Original article

Nutritional and antinutritional characteristics of *Anchote (Coccinia abyssinica)*

Habtamu Fufa Aga[1] and Kelbessa Urga Badada[1]

Abstract: The whole and peeled samples of *anchote (C*occinia abyssinica) were analyzed for their nutrient and antinutrient contents. The protein, starch, total sugars, reducing sugars, vit-A, and vitB contents were higher in peeled *anchote* than in whole *anchote* samples. The phosphorous, potassium, sodium, calcium, magnesium, iron, zinc and copper contents of whole and peeled *anchote* were determined and peeling of *anchote* reduced the contents of calcium, potassium, phosphorous, iron and magnesium by 5%, 8%, 16%, 16%, and 19%, respectively. The phytic acid, oxalic acid and tannin contents of whole *anchote* were higher than those which were peeled by 20%, 22% and 29.6%, respectively. There were no detectable trypsin inhibitor activity in both samples of *anchote.* Oxalic acid in both *anchote* samples exists as insoluble oxalate and no water soluble oxalate was detected. As it is observed from the analysis made, *anchote* contained good nutrient composition with a good supplements of vitamins and minerals. Its antinutritional contents are probably of little nutritional significance and they may be still minimized or destroyed during cooking processes. [*Ethiop. J. Health Dev.* 1997;11(2):163-168]

Introduction

A knowledge of the chemical composition of foods is essential in most quantitative studies of human nutrition and it is demanded for better and more up to date information about the chemistry of food (1).

A number of edible tubers, roots and corms form an important part of the diet of many people in different parts of the world but their nutrient composition is not fully studied or not studied at all. These food crops are usually easy to cultivate and give high yields per hectare; they contain large quantities of starch and are easily obtainable source of food energy (2). *Anchote (Coccinia abyssinica)* is the root crop of the Cucurbitaceae family (3), indigenous to Ethiopia. It is widely cultivated for food in the western and south western regions of the country.

The total yield of *anchote* is 150-180 quintals/hectare, which is in the range of the total yield of sweet potato and potato (4). *Anchote* is propagated exclusively from seeds and harvested in 4 months. *Anchote* can be safely stored under the ground, which thus gives added food security to the population in times of main crop failures. Like many other roots, *anchote* is rarely eaten raw. It undergoes some form of processing and cooking before consumption. The roots are cleaned superficially, or peeled with knife and then cooked in boiling water or grated. Cooked *anchote* is served usually with *kochkocha*, a fermented side-dish prepared from ground green pepper with green leafy varieties of spices like coriander (C*oriandrum sativum)*, sweet basil (O*cimum basilium),* ginger (Z*ingiber officinale)*, garlic and salt. *Anchote* when sliced, dried in the sun and ground, its flour remains in good conditions for a long time. The flour is used to prepare a soup when boiled with bone-marrow from animals. Such soup is particularly served to

[1] From Ethiopian Health and Nutrition Research Institute, P.O. BOX 1242, Addis Ababa

patients with broken or fractured bones or sick people. A stew locally called *anchote Ittoo* is prepared on festive occasions solely from sliced *anchote* with sufficient butter. Traditionally, it is believed that *anchote* heals broken or fractured bones, helps sick people to recuperate and makes lactating mothers healthier and stronger.

Starchy roots and tubers like potato and sweet potato contain antinutritional factors like tannin, trypsin inhibitors, phytic acid and oxalic acid (5,6, 7). The presence of antinutritional factors in the foods (raw or cooked products) reduces the bioavailability of nutrients and also the food qualities (8). Usually the consumers peel out the skin of *anchote* and use the rest. Some studies, however, showed that the crude protein content of sweet potato skin is 50-90% higher than that of the bulk of the root (6).

The purpose of this work was to determine and characterize the nutritional and antinutritional contents of whole and peeled anchote and to compare the nutritional contents of anchote with some other starchy roots (9), whose nutritional composition is already studied.

Methods

Sample preparation: Freshly harvested *anchote* samples were obtained from a farmer near Nekmte, Wollega, Ethiopia and transported to the institute in polyethylene bags. The tubers were washed to remove all soil. The peeled and the whole tubers were sliced and bulked separately. All the samples were shredded using a blender and were stored at -20^{o}C.

Reagents: All reagents used were of analytical grade.

Chemical analyses: Moisture content was measured by drying to a constant weight the shredded samples at 90^{0}C (10). For chemical analyses the bulk of the shredded anchote was freeze dried using a Labconco freeze drying system (Labconco, USA) and was ground to a fine powder using a cyclotec sample mill (Tecator, Sweden). This ground material was stored in bottles and used in all analyses.

The calorie factors used in calculating the food energy were based upon the physiological energy factors (11). Nitrogen was determined by the macro-kjeldahl method of AOAC (12). Values for protein content were computed from the nitrogen content and multiplied by a conversion factor of 6.25. Fat was determined by Soxhlet method (13). Crude fibre and ash were determined according to AOAC methods (14).

The values for carbohydrate given were as " total carbohydrate by difference", that is the sum of the figures formed from moisture, protein, ash and fat subtracted from 100. Total sugars other than starch were extracted in ethanol by reflux method and were determined by the method of Dubois, *et al* (15). Reducing sugars were determined colorimetrically by the method of Nelson (16). Starch was determined by Anthrone method (17).

Phosphorous in anchote samples was determined by the method of Fiske and Subborw (18). The iron in anchote sample was determined according to the AOAC method (19). Potassium and sodium contents of anchote were determined by flame photometer (20). Calcium, magnesium, zinc and copper were determined by atomic absorption spectrophotometer (21).

Ascorbic acid was determined colorimetrically (22). Vit-A was determined by a chemical procedure, according to Gyorgy (23). The conversion factors used for the calculation of retinol and β-carotene from International Unit were as follows: one International Unit is equivalent to 0.3 µg of retinol or, 0.6 µg β-carotene (24). Riboflavin was determined by a fluorometric method (25). The trypsin inhibitor activity was evaluated by AOCS method (26). *N*-benzoyl-*DL*-arginine-*p*nitroaniline (BAPNA) was used as the trypsin substrate. Phytic acid was determined by sensitive methods for the rapid determination of phytate (27) from standard curve. The condensed tannin were assayed colorimetrically by the method of vanillin hydrochloride described by Price et al.(28) using catechin as a standard. The tannin content was expressed as catechin equivalents. The total oxalic acid and soluble oxalic acid were determined according to AOAC method (29).

Data analysis: Tests were replicated three times. Data were subjected to analysis of variance (ANOVA). Differences were considered statistically significant at $p<0.05$.

Results

All data obtained from analyses of the dry samples are presented on a fresh weight basis. The protein, carbohydrate, total sugars, and reducing sugars contents of peeled samples were significantly higher than the whole samples. The moisture and fat of whole samples were significantly ($p<0.01$) higher than the peeled samples. Starch is the main component of the total carbohydrate followed by total and reducing sugars.

Table 1: **Proximate composition and carbohydrate contents of *anchote in 100 gram edible portion*[a]**

	peeled *anchote*	Whole *anchote*
Moisture, %	68.8±0.44	73±0.52
Energy, Kcal	117.5±0.54	103.5±0.45
Protein, g	3.9±0.2	3.00±0.14
Ash, g	1.7±0.10	2.0±0.15
Fat, g	0.12±0.01	0.17±0.02
Crude fibre, g	1.5±0.12	1.6±0.13
Carbohydrate, g	25.5±0.48	22.5±0.45
Starch, g	20.4±0.44	17.5±0.98
Total sugars, g	4±0.14	3.12±0.17
Reducing sugars, g	2.38±0.1	1.8±0.08

[a] The reported values are means ± SD of six samples of each of peeled and whole *anchote*.

The results for the mineral and vitamin content of anchote samples are given in Table 2. There is a significant difference between the peeled and whole sample contents ($P<0.001$) except for sodium, zinc and copper. The calcium, phosphorous, iron and potassium contents of whole *anchote* were higher than the peeled samples. Peeling of *anchote* results in 5% loss of calcium, 8% loss of potassium, 16% loss of phosphorous 16% loos of iron and 19% loss of magnesium. The concentrates of vitamin A and riboflavin are higher in the peeled root than in the whole root while the vit-C contents is higher in whole *anchote* than in the peeled one.

The calcium to phosphorous ratio is 2.8 to 1 and 3 to 1 in whole and peeled samples, respectively and the potassium to sodium ratio is 41 to 1 and 37.5 to 1 in whole and peeled *anchote* samples, respectively.

The content of antinutritional factors of *anchote* samples are given in Table 3. Peeling of whole *anchote* results in significant decreases of phytic acid, tannin and oxalic acid contents. The process of peeling removes 20%, 22% and 29.6% phytic acid, oxalic acid and tannin, respectively. Oxalic acid in *anchote* exists as insoluble oxalate and no water soluble oxalate content was detected. The trypsin inhibitor activity was not detected in both *anchote* samples.

Table 2: **Mineral and vitamin contents of *anchote* in 100 gram edible portion[b]**

	peeled *anchote*	whole *anchote*
Phosphorous, mg	103.5±3.98	123±4.5
Potassium, mg	610.4±3.8	663.46±7.2
Sodium, mg	16.3±0.2	16±1.2
*Calcium, mg	327±10	344±13
Magnesium, mg	124±6	80±4
Iron, mg	4.6±0.2	5.5±0.4
Zinc, mg	1.8±0.2	1.8±0.2
Copper, mg	0.5±0.02	0.4±.02
Vit-A, µg	53.3±1.47	45±1.6
Vit-B_2, mg	0.08±0.003	0.06±0.002
Vit-C, mg	8±0.4	9.56±0.37

[b] See footnote *a* in Table 1.

*The calcium to phosphorous ratio is 2.8 to 1 and 3 to 1 in whole and peeled samples, respectively, and the potassium to sodium ratio is 41 to 1 and 37.5 to 1 in while and peeled anchote samples, respectively.

Discussion

Anchote contained 3.9 g protein in 100 g of peeled samples and whole samples contained 3.0 g/100 g. The protein content of whole *anchote* is 2 times higher than the values reported for potato and sweet potato (9). The crude protein content of peeled samples of *anchote* was higher than that of the whole samples. This may indicate that there is a high protein content in the bulk of the root than in the skin part of it. This result is in contrary with the results of crude protein content of sweet potato (6) in which its skin contained more protein than the bulk of the root.

Anchote exhibits a low lipid content. These may be mainly structural lipids of the cell membrane which enhance cellular integrity, offer resistance to bruising and help to reduce enzyme browning. Since *anchote* is low in lipid, it may not be rich source of fat soluble vitamins. However, the vitaminA and riboflavin content of *anchote* are much higher than those in white fleshed sweet potato, potato and cassava (9). Due to its good vitamin-A content, consumption of *anchote* may help to reduce the problem of vitamin-A deficiency in these regions. Vit-C content of whole *anchote* is 10 mg in 100 g serving and thus *anchote* may help to make dietary iron soluble and more bioavailable.

Table 3: **Antinutritional contents of *anchote* in 100 gram edible portion[c].**

	peeled *anchote*	whole *anchote*
Phytic acid, µg	199.8±10.3	249.6±10.1
Tannin, µg	445.4±10.4	632.5±15.7
Oxalic acid, mg	7.1±1.3	9±1.2
Trypsin inhibitor, TIU	ND	ND[d]

[c]See footnote [a] in Table 1. [d]
ND=not detected

The ratio of potassium to sodium makes *anchote* particularly valuable in the diets of people who have to restrict their sodium intake. The calcium to phosphorous ratio is 3.0 in peeled *anchote*, which is similar to some infant foods in some countries, where less phosphorous is recommended than calcium (30).

Whole *anchote* contained 344 mg calcium and 5.50 mg iron in a 100 g serving, respectively. The calcium and iron content of whole *anchote* are 26 and 5 fold higher than potato, 10 and 2.8 fold higher than sweet potato and 7 and 4.6 fold higher than taro (9). The phosphorous and potassium are also higher than those of potato, sweet potato and taro (9). The recommended magnesium daily intake in most countries is 128 mg for children 1-2 years, 280 mg for women and 350 mg for men (31) and anchote (peeled) contains 124 mg in 100 g edible portion. The recommended daily intake for zinc content in most countries is 3.9 mg for infants and 7.4 mg for children (31) and anchote (peeled) contained 1.8 mg in 100 g edible portion. Thus, a serving of 100 gm per day can fulfil most of the daily requirements of these nutrients.

The carbohydrate content of *anchote* contributed the major part to its energy since it contained large quantities of starch, which is 22-25%. The peeled *anchote* contained more carbohydrate than the whole *anchote.*

Table 4: **Some nutrient composition of *anchote* and other roots and tubers (9) in 100 gram edible portion.**

Sample	protein	CHO	Ca	Fe	P	Vit-A	Vit-C	Vit-B_2
	gm	gm	mg	mg	mg	µg	mg	mg

Pottato	1.3	18	13	1.1	51	0	21	0.03
potato	1.6	28	33	2	38	75	37	0.05
(sweet) Taro	1.8	23	51	1.2	88	Tr	8	0.03
Yam	1.9	27	52	0.8	61	10	6	0.02
Cassava	1.2	35	68	1.9	42	30	31	0.05
Anchoto	3.9	25	327	4.6	104	53	8	0.08
(peeled) Anchote(whole)	3.00	22	344	5.5	123	45	10	0.06

There is no detectable trypsin inhibitor activity in both peeled and whole samples of *anchote*, whereas, several species of heat-stable protienase inhibitors have been purified from extracts of potatoes and cumulatively they can compromise over 15% soluble proteins of mature tubers (7) and this may indicate the good quality of protein from *anchote* than from potatoes. Trypsin inhibitors, when ingested by man in significant amounts, disrupt the digestive process and may lead to undesirable physiological reactions (32).

The phytic acid content of anchote is low (Table 3) relative to cereals, in which phytic acid is a major portion of phosphorus and occupies 60-80% of the total phosphorus of the grain (7) and thus, those minerals liable to interaction by dietary phytic acid are more available in *anchote* than those in cereals. This is especially important for iron, which has been found to be 100% available in banana which contained no phytic acid (33). Recently, it has been reported that cassava, cocoyam and yam contain 624, 815, and 637 mg of phytates per 100g, respectively (34) and these are significantly higher than those in *anchote*. The nutritional significance of phytate in the diet of man has assumed great importance in recent years because of its implication in the mineral deficiency so prevalent in those parts of the world, that are reliant on cereal protein (33). The tannin content obtained in peeled and whole anchote samples are 0.445 mg and 0.632 mg, respectively. The toxicity effects of the tannin may not be significant in *anchote* since the total acceptable tannic acid daily intake for a man is 560 mg (35). Tannins also form insoluble complexes with proteins and the tannin-protein complexes may be responsible for the antinutritional effects of tannin containing foods (36). However, since the tannin content of anchote is very low compared to its protein content, its antinutritional effect may be insignificant.

Anchote contains 8.3, 10.8 and 161 times less oxalic acid compared to sweet potato, potato and carrot (37), respectively. Oxalic acid inhibits the absorption of calcium by forming insoluble calcium oxalate (24). But there may be also the possibility of bacterial degradation which may occur in intestine, making the calcium available from calcium oxalate (38). The water-soluble oxalate was not detected in both the peeled and whole anchote samples. The water-soluble oxalates are comparatively more toxic as they form insoluble salts with calcium and magnesium rendering these metals unavailable from other sources of food in the digestive tract (39).

Since the amount of calcium and iron in whole grains and cereals are not easily available owing to the presence of high phytates and other components of dietary fibre (24), the contribution of *anchote* to iron and calcium needs may be essential to the areas where the staple food is based on whole grains and cereals. *Anchote* may also play a vital role in supplying the calcium requirements of infants and children of this country where milk and milk products are not easy to come by.

As shown in this study *anchote* has got a good nutrient composition with a good supplement of vitamins and minerals and its antinutritional contents are probably of little nutritional significance and they may be still minimized or destroyed during cooking process. The study of its amino acid balance is warranted, which may enhance its supplementary quality with other food items. If appropriately supplemented with cereals or legumes, *anchote* processed into flour may be used as a supplementary food for infants, young children and lactating mothers.

Acknowledgemnt

This study was funded by the former Ethiopian Nutrition Institute.

References

1. McCance RA, Widdowson EM. The composition of foods. Medical Research Council. Third revised edition of Special Report No. 235, London: Her Majesty's Stationery Office. 1969:1.
2. FAO Food and Nutrition Series. Human Nutrition in Tropical Africa. No. 11 , IAO, Rome Rev. 1 1979:171.
3. Asfaw Z , Nigatu A and Asfaw M. Survey of the indigenous food plants of Ethiopia and food preparations from the indigenous food crops. Addis Ababa. 1992:4.
4. IAR Progress Report. Department of Horticulture. Roots and Tubers team progress report for the period 1978/79. Addis Ababa. 1986:1-9.
5. Oke. Phytic acid-phosphorous content of Nigerian foodstuffs. Indian J. Med. Res. 1965; 53:417 in Toxicants naturally occurring in foods. National Academy of Science. 1973:364.
6. James H. Bradbury J, Baines B, Hammre MA and John S.Millar. Analysis of Sweet Potato (Ipomoea batatas) from the high lands of Papua New Guinea. J Agric Food Chem 1984;32:469-473.
7. Robert LO. Antinutrients and Natural toxicants in foods. Food and Nutrition Press, INC. Westport, Connecticut 06880 USA. 1981:169.
8. Liener IE, Kakade ML. Protaese inhibitors in Toxic constituents of plant foodstuffs, ed Liener I.E. Academic Press, New York 1969:8-69.
9. West CE, Pepping F. and Temalilwa CR. The Composition of Foods Commonly Eaten in East Africa. Wageningen Agricultural University. Wageningen 1988:15-17.

10. Food analysis: Theory and practice by Pomeranz and Meloan West-Port, The Avi publishing company, 1971:481490.
11. Bogert LJ, George MB, Doris HC. Nutrition and Physical fitness. Eighth Edition. W.B. Saunders Company. 1968:95-98.
12. Crooke WM, Simpson WE. Determination of ammonium in kjeldahl digest of crops by an automated procedure. J Sci Food Agric 1971;22:9-10.
13. Kungl L. Fat in food samples. Lanthruksstyrelsens Kungorelser. 1950;6:32
14. AOAC. Official Methods of Analysis. Twelvth ed. 1975:136 and 222.
15. Dubois M, Giller KA, Hamilton JK, Rebers PA, Smith F. Colorimetric method for determination of sugars and related substances Anal chem 1986;28:350-356.
16. Nelson NJ. Biol Chem 1944;153:375-378.
17. Hassid WZ, Newfel EF. Quantitative determination of starch in plant tissue. Methods Carbohydrate Chem 1964;4:33-36.
18. Fiske and Subbarow. Phosphorous in food samples in practical physiological chemistry Hawx, Oser and Summerson 12th Ed. The Blaxiston Co, U.S.A. 1947.
19. AOAC. Official methods of analysis of the Association of Official Agricultural Chemists, Tenth Edition. 1965:109-193.
20. Carol AR, Zajicek OT, Edward JC. Dry ashing vegetables for the determination of Sodium and potassium. Anal Chem 1982; 54(1):149-151.
21. Osborne DR, Voogt P. The analysis of nutrients in foods. Academic Press. 1978:168-171.
22. Bajaj KL, Gurdeep Kaur. Spectrophotometeric determination of ascorbic acid in vegetables and fruits. Analyst 1981;106:117-120.
23. Gyorgy P, Rubin SH. Vitamin Methods. Academic Press Inc. New York 1950.
24. Davidson S, Passmore R. Human Nutrition and Dietetics. Eighth Edition. Churchill Livingstone. Edinburgh London Melbourne and New York. 1986:108, 134, 233.
25. Freed M. Methods of vitamin assay, Third edition,Interscience publishers. 1966:158-167.
26. Walker RO. Official and Tentative Methods of the A.O.C.S. Third Edition. 1978: 12-75.
27. Huag W., Hans-Joachim Lantzsch HJ. Sensetive Methods for Rapid Determination of phytate in cereals and cereal products. J Food Sci Agric 1983;34:1432-1426.
28. Price ML, Van Scoyoc S. and Butler LG. A critical evaluation of the vanillin reaction as an assay for tannin in Sorghum grain. J Agric Food Chem 1978;26:1214.
29. Abeza RH, Blake JT, Fisher EJ. Oxalate determination. J Assoc of Agric Chem 1968;51:963.
30. Nutrition Abstracts and Reviews -Series A. Recommended Dietary Intake around the world. 1983;53:1075-1116.
31. Maria C. Linder. Nutritional biochemistry and metabolism with clinical applications. Second ed. 1991:194
32. Liener IE. Legume toxins in relation to protein digestibility. J Food Sci 1976;41:1076.
33. Marriott J, Lancaster PA. Bananas and Plantains. In: Chan, H.T., ed. Handbook of tropical foods. New York, Dekker, 1983:85-143.
34. Rienold JG, Ismail-Beigi F, Faradji B Nut Rep Int 1975;2:75-85.
35. Anonymous. Tannic acid gain. Food Cosmetol Toxicol. In: Toxicants Naturally occurring in foods. National Academy of Sciences. Third Edition. 1973:112.
36. Mole S, Waterman PG. Tannic acid and proteolytic enzymes: Enzymes inhibitor or substrate deprivation Phytochemistry, 1987;26:99.
37. Kasaye J, Kelbessa U. Forms and contents of oxalate and calcium in some vegetables in Ethiopia. Ethiop J Health Dev 1995;9(1):13-18.
38. Brune H, Bredehon. The physiology of bacterial degradation of calcium oxalate and the ability to utilize calcium from calcium oxalate in the pig. Chem Abstr 1962;56: 5190.
39. Pingle U, Ramassti BV. Absorption of calcium from a leafy vegetable rich in oxalate. Br J Nutr 1978;9:119-125.