CHAPTER 4

Effect of cooking on the mineral contents and anti-nutritional factors in seven accessions of *Colocasia esculenta* (L.) Schott growing in South Africa
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EFFECT OF COOKING ON THE MINERAL CONTENTS AND ANTI-
NUTRITIONAL FACTORS IN SEVEN ACCESSIONS OF COLOCASIA
ESCULENTA (L.) SCHOTT GROWING IN SOUTH AFRICA*

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Effect of cooking on the mineral contents and anti-nutritional factors in seven accessions of *Colocasia esculenta* (L.) Schott growing in South Africa

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Abstract

*Colocasia esculenta* (L.) Schott (coco Yam) is cultivated primarily for its edible tubers. The effect of cooking the tubers on the mineral and antinutrient compositions of seven accessions (UFCe1 - Ufce7) of the crop growing in South Africa was investigated. Analysis of mineral elements showed a general decrease in the mean values of cooked samples, especially phosphorus, calcium, potassium and zinc. Manganese was not detected in all the accessions studied while iron was sparingly detected in cooked accessions Ufce2, Ufce3 and Ufce5. Potassium and magnesium contents were reasonably high. The results further portray the accessions as good sources of potassium, magnesium, sodium and calcium, whose salts regulate the acid-base balance of the body. Boiling markedly reduced the level of the anti-nutritional factors, thereby improving the food quality.

**Keywords:** Accession, antinutrients, coco Yam, *Colocasia esculenta*, effects of cooking, mineral composition.

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Introduction

*Colocasia esculenta* (L.) Schott commonly known as *Taro* is closely related to *Xanthosoma sagittifolium* (L.) Schott, which is generally referred to as *Tannia*. These species are tropical root crops widely known as cocoyams. They are used as subsistence staples in many parts of the tropics and sub-tropics in Africa. Cocoyams are grown primarily for their edible starch storage corms and cormels called tubers, and secondarily as a leafy vegetable (Aregheore and Perera, 2003).

Nutritionally, the tubers supply easily digestible starch and are known to contain substantial amounts of protein, vitamin C, thiamine, riboflavin and niacin (Niba, 2003). The main nutrient supplied by cocoyam, as with other roots and tubers, is dietary energy provided by the carbohydrates. The leaves are also important sources of proteins and vitamins (Purseglove, 1972). Like other roots and tubers, it is deficient in most other vitamins and minerals but contain significant amounts of dietary fiber (Niba, 2003). The anti-nutritional factors found in taro cocoyam include oxalates, proteinase inhibitors, phytates, tannins, alkaloids, steroids and cyanogenic glucosides (Oke, 1965; Bassir, 1969). All parts of the raw *taro* plant are characterized by the presence of needle-like, calcium oxalate crystals (raphides), which must be destroyed by thorough cooking before eating (Noonan and Savage, 1999). The resulting sharp irritation and burning sensation experienced in the mouth and throat when cooked tubers are eaten is a major limiting factor to the consumption of this crop, and this is due to the presence of an irritant (a protease) on the raphides. The protein at the end of calcium oxalate crystals or diglucoside of 3,4- dihydroxybenzaldehyde, which is an irritant, brings about the discomfort or acridity (Sakai, 1979; Bradbury and Holloway, 1988).
In order to reduce the effect of antinutrients, which may have some health-hazard potentials, proper processing before consumption is necessary. Cooking improves digestibility, promote palatability, improves keeping quality, and also makes root crops safer to eat (FAO, 1990). However, cooking may reduce the nutritive value of root crops as a result of losses and changes in major nutrients during cooking (FAO, 1990). Akpan and Umoh (2004) observed a general decrease in the mineral contents when corms of *X. sagittifolium* were cooked for two hours. Whereas, cooking could also be effective in reducing the anti-nutritional factors in foods (Crabtree and Baldry 1982; Sakai, 1979, 1983), thus making foods safe for consumption. As reported by Iwuoha and Kalu (1995), boiling resulted in a marked reduction in calcium oxalate contents when three cultivars of *C. esculenta* flours were compared for calcium oxalate and some physicochemical properties.

Cocoyams, though widely cultivated in the tropical and subtropical areas, are relatively neglected in South Africa. Although the species have been cultivated for centuries in some remote parts of KwaZulu-Natal Province where they are collectively referred to as *Amadumbe*, the crop is not commercially popular in South Africa. This is in contrast with Asia, the Pacific and other African countries, where cocoyam is a commercialized staple food (Miyasaka *et al.*, 2003). Consequently, to the best of our knowledge, there is very little information on scientific research carried out on cocoyam in South Africa.

The aim of this study, therefore, was to establish the mineral and antinutrient contents of some cooked and uncooked *C. esculenta* tubers growing in South Africa and compare the information among the different accessions under study. The knowledge obtained from this study could be useful in elucidating the complete nutritional information of these tubers when combined with the results obtained from previous work on the proximate composition of these accessions (Lewu *et al.*, 2009a).
Materials and methods

Seven accessions (UFCe1 - UFCe7) of cocoyam (Colocasia esculenta) tubers (cormels) were used for this study. The accessions were collected from seven farmers’ fields located in four different villages (Umbumbulu, Makhathini, Mthwalume and Maphumulo) in KwaZulu-Natal Province, South Africa. The tubers were peeled, washed in distilled water, sliced into thin pieces and air-dried. Each sample was then separated into two equal portions of known weights. A portion from each accession was cooked by boiling at 100°C for 20 min and later air-dried (25°C and 71% relative humidity) on trays for 20 min. 800g (wet weight of peeled tubers) of each accession was used. Each sample was then separated into two equal portions (400g each). A portion from each accession was separately cooked in glassware by boiling in about 3.5 L of distilled water at 100°C for 20 min and later air-dried as before. Both the cooked and uncooked portions were further oven-dried at 60°C to constant weight. The moisture contents of the samples were determined according to the standard method of the Association of Official Analytical Chemists (AOAC, 1984); where moisture loss after oven-drying / initial weight of the sample, multiply by 100 gives the percentage moisture content in the sample.

The dried samples were separately milled, passing through a 0.5 mm sieve, using a Fritsch pulverisette 14® Rotor-Speed mill (Fritsch GMBH, Laborgeraetebau, Germany). The milled samples were stored in well labelled air-tight containers prior to the determination of their mineral and antinutrient compositions. All reagents used for these analyses were of analytical grade.

Chemical Analyses

A mixture of concentrated H₂SO₄, a catalyst (selenium), salicylic acid and hydrogen peroxide were used as reagents for sample digestion. Selenium-sulphuric acid mixture was prepared by
dissolving 3.5 g selenium powder in 1000 ml of concentrated sulphuric acid. The mixture was then heated at 300ºC until the original blackish colour of selenium suspension turns via green/blue to light yellow. A digestion mixture was also prepared by dissolving 7.2 g salicylic acid in 100 ml of selenium-sulphuric acid mixture. Thereafter, 0.3 g sample was added to 2.5 ml of the digestion mixture, heating at 110ºC for 1 h. Hydrogen peroxide was later added; heating now at 330ºC until the colour turned colourless or light yellow. The digest was cooled and made up to 50 ml. Subsequently, phosphorus, calcium, magnesium, sodium, Potassium, zinc, copper, iron and manganese in the digests were determined (Okalebo et al., 2002).

The mineral element composition was determined using the Unicam Solaar Atomic Absorption Spectrophotometer (AAS) – (Model 969 Mk II; Unicam Ltd., Cambridge, UK). Potassium, sodium, magnesium and calcium contents were determined by reading their absorbance at 766.5, 589.0, 285.2 and 422.7 nm wavelengths respectively while the copper, manganese, zinc and iron contents were measured at 324.8, 279.5, 213.9 and 248.3 nm wavelengths respectively. Total phosphorus was obtained using the ascorbic acid blue colour procedure of Okalebo et al. (2002) by reading the absorbance at a wavelength of 880 nm on a Helios Gamma spectrophotometer (Thermo Spectronic; Helios Gamma, UK).

The calcium oxalate content was determined using the method of Ukpabi and Ejidoh (1989) which was employed by Iwuoha and Kalu (1995). This involves the digestion of the sample, precipitation of the oxalate contained in the sample to remove ferrous ions on addition of ammonium hydroxide solution and then titration against permanganate solution (0.05M KMnO₄) to a faint pink colour, which persisted for 30 seconds. Tannins were determined by the method of Markkar et al. (1993) using 70% acetone, Lowry reagent, 20% sodium carbonate and tannic acid (standard) as reagents. 0.2g sample was soaked in 10 ml of 70%
acetone, placing it in iced water bath and then shaken for 12 min to extract the tannin. 0.5 ml each of distilled water, 0.5 ml of Lowry reagent followed by 2.5 ml of 20% sodium carbonate was added to the filtrate respectively. This was allowed to stand for 40 min at room temperature. Later the absorbance was read at 700 nm on a colorimeter against a reagent blank. Phytate was determined using Wheeler and Ferrel (1971) method. 4g sample was soaked in 100 ml of 2% hydrochloric acid for 3 h and then filtered. 5 ml of 0.3% ammonium thiocyanate solution was added to 25 ml of the filtrate. 53.5 ml of distilled water was also added to the mixture. This was then titrated against a standard iron (III) chloride solution until a brownish yellow colour persisted for 5 min. The phytate content was calculated from the iron determinations, using a 4:1 iron-to-phytate molecular ratio.

**Statistical Analysis**

All determinations were replicated thrice. The data obtained were subjected to analysis of variance (ANOVA) using the SAS (1999) package. Analysis was conducted in a factorial arrangement where cooking and accessions were the main factors at 2 and 7 levels respectively; and differences within and between factor means were tested using Duncan multiple range test.

**Results and Discussion**

**Mineral composition**

The results of the mineral compositions of these tubers are presented in Table 1. In general, boiling for 20 min led to significant reduction in most of the minerals, especially phosphorus, calcium, potassium and zinc. This was also supported by the findings of Akpan and Umoh (2004) where the mineral composition of *X. sagittifolium* corms dropped significantly after cooking. However, there was no significant difference in magnesium, sodium and copper
contents after boiling. Potassium and magnesium contents were reasonably high. Sodium, calcium and zinc were also present in significant amounts while copper was found in trace amounts.

Manganese content could not be detected in all the accessions studied while iron was sparingly detected in cooked samples of accessions UFCe2, UFCe3 and UFCe5. This indicated that the *C. esculenta* tubers currently being studied are not good sources of iron and manganese. This result is supported by our previous studies where cooking slightly increased the iron levels in boiled leaves of *C. esculenta* (Lewu et al., 2009b). Likewise, cooking brought about a significant increase in the availability of iron in cocoyam tubers [Lewu et al., (in press)]. The results further portray the accessions as good sources of potassium, magnesium, sodium and calcium, whose salts regulate the acid-base balance of the body. The consumption of such micronutrient-rich foods helps in building a strong immune system, thereby helping the body to absorb, utilize and digest required body nutrients (Njoku and Ohia, 2007). The study reveals high values of potassium which makes it the most abundant mineral element, and, this result agrees with the findings of Akpan and Umoh (2004) and FAO (1990). High dietary potassium in humans plays a protective role against hypertension, stroke, cardiac dysfunctions, renal damage, hypercalciuria, kidney stones, and osteoporosis (Demigne *et al.*, 2004).

**Antinutrient contents**

Table 2 shows the level of calcium oxalate, phytate and tannins in the cooked and uncooked *C. esculenta* tubers. When compared with the uncooked accessions, cooking resulted in a general reduction in the levels of these anti-nutrients.
Oxalic acid ($\text{H}_2\text{C}_2\text{O}_4$) is in the form of soluble oxalic acid and insoluble oxalate salts (Huang and Tanudjaja 1992). Oxalates have been implicated as a mechanical defence mechanism, storage reserves and stores of excess calcium (Raven and Smith, 1976; Sunnel and Healey, 1979; Smith, 1982). The levels of calcium oxalate in uncooked tubers varied widely between accessions and ranged from 265.23 to 552.45 mg/100g DM. The lowest oxalate content was recorded in accession UFCe3, while UFCe6 gave the highest value. Reduction in the levels of oxalate following boiling may be due to its solubility in hot water. Boiling may cause considerable skin rupture and facilitate the leakage of soluble oxalate into cooking water (Albihn and Savage, 2001). Catherwood et al. (2007) observed that boiling for 40 min brought about significant reduction in the concentration of soluble oxalate in four cultivars of Japanese *taro*. In another study, boiling for 60 min completely removed the irritant effect (calcium oxalate) of the species (Iwuoha and Kalu, 1995), indicating that irritation and itching caused by the acridity factor may not be observed when cocoyam is thoroughly cooked (Agwunobi et al., 2000). The mean values ranging from 265.23 to 552.45mg/100g DM of calcium oxalate obtained for uncooked tubers is comparable with 317.00 – 435.80 mg/100 g DM reported for raw taro corms from four Provinces in Thailand (Jirarat et al., 2006). It is also documented that oxalate content varies with species and cultivars (Osisiogu et al., 1974). Heat treatment or cooking has been found to be an effective measure in reducing the oxalate levels in these tubers, thus, rendering the food prepared from these accessions safe for human consumption (Ndimantang et al., 2006). This is particularly beneficial because oxalic acid and its salts can have deleterious effects on human nutrition and health, mainly by decreasing calcium absorption and aiding the formation of kidney stones (Noonan and Savage, 1999).
Tannins form complexes with proteins and reduce their digestibility and palatability (Eka, 1985). Reduction of tannin content in *C. esculenta* tubers through cooking is expected to improve its nutritional value. From the result obtained in this study, boiling resulted in the reduction in tannic acid in all the tuber samples with the highest concentration seen in raw UFCe7 while the lowest amount was recorded in accession UFCe1. This agrees with the findings of Onu and Madubuike (2006) when boiling was found to be effective in removing the anti-nutritional substances in raw wild cocoyam (*Caladium bicolor*) corms.

Phytate, a general term used to describe hexaphosphate esters of inositols, are naturally occurring substances found in a variety of plant seeds and in many roots and tubers (Harland and Oberleas, 1986). Phytales bind minerals in the gastrointestinal tract, making dietary minerals unavailable for absorption and utilization by the body (Oberleas, 1983). It markedly decreases calcium bioavailability and forms calcium-phytate complexes that inhibit the absorption of Fe and Zn (Sirkka, 1997). The levels of phytate in uncooked *C. esculenta* tubers in the current study ranged from 36.83 to 70.67 mg/100gDM. Accession UFCe2 recorded the highest level of phytate, while accession UFCe3 had the least. The general reduction in phytate contents with cooking further confirms that cooking could lower the phytate levels in several plant foodstuffs (Reddy et al., 1982; Vijayakumari et al., 1997; Saikia et al., 1999; Badifu, 2001). These results were similar to those observed by Marfo and Oke (1988) where cooking resulted in a decrease of 62%, 65% and 68% in yam, cocoyam and cassava respectively. In many cases, phytic acid content may vary depending on the crop variety, climatic conditions, location, irrigation conditions, type of soil, and the growing season of the plant (Deshpande et al., 1982).

In conclusion, the reduction in antinutrient levels due to cooking is expected to enhance the food quality of these tubers. Cooking also reduces the undesirable components of the species, particularly calcium oxalate which is one of the factors implicated in acridity. Though the
concentrations of the anti-nutritional factors studied in these accessions were found to be high in uncooked tubers, this should not pose a problem in human consumption if the tubers are properly cooked. However, there was also a reduction in some mineral elements due to cooking. Therefore, supplementation of these minerals from other sources is deemed necessary.

In addition, no tubers of the accessions studied proved to be outstandingly better than the others based on their mineral compositions. However, in terms of antinutritional factors, UFCe1, UfCe3 and UfCe7 had the least amounts of oxalate, tannins and phytate in their cooked states. Based on this result, cooked tubers of these three accessions could be recommended as being relatively safe for human consumption due to very low levels of antinutrients contained in them.

Acknowledgements

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Table 1. Elemental composition of seven accessions of cocoyam (*Colocasia esculenta* (L.) Schott) tubers. Data are in $\bar{X}$ ± S.D.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Phosphorus (mg/100g dry matter)</th>
<th>Calcium (mg/100g dry matter)</th>
<th>Magnesium (mg/100g dry matter)</th>
<th>Sodium (mg/100g dry matter)</th>
<th>Potassium (mg/100g dry matter)</th>
<th>Iron (mg/100g dry matter)</th>
<th>Copper (mg/100g dry matter)</th>
<th>Manganese (mg/100g dry matter)</th>
<th>Zinc (mg/100g dry matter)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UFCe1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncooked</td>
<td>9.36±0.63$^{D*}$</td>
<td>33.71±0.49$^{A}$</td>
<td>344.23±32.20$^{A}$</td>
<td>84.81±9.24$^{B}$</td>
<td>321.99±23.35$^{D*}$</td>
<td>-----</td>
<td>0.38±0.14$^{DE}$</td>
<td>-----</td>
<td>10.81±0.77$^{F}$</td>
</tr>
<tr>
<td>Cooked</td>
<td>6.43±0.40$^{E}$</td>
<td>23.28±3.18$^{abc}$</td>
<td>317.47±26.36$^{bc}$</td>
<td>117.08±9.61$^{A}$</td>
<td>220.77±61.16$^{abc}d$</td>
<td>-----</td>
<td>0.63±0.03$^{b}$</td>
<td>-----</td>
<td>9.10±0.42$^{f}$</td>
</tr>
<tr>
<td><strong>UFCe2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncooked</td>
<td>13.74±0.53$^{B*}$</td>
<td>27.58±1.17$^{C}$</td>
<td>350.07±7.74$^{A}$</td>
<td>95.33±32.06$^{AB}$</td>
<td>315.63±66.76$^{D}$</td>
<td>-----</td>
<td>1.40±0.18$^{A*}$</td>
<td>-----</td>
<td>71.12±2.69$^{A}$</td>
</tr>
<tr>
<td>Cooked</td>
<td>11.12±0.58$^{b}$</td>
<td>19.64±2.37$^{cd}$</td>
<td>349.48±30.98$^{ab}$</td>
<td>80.22±9.48$^{bc}$</td>
<td>161.93±3.34$^{d}d$</td>
<td>0.54±0.18$^{b}$</td>
<td>1.06±0.09$^{a}$</td>
<td>-----</td>
<td>65.72±0.79$^{a}$</td>
</tr>
<tr>
<td><strong>UFCe3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncooked</td>
<td>9.01±0.44$^{D}$</td>
<td>33.78±0.62$^{AB}$</td>
<td>359.13±31.97$^{A}$</td>
<td>120.88±24.82$^{A}$</td>
<td>368.46±52.92$^{D*}$</td>
<td>-----</td>
<td>0.23±0.13$^{E}$</td>
<td>-----</td>
<td>24.06±3.97$^{D*}$</td>
</tr>
<tr>
<td>Cooked</td>
<td>7.81±0.20$^{d}$</td>
<td>27.84±0.70$^{a}$</td>
<td>380.27±32.46$^{a}$</td>
<td>101.42±23.76$^{ab}$</td>
<td>174.52±19.63$^{cd}$</td>
<td>5.17±0.69$^{a}$</td>
<td>0.58±0.10$^{bc}$</td>
<td>-----</td>
<td>9.15±1.17$^{f}$</td>
</tr>
<tr>
<td>UFCe4</td>
<td>Uncooked</td>
<td>Cooked</td>
<td>UFCe5</td>
<td>Uncooked</td>
<td>Cooked</td>
<td>LSD: Uncooked</td>
<td>LSD: Cooked</td>
<td></td>
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<tr>
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</tr>
<tr>
<td></td>
<td>20.83±0.63^A^</td>
<td>28.10±1.66^BC^</td>
<td>327.84±31.53^AB^</td>
<td>51.18±5.35^CD^</td>
<td>783.73±59.13^A^</td>
<td>------</td>
<td>1.11±0.08^BC^</td>
<td>---</td>
<td>17.27±0.07^E^</td>
</tr>
<tr>
<td>Cooked</td>
<td>13.59±0.23^a^</td>
<td>16.33±1.05^e^</td>
<td>289.34±10.03^c^</td>
<td>67.45±23.44^bc^</td>
<td>257.82±38.00^ab^</td>
<td>------</td>
<td>0.96±0.06^a^</td>
<td>---</td>
<td>16.54±0.21^e^</td>
</tr>
<tr>
<td>UFCe5</td>
<td>Uncooked</td>
<td>Cooked</td>
<td>Uncooked</td>
<td>Cooked</td>
<td>LSD: Uncooked</td>
<td>LSD: Cooked</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncooked</td>
<td>10.48±0.15^C^</td>
<td>352.58±10.82^A^</td>
<td>76.04±12.40^BC^</td>
<td>396.18±26.00^CD^</td>
<td>------</td>
<td>0.61±0.03^D^</td>
<td>---</td>
<td>25.00±2.33^D^</td>
<td></td>
</tr>
<tr>
<td>Cooked</td>
<td>8.83±0.30^c^</td>
<td>24.80±2.60^ab^</td>
<td>327.18±18.35^bc^</td>
<td>75.50±32.83^bc^</td>
<td>199.28±61.99^bcd^</td>
<td>------</td>
<td>0.22±0.18^d^</td>
<td>---</td>
<td>19.36±2.97^d^</td>
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<tr>
<td>UFCe6</td>
<td>Uncooked</td>
<td>Cooked</td>
<td>Uncooked</td>
<td>Cooked</td>
<td>LSD: Uncooked</td>
<td>LSD: Cooked</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncooked</td>
<td>10.93±0.62^C^</td>
<td>28.54±4.00^BC^</td>
<td>297.73±29.40^B^</td>
<td>70.14±12.77^BCD^</td>
<td>555.97±137.53^BC^</td>
<td>------</td>
<td>1.26±0.21^AB^</td>
<td>---</td>
<td>54.14±0.84^B^</td>
</tr>
<tr>
<td>Cooked</td>
<td>9.24±0.33^c^</td>
<td>21.07±3.97^bc^</td>
<td>305.43±17.77^c^</td>
<td>69.17±12.38^bc^</td>
<td>285.04±12.39^a^</td>
<td>------</td>
<td>1.03±0.12^a^</td>
<td>---</td>
<td>44.89±1.44^b^</td>
</tr>
<tr>
<td>LSD: Uncooked</td>
<td>0.864</td>
<td>3.8801</td>
<td>32.92</td>
<td>29.473</td>
<td>170.37</td>
<td>------</td>
<td>0.2687</td>
<td>---</td>
<td>4.4041</td>
</tr>
<tr>
<td>LSD: Cooked</td>
<td>0.6333</td>
<td>4.4421</td>
<td>36.137</td>
<td>34.101</td>
<td>69.404</td>
<td>2.2417</td>
<td>0.247</td>
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<td>2.1426</td>
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</table>

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Values with different uppercase letters within the same column show significant differences \((P<0.05)\) among uncooked accessions, values with different lowercase letters within the same column show significant differences among cooked accessions, values with * within the same column show significant differences among treatments (cooked and uncooked) of the same accession \((P<0.05)\), --- = not detected while LSD = Least Significant Difference. Data were mean of three determinations (n=3).
Table 2. Antinutrient composition of seven accessions of cocoyam (*Colocasia esculenta* (L.) Schott) tubers. Data are in $\bar{X} \pm$ S.D.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Calcium oxalate</th>
<th>Tannin</th>
<th>Phytate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Composition (mg/100g dry matter)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>UFCe1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncooked</td>
<td>268.89±7.11$^{C*}$</td>
<td>495.00±26.90$^{E*}$</td>
<td>40.33±4.51$^{C*}$</td>
</tr>
<tr>
<td>Cooked</td>
<td>210.35±7.67$^{d}$</td>
<td>302.08±28.18$^{e}$</td>
<td>25.33±2.52$^{d}$</td>
</tr>
<tr>
<td><strong>UFCe2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncooked</td>
<td>545.79±12.47$^{A*}$</td>
<td>1433.96±16.73$^{B*}$</td>
<td>70.67±2.08$^{A*}$</td>
</tr>
<tr>
<td>Cooked</td>
<td>405.17±6.95$^{e}$</td>
<td>666.67±65.05$^{b}$</td>
<td>47.83±2.52$^{e}$</td>
</tr>
<tr>
<td><strong>UFCe3</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncooked</td>
<td>265.23±11.99$^{C*}$</td>
<td>768.75±84.55$^{D}$</td>
<td>36.83±0.58$^{C*}$</td>
</tr>
<tr>
<td>Cooked</td>
<td>140.24±7.94$^{e}$</td>
<td>468.75±70.99$^{d}$</td>
<td>23.83±1.53$^{f}$</td>
</tr>
<tr>
<td></td>
<td>Uncooked</td>
<td>Cooked</td>
<td>LSD: Uncooked</td>
</tr>
<tr>
<td>---------------</td>
<td>------------</td>
<td>----------</td>
<td>---------------</td>
</tr>
<tr>
<td><strong>UFCe4</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncooked</td>
<td>408.51±18.56&lt;sup&gt;B&lt;sup&gt;+&lt;/sup&gt;&lt;/sup&gt;</td>
<td>1410.42±65.05&lt;sup&gt;B&lt;sup&gt;+&lt;/sup&gt;&lt;/sup&gt;</td>
<td>21.452</td>
</tr>
<tr>
<td>Cooked</td>
<td>274.56±15.28&lt;sup&gt;c&lt;/sup&gt;</td>
<td>604.17±61.34&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>18.181</td>
</tr>
<tr>
<td><strong>UFCe5</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncooked</td>
<td>535.79±11.90&lt;sup&gt;A&lt;sup&gt;+&lt;/sup&gt;&lt;/sup&gt;</td>
<td>1379.17±84.86&lt;sup&gt;BC&lt;sup&gt;+&lt;/sup&gt;&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Cooked</td>
<td>411.84±9.81&lt;sup&gt;a&lt;/sup&gt;</td>
<td>841.67±41.62&lt;sup&gt;a&lt;/sup&gt;</td>
<td>32.50±1.00&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>UFCe6</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncooked</td>
<td>552.45±13.43&lt;sup&gt;A&lt;sup&gt;+&lt;/sup&gt;&lt;/sup&gt;</td>
<td>1302.08±93.61&lt;sup&gt;C&lt;sup&gt;+&lt;/sup&gt;&lt;/sup&gt;</td>
<td>60.33±2.52&lt;sup&gt;B&lt;sup&gt;+&lt;/sup&gt;&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cooked</td>
<td>267.89±7.93&lt;sup&gt;c&lt;/sup&gt;</td>
<td>552.50±46.89&lt;sup&gt;cd&lt;/sup&gt;</td>
<td>29.67±0.58&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td><strong>UFCe7</strong></td>
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<td></td>
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</tr>
<tr>
<td>Uncooked</td>
<td>418.51±13.90&lt;sup&gt;B&lt;sup&gt;+&lt;/sup&gt;&lt;/sup&gt;</td>
<td>1518.75±51.16&lt;sup&gt;A&lt;sup&gt;+&lt;/sup&gt;&lt;/sup&gt;</td>
<td>55.33±3.51&lt;sup&gt;B&lt;sup&gt;+&lt;/sup&gt;&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cooked</td>
<td>329.87±13.37&lt;sup&gt;b&lt;/sup&gt;</td>
<td>239.58±72.44&lt;sup&gt;e&lt;/sup&gt;</td>
<td>25.33±2.52&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>LSD: Uncooked</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSD: Cooked</td>
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<td></td>
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</table>
Values with different uppercase letters within the same column show significant differences (P<0.05) among uncooked accessions, values with different lowercase letters within the same column show significant differences among cooked accessions, while values with * within the same column show significant differences among treatments (cooked and uncooked) of the same accession (P<0.05) while LSD = Least Significant Difference. Data were mean of three determinations (n=3).