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E-mail: bjsir07@gmail.com

Chemical composition of wonderful kola (*Bucchlozia coriacea*) and breadfruit (*Artocarpus altilis*) seeds grown in south–south, Nigeria

M. O. Aremu[1]*, D. B. Passali[1], H. Ibrahim[2] and R. O. Akinyeye[3]

[1]*Department of Chemical Sciences, Federal University Wukari, PMB 1020 Taraba State, Nigeria*
[2]*Department of Chemistry, Federal University Lafia, PMB 146, Nasarawa State, Nigeria*
[3]*Department of Chemistry, Ekiti State University, PMB 5363, Ado–Ekiti, Nigeria*

Abstract

The proximate and amino acid compositions of *Artocarpus altilis* and *Bucchholzia coriacea* were investigated using standard analytical techniques. The respective proximate composition (%) for the *Artocarpus altilis* and *Bucchholzia coriacea* samples were: Moisture (5.91 and 5.67); ash (4.39 and 5.13); crude fat (4.42 and 2.76); crude protein (12.27 and 14.78); crude fibre (7.10 and 6.27); carbohydrate (65.91 and 65.39). The calculated fatty acids and metabolizable energy for the *Artocarpus altilis* and *Bucchholzia coriacea* samples were 3.54 and 2.21 %; 1492.60 and 1465.01 kJ/100 g, respectively. The most abundant minerals in *Artocarpus altilis* and *Bucchholzia* were potassium (658.42 and 369.64 mg/100 g) and phosphorus (382.55 and 261.38 mg/100 g), respectively. The amino acid profile revealed that *Artocarpus altilis* and *Bucchholzia coriacea* samples contained nutritionally useful quantities of most of the essential amino acids. The total essential amino acids (TEAA) (with His) were 31.14 and 34.40 g/100 g crude protein for the *Artocarpus altilis* and *Bucchholzia coriacea* samples, respectively. The first limiting amino acid was Met + Cys (TSAA) for all the samples and calculated isoeletric points (ρl) were 3.52 and 4.05 for *Artocarpus altilis* and *Bucchholzia coriacea*, respectively.

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Introduction

In developing countries like Nigeria, numerous wild edible plants are exploited as food sources; hence they provide an adequate level of nutrition to the inhabitants (Aberoumand, 2009). Breadfruit (*Artocarpus altilis)* belongs to the Mulberry family Moraceae. In Nigeria, the breadfruit is regarded as the poor man's substitute for yam (*Dioscorea esculenta* and *D. cayenensis*), because it is used in several traditional food preparations of yam, but costs less than one third the cost of procuring yam at the market. It is used in soft and stiff porridge dishes, boiled as yam, fried as chips and roasted as roast yam (Mayaki *et al.,* 2003). It's a rich source of carbohydrates, fiber, vitamins (vitamin C) and minerals (potassium) (Graham and Negron de Bravo, 1981). Breadfruit has a considerable untapped potential as a nutritious food particularly among the low-income groups of the society in developing countries, and has an advantage over cereals and roots as it yields two or three times as much minerals and vitamins as cereals and roots (Amusa *et al.*, 2002). Plants serve as an indispensable constituent of human diet supplying the body with minerals salts, vitamins and certain hormone precursors, in addition to protein and energy (Oyenuga and Fetuga, 1975). The use of plants in traditional medicine has a long history in the life of a man, and it remains the mainstay of primary health care in most of the developing countries. Plant-based medicines are used by over 60% of the world population; in both developing and developed countries where modern medicines are predominantly used (Mythilypriya *et al.*, 2007). In African countries large proportions of the population depends solely on herbal medicines for its primary health care needs. However, seeds have nutritive and calorific values which make them necessary in diets (Odoemelam, 2005), and among these plant seeds are the seeds of *Buccholzia coricea* popularly known as "Wonderful kola". *Buccholzia coricea* is a perennial plant which grows as a tree.

*Corresponding author e-mail: lekearemu@gmail.com

It belongs to the family Capparaceae and is known as uworo, owi, and uke by Yoruba, Edo and Ibo people in Nigeria respectively (Quattrochi–Umbeto, 2007). The plant parts commonly eaten are the seeds which are either cooked or eaten raw. *Bucchholzia coriacea* is a brain food, which promotes memory, useful in the treatment of hypertension and prevents premature aging. It is evident in some parts of Africa that wonderful kola has the ability to stop migraine headache (Ibrahim and Fagbohun, 2012). The *Bucchholzia coriacea* plants serves as food and medicine in many parts of African countries, hence, gave the plant a common name wonderful kolanut Ijarotimi *et al.*, 2015). Over the years, breadfruits and wonderful kola have been food in many parts of the world. In Nigeria, the seeds are native to south – western, south – south and south – eastern part; commonly eaten raw or cooked. It had been claimed that they possess nutritional values. However, this work focuses on finding the nutritive contents of these seeds as sources of food. The knowledge obtained from the study will aid policy-makers in the agriculture sector and food industry to making informed decisions aimed at broadening the nation's food security basket.

Materials and methods

Samples collection and treatment

The fresh fruits of wonderful kola (*Buccholzia coriacea*) and breadfruit (*Artocarpus altilis*) were purchased from Ogoja market in Ogoja local government area of Cross River State, Nigeria and transported to the laboratory for treatment and analyzes. Four seeds each were removed from the fruits of *Buccholzia coriacea* and *Artocarpus altilis*, washed, peeled and dried in an oven at 45^{o}C for 72 h. The dried seeds were ground into powder separately using a food blender, sieved though a 250 µm and then stored in airtight containers for further analysis.

Proximate analysis

The ash, moisture, crude fat, crude protein (N x 6.25), crude fibre and carbohydrate (by difference) were determined in accordance with the methods of AOAC (1995). All proximate analyses of the sample flour were carried out in triplicate and reported in percentage. All chemicals were of Analar grade.

Mineral analysis

The potassium and sodium were determined using a flame photometer (Model 405, Corning UK). Phosphorus was determined by Vanadomolybdate colourimetric method (James, 1996). All other metals were determined by atomic absorption spectrophotometer (Perkin–Elmer Model 403, Norwalk CT). All the minerals determined were reported in mg/100 g sample.

Determination of isoelectric point (pI), quality of dietary protein and predicted protein efficiency ratio (P–PER)

The predicted isoelectric point was evaluated according to Olaofe and Akintayo (2000):

$$\text{plm} = \sum_{(i=1)}^{(n=1)} \text{pliXi}$$

where:

pIm = the isoelectric point of the mixture of amino acids;

pIi = the isoelectric point of the ith amino acids in the mixture;

Xi = the mass or mole fraction of the amino acids in the mixture.

The quality of dietary protein was measured by finding the ratio of available amino acids in the sample protein compared with the needs expressed as a ratio. Amino acid score (AAS) was then estimated by applying the FAO/WHO (1991) formula:

$$AAS = \frac{\text{mg of amino acid in reference protein}}{\text{mg or amino acid in 1}g\text{ of test protein}} \times 100/1$$

The predicted protein efficiency ratio (P–PER) of the seed sample was calculated from their amino acid composition based on the equation developed by Alsmeyer *et al.* (1974) as stated thus; P–PER = –0.468 + 0.454(Leu) – 0.105(Tyr).

Statistical analysis of the samples

The proximate and mineral values were obtained with ± standard deviations of triplicate determinations. The fatty acid values were obtained by multiplying crude fat value of each sample with a factor of 0.8 (i.e. crude fat x 0.8 is corresponding to fatty acids value. The energy values were calculated by adding up the carbohydrate x 17 kJ, crude protein x 17 kJ and crude fat x 37 kJ for each of the samples (Kilgore, 1987).

Results and discussion

The proximate composition, calculated metabolisable energy and fatty acid values of the studied samples are presented in Table I. The moisture content of *Artocarpus altilis* (5.91 %) and *Buccholzia coricea* (5.67 %) were generally low and within the recommended dietary allowance (RDA) (3 – 10) (NRC, 1989). The low values of moisture ensured a long shelf life of the samples without microbial spoilage. The crude fat content of *Artocarpus altilis* and *Buccholzia coricea* were 4.42 and 2.76 %, respectively. None of the studied sample is qualified as oil-rich plant when compared with soybean (22.8 and 23.5%) (Paul and Southgate, 1978; Salunke *et al.*, 1985) pumpkin seed (49.2 and 47.0%) (Aisegbu, 1989; Fagbemi and Oshodi, 1991) and *C. vulgaris* (47.9–51.1%) (Ige *et al.*, 1984). Plant foods that provide more than 12% of their calorific value from protein have been shown to be good sources of protein (Ali, 2009). This shows that both *Artocarpus altilis* (12.27 %) and *Buccholzia coricea* (14.78 %) may be good sources of protein. The protein contents obtained from the samples are comparable to that of kersting's groundnut (12.90%) (Aremu *et al*, 2006a).

Table I. Proximate composition (%)[a] of *Artocarpus altilis* and *Bucchholzia coriacea*

Parameter	***Artocarpus altilis***	***Bucchholzia coriacea***
Moisture	5.91 ± 0.06	5.67 ± 0.11
Ash	4.39 ± 0.12	5.13 ± 0.08
Crude fat	4.42 ± 0.13	2.76 ± 0.22
Crude protein	12.27 ± 0.56	14.78 ± 0.32
Crude fibre	7.10 ± 0.11	6.27 ± 0.06
Carbohydrate[b]	65.91 ± 0.72	65.39 ± 0.13
Fatty acid[c]	3.43 ± 0.11	2.21 ± 0.18
Energy[d]	1492.60 ± 7.53	1465.01 ± 4.73

[a]Mean values ± standard deviations of triplicate determinations; [b]Carbohydrate percent calculated as the (100 – total of other components); [c]Calculated fatty acid (0.8 x crude fat); [d]Calculated metabolizable energy (kJ/100g) (protein x 17 + fat x 37 + carbohydrate x 17)

Ash content is a measure of mineral content of food. The result indicates that there are more minerals in *Buccholzia coricea* (5.13 %) than the *Artocarpus altilis* (4.39 %). Ash content of these samples is higher than those reported for some leafy vegetables such as *Solanium nodiflorum* (ogumo) (2.67%) (Adeleke and Abiodun, 2010). Both samples had ash content slightly lower than the lowest RDA value of 6 %. Crude fibre is a significant component in the body. It increases stool bulk and decreases the time that waste materials spend in the gastrointestinal tracks (Aremu *et al.*, 2015). Crude fibre in the diet consists mostly of the plant polysaccharides that cannot be digested by human dietary enzymes such as cellulose, hemicelluloses and some materials that make up the cell wall (Southland, 1975). The fibre content obtained in *Artocarpus altilis* (7.10 %) and *Buccholzia coricea* (6.27 %) more higher than that of *T. triangulare* (2.40 %), *T. occidentalis* (1.7 %) and *C. argentea* (1.8 %) (Akachukwu and Fawusi, 1995) and apple (3.62%) (Fasoyiro *et al.*, 2005). Therefore, the consumption of *Artocarpus altilis* and *Buccholzia coricea* may be advantageous since high fibres content of foods help in digestion, prevention of colon cancer and in the treatment of diseases such as obesity, diabetes and gastrointestinal disorders (UICC/WHO, 2005). The carbohydrate content revealed in Table I, are highly compared to the carbohydrate content in *T. occidentalis* (8.0%) (FAO, 1986), pineapple (12.30%) and orange (9.82%) (Aremu and Olonisakin, 2004). High fatty acid value in oil indicates that the oil may not be suitable for use in cooking (edibility), but however, be useful for industrial purposes, therefore oil obtained from *Artocarpus altilis* and *Buccholzia coricea* will be suitable for use in cooking because of it low acid value. The high metabolizable energy values obtained showed that the samples had energy concentration that compares fairly with those reported for some legumes such as bambara groundnut (1691.3 kJ/100 g), kersting's groundnut (1692.9 kJ/100 g) and cranberry beans (1651.7 kJ/100 g) (Aremu *et al.*, 2006a), red kidney bean (1678.4 kJ/100 g) (Audu and Aremu, 2011).

The mineral composition in mg/100 g of *Artocarpus altilis* and *Buchholzia coriacea* are presented in Table II. The result showed that toxic metals such as lead, cadmium, arsenic and chromium were not determined. The sodium content of *Artocarpus altilis* and *Buchholzia coriacea* were 67.19 mg/100 g and 58.18 mg/100 g, respectively. Sodium is an important mineral that assist in the regulation of body fluid and in the maintenance in the body tissue (Aremu *et al.*, 2012). The world health organization (WHO) recommended intake of sodium per day is 500 mg for adult and 400 mg for children (WHO, 1973). The result indicates that sodium content of *Artocarpus altilis* and *Buchholzia coriacea* were

Table II. Mean mineral composition (mg/100 g sample)[a] of *Artocarpus altilis* and *Buchholzia coriacea* seeds

Mineral	Artocarpus artilis	Bucchholzia coriacea
Sodium	67.19±0.20	58.18±0.01
Calcium	49.58±0.05	144.85±0.03
Potassium	658.42±0.011	369.64±0.02
Magnesium	206.16±0.08	115.91±0.10
Phosphorus	382.55±0.16	261.38±0.45
Iron	2.19±0.01	5.83±0.31
Copper	0.61±0.10	0.81±0.02
Zinc	3.82±0.10	0.22±0.10
Sodium/Potassium	0.10	0.16
Calcium/Phosphorus	0.13	0.55
Calciun/Magnesium	0.24	1.25

[a]Mean values ± standard deviation of triplicate determinations

Table III. Amino acid composition of *Artocarpus altilis* and *Bucchholzia coriacea* (g/100 g crude protein)

Amino acid	***Artocarpus altilis***	***Bucchholzia coriacea***
Lysine (Lys)[h]	3.35	4.03
Histidine (His)[h]	2.20	2.36
Arginine (Arg)[h]	5.16	5.76
Aspartic acid (Asp)	7.84	8.31
Threonine (Thr)[h]	2.99	3.44
Serine (Ser)	1.29	3.18
Glutamic acid (Glu)	9.99	11.35
Proline (Pro)	2.84	3.35
Glycine (Gly)	3.32	3.89
Alanine (Ala)	3.83	4.43
Cystine (Cys)	0.78	0.84
Valine (Val)[h]	3.45	4.00
Methionine (Met)[h]	0.91	1.33
Isoleucine (Ile)[h]	3.01	2.85
Leucine (Leu)[h]	6.80	7.09
Tyrosine (Tyr)	2.58	3.09
Phenylalanine (Phe)[h]	3.37	3.54
Isoelectric point (pI)	3.52	4.05
P–PER	2.35	2.43
Leu/Ile	2.26	2.49

[h]Essential amino acid; P–PER = Predicted protein efficiency ratio

below WHO recommended standard. Therefore *Artocarpus altilis* and *Buchholzia coriacea* cannot be regarded as rich source of sodium. The iron compositions were 2.19 mg/100 g for *Artocarpus altilis* and 5.83 mg/100 g for *Buchholzia coriacea.* Iron facilitates the oxidation of carbohydrates, proteins and fat (Aremu *et al*., 2012). It's also required for blood formation and normal functioning of the central nervous system (Adeyeye and Fagbohun, 2005). The RDA of iron in both adult and children is 10 mg/100 g and 15 mg/100 g for female adult per day (Delvin, 1992). Iron deficiency, anemia is mostly found among children, pregnant and menstruating women. This is reflected in dietary intake and increased frequency of achlorhydria (Delvin, 1992). The copper contents of *Artocarpus altilis* and *Buchholzia coriacea* were 0.62 mg/100 g and 0.81 mg/100 g. Report has shown that copper is required in the body for enzyme production and biological electron transport (Aremu *et al*., 2012). Zinc is an essential element for all animals including human beings and it plays an important physiological role. Zinc is also associated with many enzymes system, both as metallo-enzyme and enzymes activator (Sarma, 2006). Over 100 zinc metallo-enzymes have been described to date, including a number of regulatory proteins and both RNA and DNA polymerase (Delvin, 1992). Zinc is occasionally used therapeutically to promote wound healing and may be of some use in treating gastric ulcers (Goyer, 1997). Table II also shows that *Artocarpus altilis* and *Buchholzia coriacea* contained 3.82 mg/100 g and 0.22 mg/100 g zinc respectively. The result showed that *Artocarpus altilis* and *Buchholzia coriacea* were not good source of zinc since it is less than that the RDA (15 mg/100 g) for zinc. Copper and zinc are considered the less concentrated minerals in *Artocarpus altilis* (0.61 mg/100 g) and *Buchholzia coriacea* (0.22 mg/100 g), respectively. The most abundant mineral in both samples of *Artocarpus altilis* and *Buchholzia coriacea* were potassium 658.42 and 369.64 mg/100 g, phosphorus 382.55 and 261.38 mg/100 g, magnesium 206.16 and 115.91 mg/100 g and calcium 49.58 and 144.85 mg/100 g, respectively. Magnesium is an activator of many enzyme systems and maintains the electrical potential in nerves. Magnesium is required for all reactions involving ATP (Adenosine Triphosphate). ATP supplies the energy for physical activity by releasing energy stored in phosphate bonds. Report has shown that magnesium may help support mineral bone density in elderly women and men (Stendig–Lindberg *et al*., 1993). It has been reported that calcium in conjunction with phosphorus, magnesium, manganese, vitamin A, C and D, chlorine and protein are all

Table IV. Concentrations of essential, non–essential, acid, neutral, sulphur, aromatic, etc. (g/100g crude protein) of *Artocarpus altilis* and *Bucchholzia coriacea*

Amino acid description	*Artocarpus altilis*	*Bucchholzia coriacea*
Total amino acid (TAA)	63.61	72.84
Total non–essential amino acid (TNAA)	32.47	38.44
% TNAA	51.05	52.77
Total essential amino acid (TEAA)		
With histidine	31.14	34.40
Without histidine	28.94	32.04
% TEAA		
With histidine	48.95	47.23
Without histidine	45.50	43.99
Essential alphatic amino acid (EAAA)	16.25	17.38
Essential aromatic amino acid (EArAA)	3.37	3.54
Total neutral amino acid (TNAA)	35.17	41.03
% TNAA	55.29	56.33
Total acidic amino acid (TAAA)	17.83	19.66
% TAAA	28.03	26.99
Total basic amino acid (TBAA)	10.61	12.15
% TBAA	16.68	16.68
Total sulphur amino acid (TSAA)	1.70	2.17
% cystine in TSAA	45.88	38.71

involved in bone formation (Fleck, 1976). Modern diets that are rich in phosphorus may promote the loss of calcium to phosphorus ratio. This has led to the concept of calcium to phosphorus ratio (Ca/P). The Ca/P ratio of *Artocarpus altilis* and *Buchholzia coriacea* flour was found to be 0.13 and 0.55. Food is considered good if Ca/P ratio is above 1 and poor if the ratio is less than 0.5. While Ca/P ratio above 2 helps to increase the absorption of calcium in the small intestine. The Na/K ratio was found to be 0.10 for *Artocarpus altilis* and 0.16 *Buchholzia coriacea*. This ratio is of great significant and concern for the prevention of high blood pressure. Na/K ratio less than 1 is recommended. Thus, consumption of *Artocarpus altilis* and *Buchholzia coriacea* seeds would probably reduce high blood disease because it had Na/K ratio less than 1. The value of Ca/Mg in *Artocarpus altilis* and *Buchholzia coriacea* were 0.24 and 1.25, respectively. The recommended value of Ca/Mg ratio is 1.00 (NRC, 1989). Consequently *Buchholzia coriacea* will meet the required RDA for Ca/Mg ratio while *Artocarpus altilis* is below 1.00. Table III. shows the amino acid profile of the four legume seeds. Leu was the most concentrated (6.80 and 7.09 g/100 g cp) essential amino acid while the most concentrated amino acid was glutamic acid (9.99 and 11.35 g/100 g cp) in the *Artocarpus altilis* and *Buccholzia coricea* samples, respectively. Tryptophan was not determined. The value of leucine obtained in this study agrees and compares favourably with values obtained by some workers on studies of some Nigerian legumes (Oshodi *et al.*, 1998). The calculated isoelectric point (ρl) varied between 3.52 (*Artocarpus altilis*) and 4.05 (*Buccholzia coricea*). This is useful in predicting the ρl for protein in order to enhance a quick precipitation of protein isolate from biological samples (Olaofe and Akintayo, 2000).

The nutritive value of a protein depends primarily on the capacity to satisfy the needs for nitrogen and essential amino acids (Pellet and Young, 1980). The total essential amino acid (TEAA) values (with His) ranged between 47.23 % in *Buccholzia coricea* and 48.95 % in *Artocarpus altilis* (Table IV). These are comparable with values obtained from selected oil seeds which ranged between 33.3 and 53.6 % (Olaofe *et al.*, 1993) and soybean (46.5%) (Aisegbu, 1989), suggesting that these studied samples which are readily available in the south-south and south-east of Nigeria can be used as food supplements. Table IV also depicts the percent of total acid amino acids (TAAA) which was found to be greater than the percent of total basic amino acids (TBAA) in all the samples indicating that the protein is probably acid in nature (Aremu *et al.*, 2011). The concentrations of total sulphur amino acids (TSAA) which ranged between 1.70 and 2.17 g/100 g cp in *Artocarpus altilis* and *Buccholzia coricea* respectively are lower than the 5.8 g/100 g cp recommended for infants (FAO/WHO/UNU, 1985). Results of the amino acid scores are shown in Table V. Buccholzia coricea sample rated high when compared with Artocarpus altilis sample. However, with exception of Leu and Phe + Tyr in Buccholzia coricea, the essential amino acid contents were lower than the FAO/WHO (1991) recommended pattern. Thus by implication, dietary formula based on these plants will require some essential amino acids supplementation such as Met, Cys, Val, Ile, Thr and Lys. It has been reported that EAAs most often acting in a limiting capacity are Met (and Cys), Lys and Try (Aremu *et al,* 2006b,c). In this present study, Met + Cys (TSAA) were the first limiting amino acids in all the samples while Lys and Ile were the second limiting amino acids in *Artocarpus altilis* and *Buccholzia coricea*, respectively.

Conclusion

The present study showed that the two different plant seeds (*Artocarpus altilis* and *Buccholzia coricea*) were good

Table V. Amino acid scores of *Artocarpus altilis* and *Bucchholzia coriacea* based on FAO/WHO standards

EAA	PAAESP g/100g protein	*Artocarpus altilis*		*Bucchholzia coriacea*	
		EAAC	AAS	EAAC	AAS
Ile	4.0	3.01	0.75	2.85	0.71
Leu	7.0	6.80	0.97	7.09	1.01
Lys	5.5	3.25	0.59	4.03	0.73
Met + Cys (TSAA)	3.5	1.70	0.49	2.17	0.62
Phe + Tyr	6.0	5.95	0.99	6.63	1.11
Thr	4.0	2.99	0.75	3.44	0.86
Trp	1.0	nd	na	nd	na
Val	5.0	3.45	0.69	4.00	0.80
Total	36.0	27.15	5.23	30.21	5.84

EAA = Essential Amino Acid; PAAESP = Provisional Amino Acid (Egg) Scoring Pattern; EAAC = Essential Amino Acid Composition; AAS = Amino Acid Score; nd = Not determined; na = Not applicable sources of essential minerals and contained nutritionally useful quantities of most of the essential amino acids however dietary formula based on them may require some essential amino acids supplementation such as Ile, Lys, TSAA, Thr and Val.

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