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Full Length Research Paper

Effect of cooking on the proximate composition of the leaves of some accessions of *Colocasia esculenta* (L.) Schott in KwaZulu-Natal province of South Africa

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The effect of cooking on the proximate composition of the leaves of seven accessions (UFCe1 - UFCe7) of *Colocasia esculenta* (L.) Schott growing in KwaZulu-Natal Province of South Africa was investigated. Cooking significantly (P < 0.05) reduced the ash, carbohydrate and caloric contents of all the accessions tested in the study. In contrast, there was significant increase in the levels of moisture, crude protein, crude fibre and crude lipid in all the accessions except UFCe5 and UFCe6 where there was reduction in the crude lipid content. The results showed that cooking may improve the crude fibre contents as well as the levels of protein in the accessions. The accessions may be used in the management of obesity, diabetes, cancer and gastrointestinal disorders because of the high fibre content. The accessions can also serve as good candidates for proteins in cereal-based diets.

Key words: Cocoyam, *Colocasia esculenta*, accession, proximate composition.

INTRODUCTION

Taro cocoyam [*Colocasia esculenta* (L.) Schott] of the family Araceae is a herbaceous perennial plant cultivated as annuals. The large, green leaves often described as “elephant ear” can reach up to 1 - 2 m high during growth. The starchy tuberous root is the main edible part of the crop; however, the leaves are also used as leafy vegetables (Aregheore and Perera, 2003).

Cocoyam leaves are usually consumed by humans after heat treatments, such as boiling, blanching, steaming, stewing, frying and pressure cooking. These methods are found to be effective in improving digestibility, increasing nutrient bioavailability and also minimizing food-borne diseases (Fellows, 1990). Though, boiling can help to reduce the oxalate content in the leaves (Noonan and Savage, 1999), it may also reduce the nutritional value of food crops arising from significant losses and changes in major nutrients during cooking (FAO, 1990). In the areas where this crop is cultivated in South Africa, attention has only been paid to the tubers and not the leaves. In other parts of the world, the leaves of *C. esculenta* have been reported to be rich in nutrients, including minerals and vitamins such as calcium, phosphorus, iron, vitamin C, thiamine, riboflavin and niacin (Baruah, 2002; FAO, 1993). However, information appears scanty on the nutritional composition of this vegetable growing in South Africa. This study therefore aims to find out the effect of cooking on the proximate composition of seven accessions of cocoyam leaves growing in South Africa. Studies such as this may further provide information on the nutritional value of the leaves of the accessions tested in this study as well as the effect of cooking on the proximate composition.

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MATERIALS AND METHODS

Cocoyam and reagents

The leaves of seven accessions of cocoyam [*C. esculenta* (L.) Schott], named University of Fort Hare *Colocasia esculenta* 1 to 7 (UFCe1 - UFCe7) were obtained from their tubers. These accessions were collected from seven farmers’ fields located in four different villages (Umbumbulu, Makhathini, Mthwalume and Maphumulo) in KwaZulu-Natal Province, South Africa. All reagents used for the chemical analysis were of analytical grade and were obtained from Merck Chemicals (PTY) Ltd.

Cooking

The seven accessions of cocoyam tubers were grown in polythene bags in the greenhouse of the Teaching and Research Farm of the University of Fort Hare. Five months after planting, the leaves were destalked from the plants and labeled according to accessions for identification. The leaves from each accession was washed in distilled water, chopped into thin pieces and air-dried. Each leaf sample was then separated into two equal portions of known weights. A portion from each sample (500 g) was cooked by boiling in distilled water at 100°C for 5 min; the cooking water was discarded and the sample was later air-dried. Both the cooked and uncooked portions of the leaves were further oven-dried at 60°C to constant weight. The dried leaf samples were milled separately using a Fritsch pulverisette 14® Rotor-Speed mill (Fritsch GMBH, Laborgeraetebau, Germany) and stored in well labeled air-tight containers for the proximate analysis.

Proximate analysis

The moisture, dry matter, ash, crude lipid and crude fiber contents of the seven accessions of *C. esculenta* were determined using the method described by Association of Official Analytical Chemists (AOAC, 1984). Crude protein (N x 6.25) was determined on LECO® TruSpec® CN (Carbon/Nitrogen Determinator, Michigan, USA) using 0.1 g sample. Carbohydrate content was obtained using estimation by difference. The caloric value of each sample was calculated using Atwater factor method [(4 x crude protein) + (9 x crude lipid) + (4 x carbohydrate)] as described by Ihekoronye and Ngoddy (1985). All determinations were replicated three times.

Statistical analysis

The data obtained were subjected to analysis of variance (ANOVA) using the SAS (1999) package and difference between means were tested with Duncan Multiple Range Test.

RESULTS AND DISCUSSION

Comparison of uncooked and cooked leaves revealed that, cooking significantly reduced the ash, carbohydrate and caloric contents in all the accessions tested in this study except UFCe4 where the caloric content increased after cooking (Table 1).

The ash content is a measure of the nutritionally important mineral contents present in the food material. In this case, the observed decrease in ash content after cooking implies that the potential ability of these leafy vegetables to supply essential mineral has been reduced. This is in accordance with the observation of Onyeike and Oguike (2003) on boiled groundnut (*Arachis hypogaea*) seeds. According to the authors, this may be due to water absorption during boiling leading to dilution, and hence, low amount of the ash. Nevertheless, the results of the ash contents obtained in this study (7.02 - 9.43% DM) after cooking and (11.58 – 12.78% DM) in the uncooked accessions, are still considered high enough when compared with commonly consumed leafy vegetables like lettuce (0.4% DM), spinach (0.7% DM) and chomte (1.7% DM) (Salazar et al., 2006). The upper range in this study (11.58 - 12.78% DM) is however close to 13.3% DM for *Xanthosoma sagittifolium* (Rodríguez et al., 2006) and 12.4% reported for *C. esculenta* leaves (FAO, 1993) in the raw states. This shows that *C. esculenta* leaves could be good sources of mineral elements, cooking notwithstanding. The leaves of cocoyam are low in carbohydrate. A possible explanation may be that the species deposit most of their carbohydrate food reserve in the tuberous root; and the leaves are therefore consumed for their mineral and other nutrient contents (Duru and Uma, 2002). The carbohydrate contents obtained in the uncooked samples ranged from 23.55 to 31.78% while accession UFCe3 had the highest carbohydrate content. This is slightly less than 33.8% reported for another cultivar of sun-dried raw *C. esculenta* leaves in Nigeria (Mepba et al., 2007).

Cooking appears to retain the energy value of cocoyam leaves. Considering the results obtained in this study, the leaves of *C. esculenta* may be a good source of energy for both human and livestock that may eat them either cooked or raw. This result agrees with the findings of Davidson et al., (1975) on the leaves of *X. sagittifolium* and *C. esculenta*.

With the exception of accessions UFCe5 and UFCe6 where their crude lipid reduced slightly (Table 1), cooking significantly increased the levels of the crude protein, fibre and lipid contents of all the accessions studied.

The seven accessions investigated were high in moisture. High moisture content in leafy vegetables is indicative of freshness as well as easy perishability (Fennema and Tannenbaum, 1996). High amount of moisture in leafy vegetables makes them vulnerable to microbial attack, hence, spoilage (Desai and Salunkhe, 1991). In the tropics, wastage of vegetable crops is estimated to be around 50% due to high moisture content compared to 10 to 25% in developed countries where vegetables are processed to minimize losses (Thompson, 1996). Thomas and Oyediran (2008) reported 82.8% moisture content for the leaves of *C. esculenta* which is consistent with the range of moisture content obtained in this study.

The crude protein contents are high (25.71 – 31.47%) and also compared well with early report on the leaves of taro (FAO, 1993; Baruah, 2002; Buntha et al., 2008). This indicates that the leaves of cocoyam may be another cheap source of plant protein for marginal resource communities of South Africa. In addition, it may also be a good compliment to its tuber which is low in protein (FAO, 1990). More levels of protein after cooking could be linked to the breakdown in tannin which is well known to form complexes with protein thereby, inhibiting protein availability (Onu et al., 2001).

High levels of crude fibre in all the accessions investigated in this study confirm that non-starchy vegetables are the richest sources of dietary fibre (Agostoni et al., 1995). It is therefore suggested that the leaves of the

Table 1. Proximate composition of seven accessions of cocoyam (*Colocasia esculenta* (L.) Schott) leaves.

Accession	Moisture	Ash	Crude Protein	Crude Fibre	Crude Lipid	Carbohydrate	Caloric value (kcal)
UFCe1							
Uncooked	85.95±0.29^{ABC}	12.59±0.05^{AB*}	25.71±0.21^{D}	24.44±0.31^{B}	9.82±0.01^{E}	27.44±0.51^{B*}	300.93±1.26^{E*}
Cooked	89.11±0.52^{bc*}	8.08 ±0.02^{d}	30.33±0.71^{ab*}	42.60±0.09^{a*}	10.53±0.01^{e*}	8.46±0.70^{f}	249.89±0.34^{g}
UFCe2							
Uncooked	85.94±0.23^{ABC}	12.76±0.08^{A*}	28.20±0.34^{AB}	21.45±0.36^{E}	10.42±0.03^{D}	27.16±0.28^{B*}	315.26±1.79^{C*}
Cooked	89.85±0.64^{ab*}	8.05±0.01^{d}	30.57±0.68^{ab}	39.32±0.16^{b*}	10.83±0.01^{d*}	11.24±0.80^{e}	264.67±0.58^{f}
UFCe3							
Uncooked	85.36±0.44^{BC}	11.58±0.16^{D*}	28.19±0.08^{AB}	17.48±0.19^{F}	10.98±0.02^{A}	31.78±0.20^{A*}	338.65±1.16^{A*}
Cooked	88.50±0.64^{c*}	7.02±0.08^{e}	30.13±1.00^{b}	35.31±0.21^{c*}	11.32±0.01^{c*}	16.22±1.05^{d}	287.31±0.76^{d}
UFCe4							
Uncooked	86.51±0.72^{A}	12.78±0.07^{A*}	26.50±0.11^{C}	26.24±0.13^{A}	10.93±0.02^{B}	23.55±0.14^{D*}	298.61±0.34^{E}
Cooked	89.98±0.45^{ab*}	8.09±0.02^{d}	30.73±0.44^{ab*}	29.53±0.73^{f*}	11.55±0.01^{b*}	20.10±0.35^{b}	307.28±2.95^{b*}
UFCe5							
Uncooked	86.04±0.11^{AB}	12.45±0.03^{BC*}	28.61±0.05^{A}	23.44±0.57^{C}	10.92±0.01^{B*}	24.58±0.56^{C}	310.99±2.21^{D}
Cooked	89.95±0.73^{ab*}	8.67±0.04^{c}	31.47±0.22^{a*}	25.91±0.51^{g}	9.73±0.02^{f}	24.22±0.74^{a}	310.32±2.18^{a}
UFCe6							
Uncooked	85.25±0.21^{C}	11.75±0.12^{D*}	27.96±0.38^{B}	22.36±0.02^{D}	10.98±0.01^{A*}	26.94±0.27^{B*}	318.48±0.52^{B*}
Cooked	90.35±0.72^{a*}	8.92±0.03^{b}	29.86±0.39^{b}	34.19±0.29^{d*}	9.76±0.03^{f}	17.28±0.54^{cd}	276.38±1.11^{e}
UFCe7							
Uncooked	86.10±0.27^{A}	12.34±0.10^{C*}	26.49±0.35^{C}	23.43±0.29^{C}	10.51±0.01^{C}	27.23±0.46^{B*}	309.45±1.21^{D*}
Cooked	90.02±0.10^{ab*}	9.43±0.08^{a}	29.96±0.06^{b*}	30.93±0.66^{e*}	12.17±0.01^{a*}	17.52±0.58^{c}	299.46±2.33^{c}
LSD: Uncooked	0.6579	0.1801	0.4037	0.5356	0.0282	0.5116	2.3761
LSD: Cooked	0.9065	0.0829	1.1083	0.6885	0.0297	1.2021	2.5871

Data are in ± S.D. Composition (% dry matter).
Values with different superscript (uppercase) within the same column show significant differences among uncooked accessions, values with different superscript (lowercase) within the same column show significant differences among cooked accessions while values with * within the same column show significant differences among treatments of the same accession ($P < 0.05$). LSD = Least Significant Difference.

species may be employed in the treatment of diseases such as obesity, diabetes, cancer and gastrointestinal disorders (Saldanha, 1995). High levels of fibre in foods help in digestion and prevention of colon cancer (Saldanha, 1995; UICC/WHO, 2005). The results obtained for crude fibre of uncooked samples (17.48 – 26.24%) in this study are higher than those (12.4 and 14.2%) reported for the leaves of *C. esculenta* and *X. sagittifolium* respectively (Baruah, 2002; Mepba et al., 2007). However, these differences may be due to genotype and growing conditions (Debre and Brindza, 1996).

The increase in crude lipid contents observed with almost all the cooked accessions investigated except UFCe5 and UFCe6 shows that boiling may increase the levels of lipid. The results of this study are higher when compared with the average for vegetables consumed in South Africa. However, these results are in the lower range when compared with reported values (8.3 – 27.0% DW) in some vegetables consumed in Nigeria and Republic of Niger (Ifon and Bassir, 1980; Sena et al., 1998). This shows that accessions of cocoyam studied have moderate lipid contents, which further agrees with the findings that leafy vegetables are low lipid containing food, and this may be an advantage for people suffering from obesity (Lintas, 1992).

Conclusion

In conclusion, this study has shown that cooking may increase the protein, fibre and lipid contents of the *C. esculenta* leaves. Cooking may also decrease the mineral, carbohydrate and caloric contents of the leaves of the accessions. The leafy vegetable may therefore, be recommended as a cheap source of plant protein.

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