Effect of cooking on the proximate composition of seven accessions of Colocasia esculenta (L.) Schott tubers growing in South Africa

Muinat N. Lewu a; Patrick O. Adebola b; Anthony J. Afolayan a

a Department of Botany, University of Fort Hare, Alice, South Africa
b Plant Breeding Division, ARC-Vegetable and Ornamental Plant Institute, Pretoria, South Africa

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Effect of cooking on the proximate composition of seven accessions of *Colocasia esculenta* (L.) Schott tubers growing in South Africa

MUINAT N. LEWU¹, PATRICK O. ADEBOLA² & ANTHONY J. AFOLAYAN¹

¹Department of Botany, University of Fort Hare, Alice, South Africa, and ²Plant Breeding Division, ARC-Vegetable and Ornamental Plant Institute, Pretoria, South Africa

Abstract

*Colocasia esculenta* (L.) Schott (cocoym) is cultivated mainly for its edible tubers. The effect of cooking the tubers on the proximate composition of seven accessions (UFCe1–UFCe7) of the crop growing in South Africa was investigated. When compared with the uncooked, the ash and crude fibre contents of the accessions significantly decreased after cooking. The moisture content, crude protein, crude lipid, carbohydrate and caloric contents increased with cooking in all the accessions, except UFCe1 and UFCe5 where the crude lipid content reduced. The results indicate that cooking enhanced the carbohydrate, energy and protein contents of the tubers. They further showed that the tubers could be used for allergic infants, old people and invalids since the fibre contents were still appreciably high despite the slight reduction after cooking the tubers.

Keywords: *Colocasia esculenta*, cocoym, proximate composition, accession

Introduction

*Colocasia esculenta* (L.) Schott, an edible aroid commonly known as Taro cocoym, is cultivated mainly for its edible corms or cormels called tubers. The leaves are also consumed as a vegetable (Aregheore and Perera 2003). It is an important staple crop throughout the tropical and subtropical regions of the world, particularly in Asia and the Pacific Islands. *C. esculenta* has a close relative known as *Xanthosoma sagittifolium* (L) Schott, which is commonly referred to as Tania. Both edible aroids are generally cultivated for the same purpose.

Owing to the emphasis placed on the nutritional value of food by consumers, there is a great need for information on the nutritional composition of this crop. Several workers have investigated the chemical composition of cocoym, and observed that it has a high nutritional value (Onayemi and Nwigwe 1987; Niba 2003). The crop is an important source of good-quality carbohydrate with readily digestible starch, minerals, vitamins and essential amino acids (Hussain et al. 1984; Lyonga and Nzietchueng 1986; Onayemi and Nwigwe 1987). Its protein content is higher than that of many other tuber crops, such as cassava and yam (Hussain et al. 1984).
Coursey (1968) revealed that the compositions of food commodities are dependent on the variety, location, season, method of processing and storage. This was supported by the observed differences in the nutritional composition of 32 cultivars of *X. sagittifolium* and *C. esculenta* (Agbor-Egbe and Richard 1990).

Cooking has been reported to improve digestibility, promote palatability, improve keeping quality, and also makes root crops safer to eat (FAO, 1990). However, cooking may reduce the nutritional value of root crops as a result of losses and changes in major nutrients during cooking (FAO, 1990). Typical is the loss in some minerals when yam and potato are baked, boiled or steamed (Bradbury and Holloway 1988).

In South Africa, however, cocoyams—are collectively referred to as *Amadunbe*—are not well known. Although they have been cultivated for centuries in some remote parts of KwaZulu-Natal Province in association with other indigenous food crops like sweet potatoes, landrace potatoes and green beans, cocoyams have remained relatively obscure in the nation. Unlike Asia, the Pacific and other African countries, where cocoyam is a popular commercialized staple (Jacobs and Clarke 1993; Miyasaka et al. 2003; Srikanta et al. 2003; Zárate et al. 2003; Yang and Yeh 2005), the crop is not commercially popular in South Africa; hence there is very little information on scientific research on the crop.

Since this crop is always eaten cooked, there is the need for an investigation into the effect of cooking on the proximate composition of cocoyam tubers growing in South Africa. Seven accessions of cocoyams were investigated in this study in order to verify possible differences in the cooking performance of different accessions of the species.

Materials and methods

Seven accessions of cocoyam (*C. esculenta*) tubers (cormels) named University of Fort Hare *C. esculenta* 1 to 7 (UFCe1–UFCe7) were collected in August (winter) 2007 and 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. (Seven fields were sampled because those were the areas where we had contacts and the farmers were also ready for their farms to be sampled.) 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. Both the cooked and uncooked portions were further oven-dried at 60°C to constant weight. The dried samples were separately milled using a Fritsch pulverisette 14® Rotor-Speed mill (Fritsch GMBH, Laborgeraetebau, Germany). The milled samples were stored in well labelled air-tight containers for the determination of their proximate compositions.

All reagents used were of analytical grade. The moisture, dry matter, ash, crude lipid and crude fibre contents of the cocoyam accessions were determined according to the method of the Association of Official Analytical Chemists (1984). Crude protein (N × 6.25) was obtained using 0.1 g sample and was subsequently determined on the LECO® TruSpec® CN carbon/nitrogen determinator (Leco Corporation, TruSpec C/N Determinator, Michigan, USA). The carbohydrate content was obtained using estimation by difference. The caloric value of each sample was obtained as the sum of the products of crude protein, crude lipid and
carbohydrate by their respective Atwater factors (4, 9 and 4). All analyses were replicated three times.

The data obtained were subjected to analysis of variance using the SAS (1999) package, and the means were tested with the Duncan multiple range test.

**Results and discussion**

When compared with the uncooked accessions of cocoyam tubers, cooking resulted in a decrease in ash and crude fibre contents as shown in Table I. In contrast, the moisture content, crude protein, crude lipid, carbohydrate and energy contents of all the accessions of the cocoyam tubers were significantly made more available after cooking, except in accessions UFCe1 and UFCe5 where the crude lipid contents dropped significantly. In all, accession UFCe7 had the highest moisture, ash, protein, crude fibre and crude lipid contents, while its carbohydrate and energy contents were the lowest.

The amount of ash in food is an indication of its mineral content. The reduction in ash content obtained in this study after cooking shows that the potential of these tubers for supplying essential minerals in human diets could be reduced by cooking (FAO, 1990). The value of crude fibre content obtained in this work was higher than those reported for potato, sweet potato and yam (Bradbury and Holloway 1988). This result confirms that cocoyam is a good source of fibre when compared with other root and tuber crops (Bradbury and Holloway 1988). The high fibre contents of the accessions of cocoyam studied in this work highlight their superiority with regard to good digestion when consumed (Sotozono 1989). Cocoyam-based foods can therefore be given to allergic infants, old people, persons with gastro-intestinal disorders and invalids because of the small particle size of its starch, which makes it readily digestible (Hussain et al. 1984; Lyonga and Nzietchueng 1986). The moisture contents of 69–79% obtained for the accessions in the current study compared well with the 63–85% reported for *taro* and *tannia* by Bradbury and Holloway (1988). High moisture content enhances microbial attack. The high moisture content observed in the accessions may further explain why post-harvest loss due to spoilage is always high for cocoyam (Passam 1982). The increase in the availability of protein after cooking might be due to the tannin–protein complex, which was destroyed by cooking. Tannins have been reported to form complexes with protein, thereby limiting protein availability (Eka 1985). Roots and tuber crops including cocoyam are generally low in protein; hence, food products from these crops should be supplemented with other high-protein products for balanced nutrition (Bradbury 1988). The high crude protein content of accession UFCe7 (17.03%), compared with the approximate 10% in potato (Diviš et al., 2007), is particularly interesting. This accession may not need fortification with other sources of protein products. However, wide variations in crude protein contents (7.86–17.03%) observed among the accessions in this study may be due to the genotype and growing conditions (Debre and Brindza 1996). Interestingly, cooking increased the lipid content in most of these tubers. The slight increase in lipid in this case, notwithstanding, may not pose any problem since it is an established fact that the lipid in cocoyam is generally low (Mondy and Mueller 1977), which makes it beneficial for weight control. The low crude lipid content is consistent with the findings of Mondy and Mueller (1977) that all root crops including cocoyam exhibit very low lipid contents (before and after cooking).
Table I. Proximate composition of seven accessions of Cocoyam (*Colocasia esculenta* (L.) Schott) tubers.

<table>
<thead>
<tr>
<th>Accession</th>
<th>Moisture</th>
<th>Ash</th>
<th>Crude protein</th>
<th>Crude fibre</th>
<th>Crude lipid</th>
<th>Carbohydrate</th>
<th>Caloric value (kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UFCe1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncooked</td>
<td>69.75±1.39\textsuperscript{D}</td>
<td>4.02±0.02\textsuperscript{G*}</td>
<td>9.06±0.29\textsuperscript{D}</td>
<td>3.57±0.10\textsuperscript{C*}</td>
<td>0.76±0.01\textsuperscript{E*}</td>
<td>82.59\textsuperscript{a±0.28}</td>
<td>373.43\textsuperscript{a±0.36}BC</td>
</tr>
<tr>
<td>Cooked</td>
<td>69.75±0.54\textsuperscript{A}</td>
<td>2.98±0.01\textsuperscript{de}</td>
<td>9.92±0.15\textsuperscript{e*}</td>
<td>1.76±0.10\textsuperscript{d}</td>
<td>0.02±0.00\textsuperscript{g}</td>
<td>85.32±0.13\textsuperscript{a*}</td>
<td>381.15±0.39\textsuperscript{d*}</td>
</tr>
<tr>
<td><strong>UFCe2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncooked</td>
<td>69.73±1.22\textsuperscript{D}</td>
<td>4.16±0.03\textsuperscript{F*}</td>
<td>10.99±0.17\textsuperscript{B}</td>
<td>3.94±0.26\textsuperscript{C*}</td>
<td>1.07±0.16\textsuperscript{E}</td>
<td>79.85±0.35\textsuperscript{C}</td>
<td>372.96±1.21\textsuperscript{C}</td>
</tr>
<tr>
<td>Cooked</td>
<td>71.90±0.65\textsuperscript{A}</td>
<td>3.04±0.03\textsuperscript{d}</td>
<td>11.36±0.11\textsuperscript{c}</td>
<td>2.54±0.05\textsuperscript{b}</td>
<td>2.32±0.03\textsuperscript{c*}</td>
<td>80.74±0.19\textsuperscript{e}</td>
<td>389.30±0.25\textsuperscript{b*}</td>
</tr>
<tr>
<td><strong>UFCe3</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncooked</td>
<td>72.21±0.22\textsuperscript{C}</td>
<td>4.88±0.01\textsuperscript{D*}</td>
<td>6.44±0.16\textsuperscript{E}</td>
<td>4.42±0.22\textsuperscript{B*}</td>
<td>1.93±0.01\textsuperscript{C}</td>
<td>82.33±0.33\textsuperscript{A}</td>
<td>372.42±0.92\textsuperscript{C}</td>
</tr>
<tr>
<td>Cooked</td>
<td>72.84±0.70\textsuperscript{c}</td>
<td>3.53±0.02\textsuperscript{c}</td>
<td>7.86±0.16\textsuperscript{c}</td>
<td>2.11±0.16\textsuperscript{c}</td>
<td>2.55±0.05\textsuperscript{b*}</td>
<td>83.93±0.27\textsuperscript{b*}</td>
<td>390.98±1.19\textsuperscript{b*}</td>
</tr>
<tr>
<td><strong>UFCe4</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncooked</td>
<td>69.64±0.53\textsuperscript{D}</td>
<td>6.27±0.04\textsuperscript{B*}</td>
<td>8.84±0.20\textsuperscript{D}</td>
<td>4.53±0.38\textsuperscript{B*}</td>
<td>0.83±0.01\textsuperscript{E}</td>
<td>79.53±0.24\textsuperscript{C}</td>
<td>360.96±1.47\textsuperscript{D}</td>
</tr>
<tr>
<td>Cooked</td>
<td>70.67±0.35\textsuperscript{f}</td>
<td>4.57±0.07\textsuperscript{a}</td>
<td>10.46±0.36\textsuperscript{d*}</td>
<td>1.84±0.01\textsuperscript{d}</td>
<td>1.49±0.01\textsuperscript{f}</td>
<td>81.63±0.37\textsuperscript{c*}</td>
<td>381.82±0.36\textsuperscript{d*}</td>
</tr>
<tr>
<td><strong>UFCe5</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncooked</td>
<td>73.24±0.12\textsuperscript{B}</td>
<td>5.41±0.02\textsuperscript{C*}</td>
<td>10.27±0.05\textsuperscript{C}</td>
<td>3.83±0.20\textsuperscript{C*}</td>
<td>2.42±0.03\textsuperscript{A*}</td>
<td>78.07±0.22\textsuperscript{B}</td>
<td>375.17±1.05\textsuperscript{AB}</td>
</tr>
<tr>
<td>Cooked</td>
<td>74.50±0.15\textsuperscript{a}</td>
<td>3.85±0.07\textsuperscript{b}</td>
<td>11.82±0.34\textsuperscript{c}</td>
<td>2.46±0.10\textsuperscript{b}</td>
<td>1.92±0.01\textsuperscript{c}</td>
<td>79.94±0.33\textsuperscript{c}</td>
<td>384.37±0.18\textsuperscript{f*}</td>
</tr>
<tr>
<td><strong>UFCe6</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncooked</td>
<td>73.23±0.26\textsuperscript{B}</td>
<td>4.80±0.00\textsuperscript{E*}</td>
<td>10.04±0.06\textsuperscript{C}</td>
<td>2.67±0.15\textsuperscript{D*}</td>
<td>1.38±0.06\textsuperscript{D}</td>
<td>81.11±0.14\textsuperscript{B}</td>
<td>376.99±0.29\textsuperscript{A}</td>
</tr>
<tr>
<td>Cooked</td>
<td>75.17±0.29\textsuperscript{b*}</td>
<td>2.92±0.00\textsuperscript{c}</td>
<td>11.58±0.25\textsuperscript{bc*}</td>
<td>2.42±0.07\textsuperscript{b}</td>
<td>1.99±0.04\textsuperscript{d*}</td>
<td>81.09±0.23\textsuperscript{d}</td>
<td>388.59±0.29\textsuperscript{b*}</td>
</tr>
<tr>
<td><strong>UFCe7</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncooked</td>
<td>78.68±0.70\textsuperscript{A}</td>
<td>7.80±0.04\textsuperscript{A*}</td>
<td>17.03±0.02\textsuperscript{A*}</td>
<td>5.23±0.22\textsuperscript{A*}</td>
<td>2.11±0.02\textsuperscript{B}</td>
<td>67.83±0.20\textsuperscript{E}</td>
<td>358.39±0.98\textsuperscript{E}</td>
</tr>
<tr>
<td>Cooked</td>
<td>79.40±0.33\textsuperscript{a}</td>
<td>4.51±0.03\textsuperscript{a}</td>
<td>16.29±0.22\textsuperscript{a}</td>
<td>4.05±0.02\textsuperscript{a}</td>
<td>2.76±0.02\textsuperscript{a*}</td>
<td>72.38±0.20\textsuperscript{a}</td>
<td>379.59±0.08\textsuperscript{a}</td>
</tr>
</tbody>
</table>

**Least Significant Difference**

<table>
<thead>
<tr>
<th>Moisture</th>
<th>Ash</th>
<th>Crude protein</th>
<th>Crude fibre</th>
<th>Crude lipid</th>
<th>Carbohydrate</th>
<th>Caloric value (kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uncooked</td>
<td>0.8911</td>
<td>0.0504</td>
<td>0.3071</td>
<td>0.4285</td>
<td>0.1177</td>
<td>0.464</td>
</tr>
<tr>
<td>Cooked</td>
<td>0.5516</td>
<td>0.0769</td>
<td>0.2965</td>
<td>0.1543</td>
<td>0.0494</td>
<td>0.34</td>
</tr>
</tbody>
</table>

Data presented as mean ± standard deviation. Composition (% dry matter). Values with different uppercase superscript letters within the same column show significant differences \((P<0.05)\) among uncooked accessions. Values with different lowercase superscript letters within the same column show significant differences among cooked accessions. * Significant differences within the same column among treatments of the same accession \((P<0.05)\).
The carbohydrate content of the accessions ranged from 72.38% to 85.32%, which implies high caloric values, indicating the potential of cocoyam tubers in meeting the energy requirement of the consumer. This result is consistent with the findings of Eka (1998) that tuber and root crops are generally rich in carbohydrates. The caloric values obtained in these accessions (358.39–390.98 kcal) were slightly higher than those reported by Davidson et al. (1975) for *C. esculenta* (355.19 kcal) and *X. sagittifolium* (340.99 kcal).

Wide variations were observed in the proximate composition values of the accessions studied. Such variations have been ascribed to the differences in the genetic background, climate, season and the agronomic factors during cultivation (Onwueme 1982).

In general, accession UFCe7 was better regarding ash, crude protein, crude fibre and crude lipid contents but with a higher moisture content. Based on this study, it could be recommended as being richer in mineral, protein and fibre contents but should not be stored for long after harvesting to minimize rotting.

**Acknowledgement**

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**References**


