, the higher the phytate loss. Toasting also reduced the phytate content significantly (P=0.05) up to 40% (Table 2). Oven toasting was less effective compared to pan toasting In reducing phytates while pan toasting for 10min was more effective than 30min. This was because more moisture was lost when the toasting time was increased. This agreed with the trend reported for roasted maize [33] and toasted pigeon pea [24]. Fermentation has been reported to be the most effective in reducing phytates [26].

From Table 2, the values of oxalates were 13.12%, 5.46-8.28% and 2.97-5.67% for raw, soaked and toasted tigernut. Soaking reduced oxalate by 37-58% while toasting reduced it by 57-77%. Obasi and Wogu [34] observed a significant reduction in the oxalate content of yellow maize soaked in water for 12h. Soaking at higher temperature had a significant (P=0.05) effect on oxalate reduction but longer time did not. Toasting on the other hand reduced oxalate content significantly (P=0.05) especially when toasted in open pan for 30min. The higher loss of oxalate in toasted tigernut could be attributed to the destruction of the oxalate at high temperature. This result shows that oxalates are water soluble and heat labile.

The alkaloid content of raw, soaked and toasted tigernut were 2.63%, 2.29-2.55% and 1.93-2.30% respectively. The value (2.63%) was higher than 0.26% but lower than 9.61% reported for pigeon pea and vegetable cowpea respectively [18]. Soaking and toasting reduced the alkaloid content to only 13% and 27% respectively, values that were significant (P=0.05). Increase in soaking temperature from ambient to 60°C reduced alkaloid concentration significantly (P=0.05). Oven toasting was more effective in reducing alkaloid than both soaking and open pen toasting. Soaking in water has been reported to reduce alkaloid in vegetable cowpea significantly (P=0.05). Although the alkaloid was reduced by soaking, the percentage reduction was small compared to the effect of cooking [18].

## CONCLUSION

From the results obtained in this study, both soaking and toasting had significant influence on the nutrients and anti-nutrients of tigernut. Soaking at higher temperature (60°C) effectively increased the protein content while toasting in open pan increased the fat content of tigernut.

The anti-nutritional factors in tigernut were significantly reduced by soaking and toasting. Toasting reduced the anti-nutrients more than soaking. Increase in soaking temperature and toasting time also influenced the reduction of the anti-nutrients except alkaloids. Therefore, the anti-nutrients in tigernut can be reduced significantly by soaking in water at 60°C for 6h or toasting in open pan for 30min.

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