Effects of traditional soaking on the nutritional profile of taro flour (Colocasia esculenta L. Schott) produced in Chad

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SUMMARY

The fresh taro chips are traditionally dipped in water or in a corn or tamarind infusion to remove the acridity. The objective of this study was to determine the effects of traditional soaking on the nutritional profile (dry matter, crude protein, ash, crude fibre, minerals and some trace elements) of taro. Fresh taro chips were dipped for 0, 1, 3, 6, 12 and 24 hours in water, or in the corn infusion or in the tamarind infusion. Each sample was dried in the sun and milled into flour. The tamarind infusion induced a significant decrease of the protein content. The crude fibre content was not affected by the tamarind infusion but significantly decreased with the other treatments. All processes led to a significant decline of the mineral content except for the sodium content which in fact increased (due to the quality of the water) and also phosphorus in the corn infusion (probably due to the hydrolysis of phytates in the soaking solution).

Keywords: Colocasia esculenta L. SCHOTT, soaking, nutritive value, corn (Zea mays L.), tamarind (Tamarindus indica L.), minerals, trace elements.

RÉSUMÉ

Effets du trempage traditionnel sur le profil nutritionnel de la farine de taro (Colocasia esculenta L. Schott) produite au Tchad

Les cossettes fraîches de taro sont traditionnellement trempées dans de l’eau ou une solution de trempage de maïs ou une infusion de tamarin pour éliminer l’âcreté du tubercule. Les objectifs de cette étude étaient de déterminer les effets du trempage traditionnel sur le profil nutritionnel (protéines brutes, cendres, macro-éléments minéraux et oligo-éléments, fibres brutes) du taro. Des cossettes fraîches ont été trempées pendant 0, 1, 3, 6, 12 et 24 heures dans de l’eau, ou une solution de trempage de maïs ou une infusion de tamarin. Chaque échantillon a été séché au soleil puis broyé en farine. Seul le trempage dans une infusion de tamarin a induit une baisse de la teneur en protéines brutes. L’infusion de tamarin n’a pas modifié la teneur en fibres brutes alors que les autres l’ont fortement diminuée. Toutes les méthodes de trempage ont entraîné une diminution significative des minéraux, à l’exception d’une augmentation des teneurs en sodium (due à la qualité de l’eau des préparations) et en phosphore lorsque le trempage a été réalisé dans une solution de maïs (probablement due à l’hydrolyse des phytates de ce dernier).

Mots clés : Colocasia esculenta L. SCHOTT, trempage, valeur alimentaire, maïs (Zea mays L.), tamarin (Tamarindus indica L.), minéraux, oligo-éléments.

Introduction

The taro is a tuber very rich in carbohydrates, ranging between 73 and 80% on the dry matter (DM) basis [10], mainly starch (77.9% DM) and 1.4% crude fibre on the DM basis [13]. Because of its high carbohydrate content, this tuber represents one of the main sources of energy in many parts of the tropics and sub-tropics providing about a third of the food intake of more than 400 million people in these areas [8]. Africa represents 75% of the total world production [4].

The taro also contains minerals: potassium (between 3.23 to 5.30 g/kg on the fresh product (FP) basis) is the most abundant [6]. Calcium (110 to 450 mg/kg FP) and magnesium (190 to 370 mg/kg FP) contents are low but sodium remains the less abundant macro-element in the taro (0 to 3mg/100g FP) [18]. Anti nutritional factors, like oxalates, are present up to 2.05 to 4.21% DM [12] and they are supposed to be responsible for the acridity of these tubers that often limited their consumption.

In the area of Mayo-Kebbi in Chad, representing the main area of culture of taro in this country, numerous methods were traditionally used to transform these tubers into chips and then into flour. The usual procedure in this area was to dip the fresh taro chips into water or into a filtered solution of corn (Zea mays L.) or into a filtered infusion of tamarind (dry pods of Tamarindus indica L.) for at least 24 hours and then to dry them in the sun for 48 hours. According to the investigations that were carried out among farmers, these traditional practices were performed to reduce the acridity of the tubers.

The purpose of this study was to measure the effects of these different traditional practices of soaking on some parameters of the nutritional value of taro.

Materials and Methods

NATURE, ORIGIN AND PROCESSES OF THE TARO SAMPLES
The taro samples (*Colocasia esculenta* L. Schott) came from the village of Kolobo (region of Mayo-Kebbi (Chad), figure 1). They belonged to the variety known as “Gouning Sosso” that presented a lower acridity and a reduced cooking time (45 minutes vs. 6 to 8 hours).

The methods of treatments were a faithful reproduction of those of the farmers in this region. The freshly harvested taro tubers were carefully washed in tap water then peeled (thickness of peelings: about 5 mm) and cut into 1 cm thick slices (or chips). The chips were immediately dipped into three different solutions: water or corn infusion or tamarind infusion. Both corn and tamarind infusions were prepared with 45% (mass/volume) of corn seeds or tamarind pulp with the seeds macerating respectively 3 days and 3 hours in water. They were then filtered through a cooking sieve. The proportion of taro chips that were dipped into the soaking solutions was 40% (m/v) and the temperature of these solutions was 22°C. Five different soaking durations were applied: 1, 3, 6, 12 and 24 hours. An untreated sample of dried chips (Time 0) served as a control. This is equivalent to a type of experimental design $1 \times 3 \times 5$, where 1 is the variety of tuber, 3 the solutions (of soaking) and 5 the durations of soaking. After soaking, the chips were dried in the sun for 24 hours at a temperature of about 46°C. The dried chips were ground in the laboratory with an electrical grinder to obtain a size of the particles of flour less than 500µm (figure 2).

**NUTRITIONAL ANALYSES**

A series of analyses was carried out on the flour coming from different soaking solutions as well as on the control sample.

The level of dry matter and the total ash content were determined according to the AOAC methods [3]. The crude fibre content was determined according to the WEENDE method [1] and the content of crude proteins was determined by the method of KJELDAHL [1].

Calcium, potassium, sodium and magnesium were measured by flame spectrophotometry after a dry mineralization [9]. The assessment of total inorganic phosphorus was performed according to the AFNOR method [1]. The trace elements (Zinc, Iron) were measured by atomic absorption spectrophotometry after oven mineralization and solution into diluted (10% v/v) nitric acid [5].

**STATISTICAL ANALYSES**

The effect of soaking for each type of solution was studied by analysis of variance and each sample is repeated according to the duration of soaking. Calculations of data were carried out by SPSS software [17] and by Excel (Mac 2004, version 11.1.1 on the iBook G4 computer). The threshold significance of all tests was fixed at $P < 0.05$.

**Results and Discussion**

All samples of taro were rich in dry matter (94.33 to 96.30%) which proved the efficiency of sun drying to allow a long term preservation of the taro flour.

**INFLUENCE OF SOAKING ON THE CRUDE PROTEIN OF TARO**

The taro is poor in protein with a maximum content of 3.43%. These results are similar to those reported by
AGBOR-EGBE and RICHARD [2] who have shown that the protein content of taro generally varies between 3 and 6%. The different soaking systems in water and in the solution of corn did not involve any significant modification of the protein content of chips (figure 3). The soaking in the solution of tamarind led to a significant ($P < 0.001$) declining rate of crude protein from the sixth hour of soaking until the twenty fourth hour (3.26 % DM at T0 to 2.68 % DM at T24) and the final content was significantly different compared to the results obtained respectively with soaking in water ($P = 0.002$) and soaking in corn infusion ($P < 0.001$).

INFLUENCE OF SOAKING ON THE CRUDE FIBRE CONTENT

The crude fibre content of taro produced in Chad was higher (3.25% DM for control) than that reported by ONWUEME et al. [13] in taro corms produced in Pacific areas with a crude fibre content ranging between 0.6 and 1.4% DM. Significant decreases of the crude fibre contents in the samples of taro dipped in water ($P = 0.009$) and in the corn solution ($P < 0.001$) were observed (figure 4). Therefore, the corn solution was supposed to be rich enough in soluble nitrogen which stimulated an earlier fermentation. By contrast, the fibre content was not significantly modified when the taro chips were dipped in the tamarind infusion (from 3.27% DM at T3 to 3.24% DM at T24).

INFLUENCE OF SOAKING ON THE ASH CONTENT OF TARO

The taro chips had a very low mineral content (2.03% of DM for the control sample). The three processes of soaking decreased slightly but significantly ($P < 0.001$) the ash content of taro (Table I). This loss is statistically similar for the all processes (2.03% DM for control and 1.57% DM, 1.50% DM and 1.54% DM for corn infusion, water soaking and 24 hours long tamarind infusion, respectively).

INFLUENCE OF SOAKING ON THE TARO CONTENTS OF MAJOR MINERALS (CALCIUM, PHOSPHORUS, POTASSIUM, SODIUM, MAGNESIUM) AND OF SOME TRACE METALS (IRON AND ZINC)

The calcium content obtained on the taro grown in Chad (0.89 g/kg DM) were clearly higher than that reported by

<table>
<thead>
<tr>
<th>Soaking duration</th>
<th>Water</th>
<th>Corn infusion</th>
<th>Tamarind infusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (control)</td>
<td>2.005 ± 0.034</td>
<td>2.005 ± 0.034</td>
<td>2.005 ± 0.034</td>
</tr>
<tr>
<td>1 hour</td>
<td>1.822 ± 0.013</td>
<td>1.986 ± 0.083</td>
<td>1.940 ± 0.009</td>
</tr>
<tr>
<td>3 hours</td>
<td>1.696 ± 0.124</td>
<td>1.898 ± 0.075</td>
<td>1.694 ± 0.023</td>
</tr>
<tr>
<td>6 hours</td>
<td>1.587 ± 0.251</td>
<td>1.624 ± 0.015</td>
<td>1.596 ± 0.092</td>
</tr>
<tr>
<td>12 hours</td>
<td>1.738 ± 0.140</td>
<td>1.775 ± 0.099</td>
<td>1.657 ± 0.147</td>
</tr>
<tr>
<td>24 hours</td>
<td>1.503 ± 0.021</td>
<td>1.568 ± 0.066</td>
<td>1.537 ± 0.071</td>
</tr>
</tbody>
</table>

Table I : Ash content (%DM) of the taro flour during the traditional soaking according to the nature of the soaking solutions (n = 3) and to the soaking duration (n = 5). Each experiment was made in triplicate and results are expressed as mean ± standard deviation.
WILLS et al. [18] on the varieties of taro cultivated in Papua New Guinea (from 0.11 to 0.45 g/kg DM). This difference might probably be linked to the nature of the soil, and also to the plant variety as COURSEY [7] indicated that the composition of food depended on the variety, location and season. The contents of calcium in the all 3 processes decreased significantly from the onset of the soaking ($P < 0.001$). The higher decline was noted with the corn infusion (0.89 g/kg DM for control to 0.45 g/kg DM after 24 hours). The treatments with corn infusion and with water had a statistically similar effect. In contrast, the soaking in tamarind infusion was significantly different from the corn infusion ($P = 0.03$) and from the water ($P = 0.04$). Within the tamarind infusion soaking, the Ca level decreased and seemed to stabilize after the 6th hour (figure 5). The calcium being the most abundant mineral in tamarind with content up to 0.77 g/kg DM [14], this could be due to an osmotic balance between the taro and the soaking solution.

All treatments of soaking caused significant ($P < 0.05$) changes of the phosphorus content in the taro. The inorganic phosphate concentration of the raw taro (0.69 g/kg) was in agreement with that reported by SEFA-DEDEH and AGYIR-SACKEY [16] from 0.60 to 0.61 g/kg. There was a significant ($P < 0.001$) increase of phosphorus content in the taro treated by the corn solution from 0.69 g/kg DM for control to 1.02 g/kg DM after soaking for 24 hours. On the contrary, significant ($P < 0.05$) declines of the inorganic phosphorus contents of taro were observed after tamarind and water soaking (0.58 g/kg DM and 0.54 g/kg DM at T12, respectively) (figure 6).

As in the most tubers, the potassium constituted the most abundant mineral in the taro (10.2 g/kg DM for the control or at $T_0$). BRADBURY and HOLLOWAY [6] also showed that the taro was particularly rich in potassium compared to other minerals. Their levels varied between 3.23 to 5.30 g/kg FP with an average level of 33.2% DM. These values were quite equivalent to those of the variety cultivated in Chad. This appreciable content of potassium decreased significantly ($P < 0.001$) during the three processes of soaking (7.3 g/kg DM for the water treatment, 6.6 g/kg DM for the tamarind infusion and 6.4 g/kg DM for the corn infusion after 24 hours) (figure 7). Moreover, the tamarind infusion and the corn infusion had a statistically similar effect but both of them were significantly different ($P < 0.05$) from the water treatment.

FIGURE 5 : Variations of the calcium contents of taro chips according to the soaking modalities (in water, in tamarind infusion or in corn solution – soaking duration: from 0 to 24 hours).

FIGURE 6 : Variations of the inorganic phosphate contents of taro chips according to the soaking modalities (in water, in tamarind infusion or in corn solution – soaking duration: from 0 to 24 hours).

FIGURE 7 : Variations of the potassium contents of taro chips according to the soaking modalities (in water, in tamarind infusion or in corn solution – soaking duration: from 0 to 24 hours).

FIGURE 8 : Variations of the sodium contents of taro chips according to the soaking modalities (in water, in tamarind infusion or in corn solution – soaking duration: from 0 to 24 hours).
Sodium was the least abundant macro-element (0.45 g/kg DM for the control). This result was in accordance with those of Bradbury and Holloway [6], who have shown that the potassium constituted the most abundant macro-element in taro and sodium the least abundant one. However, the results published by SEFA-DEDEH and AGYIR-SACKEY [16] for tubers grown in Ghana, are slightly lower in sodium, from 0.28 to 0.35 g/kg DM. The three treatments induced a significant (P < 0.001) increase of the sodium content (figure 8). This increase could be linked to the nature of solutions of soaking. There was no significant difference between the tamarind infusion and the corn infusion and between the tamarind infusion and the water treatment. But there was a significant difference between the corn infusion and water treatment (P = 0.01).

The initial magnesium contents in the taro that had grown in Chad were greatly higher than the previous results, 0.48-0.65 g/kg [16] for taro from Eastern Ghana or 0.19-0.37 g/kg DM [18] for Papua New Guinea cultivars. The three solutions of soaking induced a significant (P < 0.001) decrease of the magnesium content (figure 9). However, the magnesium loss during soaking was less intense, although significant (P < 0.05) in the case of the corn infusion than with the other solutions (0.76 g/kg DM for the corn infusion, 0.57 g/kg DM for the tamarind infusion and 0.54 g/kg DM for the water treatment after 24 hours, corresponding to reductions of 16.48%, 37.36% and 40.65% respectively).

The iron contents in the taro from Chad were greatly higher than previously mentioned (from 27 to 37 mg/kg DM [16]). An immediate and significant decrease of the iron concentration during the 3 soaking processes was evidenced (figure 10). The most important decrease was observed with the water treatment (from 144 mg/kg DM for the control to 89 mg/kg DM after 24 hours) and with the corn solution treatment (from 144 mg/kg DM to 87 mg/kg DM after 24 hours) corresponding to iron losses of 38.2% and 39.6% respectively. The lower loss was observed with the tamarind infusion (from 144 mg/kg DM to 99 mg/kg DM after 24 hours) corresponding to an iron loss of 31.2%. There was a significant difference (P < 0.001) between these three processes. These results clearly showed that soaking over a period of 24 hours induced a widespread dissemination of iron (between 30% and 40%) in the soaking solutions. Previously, SAHARANE et al. [15] reported that the soaking led to a reduction of concentrations in minerals (including the iron) which diffuse in the soaking medium. LESTIENNE et al. [11] have shown that the soaking of seeds from cereals and legumes for 24 hours in the water has induced a reduction of the content of seed phytates, leading to a better availability of the bivalent cations, and at the same time widespread iron dissemination. The rather high contents of phytates in the taro corms might be a real problem for the availability of iron or other bivalent cations. The supposed positive effect of soaking on the phytate contents [8] should be further investigated in comparison with the diffusion and the consequent iron loss in the soaking solutions.

The zinc content of the Chadian taro corms (178 mg/kg DM for the control) was very high in comparison with the requirements of most animal species but in accordance with the previous references (170-280 mg/kg DM in SEFA-DEDEH et al. [16]) and lower than the zinc content of Xanthosoma species (from 200 to 510 mg/kg DM in SEFA-DEDEH et al. [16]). The soaking in water or in the tamarind infusion did not significantly alter the zinc content of the taro chips (respectively 217 and 238 mg/kg DM after 24 hours of soaking) but the infusion with corn caused a significant (P < 0.001) decline of the zinc content (135 mg/kg DM after 24 hours of soaking) compared to the control sample and to the 2 other soaking processes (tamarind infusion and water treatment).

As a conclusion, the traditional sun drying used in the region of Mayo-Kebbi (Chad) after the soaking of taro chips significantly reduced the water content of the product (3.70 to 5.67%) and allows a long term preservation without risk of microbial development. The taro samples that had grown in that district of Chad were rich in crude fibre, calcium, sodium, magnesium and iron than the previous references. The contents of proteins, phosphorus, potassium and zinc were in accordance with the literature. In general, the soaking process induced significant losses of all studied parameters.
except proteins for the water and the corn infusions, crude fibres in the tamarind infusion, phosphorus in the corn infusion and zinc in the water and the tamarind infusions. The decrease of the protein content in the tamarind solution could be due to the pH of the solution that could improve the solubilisation of low molecular weight proteins. The stability of the crude fibres using the tamarind solution could be the consequence of the mucilage solubilisation that would induce a lower microbial activity of the solution. The increased phosphorus content in the corn solution could be due to hydrolysis of the corn phytates during the preparation of the soaking solution, leading to phosphorus absorption by the taro chips during the soaking period. The sodium increases with all treatments could be due to the quality of the water: in this Chad area, the water is often naturally rich in sodium carbonate. Finally, the considerable iron loss would be related to the high solubility of this trace metal in tubers whereas zinc was much less soluble.

References