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NUTRIENTS, ANTINUTRIENTS, THEIR CORRELATIONS AND MINERALS RATIOS IN THE FRUITS OF ORGANICALLY PRODUCED (*Corchorus olitorius*) CULTIVARS

Samuel O. Baiyeri[1*], Olawale T. Adeniji[1], Elias A. Jandong[2], Chimaluka C.A. Samuel-Baiyeri[3], Uju C. Osakwe[4], Oluyinka B. Adewoyin[1], Grace T.O. Otitoju[5]

[1]Department of Crop Science and Horticulture, Federal University, Oye-Ekiti, Nigeria.
[2]Department of Agronomy, Taraba State University, P.M.B. 1167, Jalingo, Nigeria.
[3]Department of Food Science and Technology, Federal University, Oye-Ekiti, Nigeria
[4]Department of Soil Science and Land Resources Management, Federal University, Oye-Ekiti, Nigeria
[5]Department of Hospitality and Tourism Management, Federal University, Wukari, Taraba State.

Corresponding author:1*

ABSTRACT- Most neglected, forgotten and under-exploited vegetables may go into extinction except their food, nutritional and nutraceutical potentials are discovered and harnessed. The fruit of *Corchorus olitorius* is one of its edible portions currently being under-exploited for dietary purposes due to poor awareness of their nutritional and anti-nutritional profiles. In order to unravel the potentials in *Corchorus* fruit for human nutrition and promote its utilization, organically produced *Corchorus* fruits were analyzed for nutrients and anti-nutrients, their correlations and mineral ratios using standard analytical procedures. Results showed that the fruits of *Corchorus* accessions varied significantly ($p<0.05$) in the nutritional and anti-nutritional parameters investigated. The fruits were rich in calcium, potassium, magnesium and phosphorus had appreciable iron and zinc but low in sodium and copper. The Ca/P ratios ranged from 11.04 to 25.53 while the Na/K was in the range of 0.0184-0.0202. Zinc showed a significantly negative relationship with phytate (r= -0.80**). Magnesium had significantly negative relationship with saponin (r= -0.69*). Crude fibre was significantly and negatively correlated with phytate (r=-0.79**). Dry matter had significantly negative relationship with saponin (-0.67*). The results indicated that the organically produced fruits were nutrient-rich with excellent mineral ratios suggesting their nutritional and nutraceutical benefits.

Key words: *Corchorus olitorius*, fruits, organically produced, mineral ratios, underutilized

1.0 INTRODUCTION

Crop biodiversity is an invaluable asset in the fight against poverty, food insecurity, and climate change vulnerability [7]. According to the Kew Royal Botanical Garden, [26] there are currently 391,000 plant species known to science, with 2,000 new species being found and named annually on the average; but a few number of crops are taking over the world's food systems [13]. Despite their importance in ensuring the food and nutritional security and generating money for the rural poor, many plant species that are grown for food around the world are underutilized [27]. Crops relegated to the fringes of research and development referred to as neglected and under-exploited crops (NUS). Comparing these species to common commercial crops, the word "neglected" highlights the low amount of research investment spent on them, and "under-exploited" alludes to their unrealized potential for subsistence [7]. Their potential worth has been undervalued and underutilized as a result of lack of attention. Additionally, it puts them in danger of additional genetic erosion and extinction, which would limit the poor's chances for progress. Numerous NUS are nutrient-rich [34; 22; 16].

Corchorus olitorius is an important neglected and under-exploited fruit, leafy and fibre vegetable that is usually produced mainly for its edible leaves and jute fibre. *Corchorus* has wide adaptation to varying climatic and soil factors and biotic stresses. Some decades back, the crop was widely consumed in various parts of Nigeria, and the vegetable was included in traditional cropping systems, but today the consumption of *Corchorus* is reducing due to the presence of some other vegetables that are considered more important than it. Very little conservation effort has been made on this very important vegetable due to poor funding and the underutilized state of the crop in Nigeria. Hence, there is currently genetic erosion of the biodiversity of *Corchorus* in Nigeria. Various aspects of the leaf have been investigated but not the fruit. Huge food, nutritional and economic losses are currently being incurred in Nigeria by farmers and especially women that grow *Corchorus* for its leaf but not aware of the dietary and economic potentials of the fruits. Some tribes in Kogi/Kwara States of Nigeria consume *Corchorus* fruits as well as its leaves. In the communities where *Corchorus* fruit is consumed, it is used in the preparation of delicious soups and the markets for *Corchorus* fruits are well developed. The huge losses are not only limited to Nigeria alone, the fruits of this vegetable are also not utilized in most parts of Africa. As the crop reaches maturity, a large number of *Corchorus olitorius* fruits are produced, which are then allowed to dry before the seeds burst from the dried pods. Consumers of this vegetable are unaware that the succulent fruits are edible and have food value in many regions of the world, including some parts of Nigeria [6].

Most people especially the elite and educated are usually skeptic about consuming a new food product without adequate knowledge of its nutritional and anti-nutritional compositions. Nutritional information about *Corchorus* fruits is still scanty in the literature. Samuel *et al.* [37] reported the nutrient and antinutrient compositions of *Corchorus* fruit in one cultivar while Baiyeri and Samuel-Baiyeri [6] investigated nutrient composition of the fruits of five accessions that were grown using inorganic fertilizer (NPK). The nutritional composition of various cultivars of the same crops varies, and it can also change depending on the fertilizer and pesticide treatment, growth conditions, season, and other factors [14]. Crops produced organically are more in demand [9]. There is currently no information on the variation in the nutrient and antinutrient compositions of *Corchorus* fruits that are organically grown. In spite of the huge mineral density reported by the earlier researchers on the fruits, no documented study has reported that the mineral ratios in *Corchorus* fruits are within the acceptable limits. The relationships among the proximate and antinutrients, minerals and antinutrients in the fruits are also scarce in the literature. The objective of this study were therefore to: a) determine the proximate, minerals, viscosity and antinutrients of the fruits of organically grown *Corchorus* accessions; b) investigate their mineral ratios; c) evaluate the correlations among proximate, minerals and the antinutrients in the fruits.

2.0 MATERIALS AND METHODS

2.1 Sample Collection

The *Corchorus* fruits analyzed in this study were collected from the agronomic evaluation trial of *Corchorus olitorius* accessions using poultry manure applied at 5 tonnes/ha. No other agro-chemicals were applied in the trial. The trial was located at the Research farm of the Ikole Campus of the Federal University, Oye-Ekiti (FUOYE), Nigeria. The biochemical analysis for the proximate, minerals, antinutrients and viscosity were carried out at the analytical laboratory at Faculty Agriculture, Ikole Campus FUOYE.

2.2 Proximate analysis of the fresh Corchorus fruits

The AOAC [5] method was used for the proximate analysis. Kjeldahl AOAC (955.04) technique was used to calculate crude protein. Using the oven drying AOAC method (930.15), the moisture content of fresh *Corchorus olitorius* fruits was determined. The AOAC (954.02) method for acid hydrolysis was used to determine the fresh fruit's crude fat content. The dry ashing AOAC (920.117) method was used to determine the fresh fruit's ash content. By employing the AOAC (978.10) method, crude fiber analysis was performed. The following formula was used to determine the amount of carbohydrates present in fresh *Corchorus olitorius* fruits: *Corchorus* fresh fruit's carbohydrate content is 100% - (%moisture + %protein + %fat + % ash + fibre).

2.3 Mineral analysis of the fresh Corchorus fruits

In order to analyze minerals, AOAC [5] method 968.08 was used. Using a Buck Scientific Atomic Absorption Spectrophotometer (Model: 210VGP) and particular cathode lamps for each micronutrient, the micronutrient concentrations in samples of digested fresh *Corchorus* fruit were calculated. With the use of a flame photometer, sodium and potassium were measured (Model: FP10). Based on calibration curves of the mineral standard solutions, the micronutrients were quantified. Each batch of analysis contained blanks, and verified reference standards were utilized to evaluate the analytical method's precision.

2.4 Determination of the Viscosity of the fresh Corchorus fruits

Five grams (5 g) of the milled fresh *Corchorus* fruits and 100 ml of the distilled water were combined in a beaker with vigorous stirring. Using a viscometer, the viscosity of each sample was determined.

2.5 Anti-nutrient determination in the fresh Corchorus fruits

The Davis and Reld method, as modified by Abulude, was used to determine the phytic acid concentration in fresh *Corchorus* fruit [1]. The Amorim *et al.* [4] method was used to determine tannin. The analytical technique developed by Obdoni and Ochuko [32] was used to determine saponin. AOAC [5] technique (915.03) was used to determine the fresh fruit's oxalate concentration.

2.6 Statistical analysis

Using the *R* statistical analysis software version 4.1.1, all data gathered were analyzed. The significance of the treatment means (determined by Fisher's least significant difference (F-LSD) at 5% probability level was done using the library *Agricolae*. The Pearson's correlation analysis using the library *Hmisc* was done to understand the strength of relationships that existed among the proximate qualities, antinutrients and the micronutrients studied in the fresh fruits of the *Corchorus olitorius* accessions.

3.0 RESULTS AND DISCUSSION

3.1 Proximate composition of the Corchorus fruits

The results of the proximate composition of the organically produced *Corchorus* fruit are shown in table 1. The crude protein content was significantly ($p<0.05$) influenced by accession. Co-Osun (3.08%) recorded the highest crude protein content; next to it was Co-Ondo (2.82%) while Co-Oyo (2.45%) had the least crude protein content. It was only crude fat among proximate parameters analyzed that was not significantly ($p>0.05$) affected by accession. Co-Osun and Co-Ekiti both recorded (0.16%) for crude fat, although statistically similar to the rest of the accessions, they recorded higher value for fat content. The crude ash content was significantly different and ranged from Co-Lagos (1.56%) to Co-Osun (1.31%). The moisture and dry matter contents of the *Corchorus* fruits were also significantly ($p<0.05$) affected by accession. Co-Ondo that recorded the least moisture content (85.69%) had the highest dry matter content (14.32%) while Co-Osun with the highest moisture content (89.50%) had the least dry matter (10.50%). Carbohydrate varied from Co-Ondo (8.38%) to Co-Osun (4.33%). Co-Oyo (7.27%) was also notably high in carbohydrate content. Crude fibre content of the accessions differed significantly and ranged from Co-Ekiti (1.77%) to Co-Ondo (1.52%). The proximate composition of the organically grown *Corchorus* fruits agreed with what has been reported for it by Samuel *et al.,* [37] and what has been reported for the fruits grown using inorganic fertilizer [6] except the fat and dry matter that were lower than what they reported. The proximate composition of the organically produced *Corchorus* fruits has revealed the fruits are nutritious. Its low in fat and low carbohydrate contents could make it an appealing vegetable for body weight management while the protein content could in some little way contribute to protein contents of the diets that are prepared with it. It is interesting to note that the Co-Osun that recorded the highest crude protein and the least carbohydrate in the present study also had similar composition among the accessions when they were evaluated with inorganic fertilizer [6] suggesting stability in these traits in this accession irrespective of the fertilizer type used in growing it.

Table 1. Proximate composition (%) of the fresh fruits of organically grown *Corchorus olitorius* accessions

Accession	Crude protein	Crude fat	Crude ash	Moisture	Dry matter	Carbohydrate	Crude fibre
Co-Ekiti	2.615	0.155	1.380	87.320	12.680	6.76	1.77
Co-Lagos	2.615	0.150	1.555	87.390	12.610	6.76	1.53
Co-Ondo	2.820	0.145	1.450	85.685	14.315	8.38	1.52
Co-Osun	3.080	0.155	1.305	89.500	10.500	4.33	1.63
Co-Oyo	2.450	0.150	1.445	87.150	12.850	7.27	1.57
Mean	2.716	0.151	1.427	87.409	12.591	6.7	1.604
$F\text{-}LSD_{(0.05)}$	0.091	NS	0.086	0.453	0.454	0.447	0.181
$CV_{(\%)}$	1.306	5.540	2.335	0.202	1.4012	2.598	4.390

NS= non-significant at 0.05 level

3.2 Mineral Composition of the Corchorus fruits

The results of the mineral composition of the organically grown *Corchorus* fruits are shown in Table 2. All the minerals were significantly ($p<0.05$) influenced by accession. The potassium (K) content of the fruits ranged from Co-Ekiti (636.5 mg/100 g) and was statistically similar to, and was closely followed by Co-Osun (635.7 mg/100 g) to Co-Ondo (563.4 mg/100 g) that recorded the least K content. The calcium (Ca) content of the fruits also ranged from Co-Osun (994.0 mg/100 g) to Co-Lagos (792.25 mg/100 g). Co-Ondo (984.00 mg/100 g) ranked second in the calcium concentration. Magnesium (Mg) varied from Co-Ondo (118.90 mg/100 g) to Co-Osun (102.20 mg/100 g). The phosphorus (P) content of the organically produced *Corchorus* fruits was significantly ($p<0.05$) affected by accession. Co-Ondo (89.15 mg/100 g) had the highest P content while Co-Oyo (35.00 mg/100 g) had the least P concentration. Iron was highest in the organically produced *Corchorus* fruits of Co-Osun (6.84 mg/100 g) while Co-Oyo (5.17 mg/100 g) had the least iron content. Co-Ekiti (4.09 mg/100 g) had the highest zinc content while Co-Ondo (3.43 mg/100 g) had the least zinc concentration. Co-Ondo (5.16 mg/100 g) was the most prominent for manganese while Co-Ekiti (1.76 mg/100 g) had the least content. Sodium (Na) ranged from Co-Ondo (11.15 mg/100 g) to Co-Ekiti (11.38 mg/100 g). The copper (Cu) ranged from Co-Oyo (0.21 mg/100 g) to Co-Lagos (0.17 mg/100 g).

The mineral contents of the fresh organically produced fruits were higher than what has been reported for dry okra fruits by Habtamu *et al.*, [18], were within the range of the mineral values reported for fresh C*orchorus* fruits grown with NPK by Baiyeri and Samuel-Baiyeri [6] but higher than what has been reported for fresh *Corchorus* fruits by Samuel *et al.* [37] for Ca, Mg, K, Fe and P. In the present study, K was better enhanced in the fruits of the *Corchorus* accessions except in Co-Ondo than what have been reported for K when the accessions were evaluated using NPK. Manganese was however lower in the present study except in Co-Ondo than the values reported in the fruits of these same accessions grown with inorganic fertilizer. The results further suggest that nutrient composition in *Corchorus* fruits may be largely influenced by accession and fertilizer types applied when it is being cultivated. The results of this study have revealed that the organically produced *Corchorus* fruits were rich in minerals. The *Corchorus* fruits were especially dense in Ca, K and Mg, had appreciable P, Fe and Zn but low in Na and Cu. This suggests that the fruits have potentials for the prevention and management of high blood pressure and hypertension. People with high blood pressure are encouraged to consume diets rich in K, Mg and low in Na. Magnesium, the second-most prevalent intracellular cation after K, participates in more than 600 enzymatic processes, including protein synthesis and energy consumption. Numerous illnesses, such as migraines, cardiovascular conditions, and diabetes, have been treated using magnesium [10]. It has been

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suggested that high K increases iron consumption [12]. The stability of the intracellular substances as well as blood clotting depends on calcium, which is also a key component of bone and teeth [33]. While zinc is crucial for many cellular functions, including appropriate growth, iron is necessary for the synthesis of hemoglobin, the regular operation of the central nervous system, and the oxidation of carbohydrates, protein, and fat [25; 31].

Table 2. Mineral composition (mg/100 g) of fresh fruits of organically grown *Corchorus olitorius* accessions

Accession	Potassium	Calcium	Magnesium	Phosphorus	Iron	Zinc	Manganese	Sodium	Copper
Co-Ekiti	636 5	947.00	112.60	54.80	6.525	4.090	1.755	12.145	0.185
Co-Lagos	631 4	792.25	112.40	71.05	5.835	3.530	2.740	12.000	0.165
Co-Ondo	563 4	984.00	118.90	89.15	5.785	3.430	5.160	11.380	0.185
Co-Osun	635 7.	994.00	102.20	62.15	6.835	3.625	2.335	11.715	0.180
Co-Oyo	622 2	893.00	109.05	35.00	5.170	3.875	2.325	11.705	0.210
Mean	617.4	922.05	111.03	62.43	6.03	3.71	2.863	11.789	0.185
$F\text{-}LSD_{(0.05)}$	12.90	13.013	3.4421	2.705	0.192	0.139	0.168	0.1623	0.021
CV	0.813	0.549	1.206	1.685	1.241	1.461	2.282	0.535	4.522

3.3 Results of anti-nutrients concentration in the Corchorus fruits

Table 3 shows the results of the analyzed antinutrients of the fresh organically produced *Corchorus* fruits. All the antinutrients were significantly influenced by accession. The phytate ranged from contents ranged from Co-Ekiti (42.51 mg/100 g) to Co-Lagos (47.70mg/100 g) that recorded the highest phytate content. The oxalate in the raw *Corchorus* fruits ranged from Co-Osun (60.55 mg/100 g) to Co-Ekiti (72.78 mg/100 g) that recorded highest oxalate content. Co-Osun recorded the highest value (142.50 mg/100 g) for tannin followed by Co- Ekiti (138.65 mg/100 g) while Co-Oyo (133.04 mg/100 mg) had the least tannin concentration. Co-Lagos and Co-Osun both recorded the highest saponin content (78.60 mg/100 g) and were significantly ($p<0.05$) higher than the rest of the accessions in their saponin concentrations with Co-Ondo (72.64 mg/100 g) having the least saponin content.

The levels of the anti-nutrients in the fruits of the organically produced fruit are comparable to what has been reported for oxalated, saponin, tannin and phytate in *Corchorus* fruits[20; 6] and lower than what has been reported for oxalate, phytate, tannin and saponin in the commonly consumed edible fruits in Northern Nigeria [41]. Boiling, steaming, frying, cooking, fermenting among many traditional food preparation methods have been found to be effective in reducing their antinutrients [15]. Despite claims that antinutrients impair nutrient uptake, recent research has shown that they also have significant health advantages, including anti-carcinogenic and antioxidant activity, the ability to chelate toxic metals like palladium and cadmium or excess Fe, and the prevention of harmful fenton reactions[38; 35]. Future breeding programmes and selection for lower antinutrients in *Corchorus* fruits could be of immense contribution to their nutrition. In common beans, several mutants with reduced phytic acid have been bred [40; 8], while genetic improvement has been used to develop a cultivar of fava beans with no tannins [17].

Table 3. The anti-nutrient concentrations (mg/100 g) of the fruits of organically grown *Corchorus olitorius a*ccessions

Accession	Phytate	Oxalate	Tannin	Saponin
Co-Ekiti	42.51	72.775	138.65	72.40
Co-Lagos	47.70	63.630	136.15	78.60
Co-Ondo	46.79	70.360	134.45	72.64
Co-Osun	44.30	60.550	142.50	78.60
Co-Oyo	45.50	64.400	133.04	76.56
Mean	45.36	66.343	136.96	75.76
$F\text{-}LSD_{(0.05)}$	0.709	0.7461	2.8914	0.962

3.4 The ratios of the minerals analyzed in the Corchorus fruits

The mineral ratios of the sodium and potassium in the *Corchorus* fruits are shown in Table 4. The ratio of sodium to potassium (Na/K ratio) of the organically grown raw *Corchorus* fruits varied significantly (p<0.05) among the accessions. The Na/K ratios were generally low. Co-Osun (0.0184) fruits recorded the least Na/K ratio and followed closely by Co-Oyo (0.0188) while Co-Ondo (0.0202) recorded the highest Na/K ratio. The Ca/P ratio of the raw organically grown *Corchorus* fruits analyzed in the accession differed significantly. Co-Oyo (25.53) recorded the highest Ca/P ratio, next to it was Co- Ekiti (17.29) while Co-Osun (11.04) recorded the least value. A healthy Na/K ratio is crucial since it is linked to the management of high blood pressure [43]. According to Yusuf *et al*., [43] a Na/K ratio of less than one is ideal and healthy. The Na/K ratios of the organically produced raw *Corchorus* fruits were far less than one (<1) which suggests their consumption could greatly enhance blood pressure control. With no exception, all the accessions recorded Na/K ratios that were less than 1 which were within the acceptable levels and this could make it quite desirable in the prevention of high blood pressure and its management in humans.

The idea of Ca/P was introduced by Shills and Young [39], who noted that diets high in animal protein and phosphorus tend to stimulate calcium loss in urine, which lowers the calcium levels in bones. According to Akinyeye *et al.* [3], a food source is healthy if the Ca/P ratio is greater than 1, and it is unhealthy if it is less than 0.5. It is interesting however, to note that the raw fruits of the organically produced *Corchorus* accessions had Ca/P ratios far above 1. The fruits of Co-Ondo accession with the highest Ca/P ratio, was as high as (25.53), which implies that *Corchorus* fruits are excellent and promising sources of minerals for bone formation and the maintenance of healthy bones.

Table 4. Mineral ratios of the fresh fruits of organically grown *Corchorus olitorius* accessions

Accession	Na/K	Ca/P
Co-Ekiti	0.0191	17.28
Co-Lagos	0.0190	11.15
Co-Ondo	0.0202	11.04
Co-Osun	0.0184	15.99
Co-Oyo	0.0188	25.53
Mean	0.0191	16.20
$F\text{-}LSD_{(0.05)}$	0.0004	1.15
$CV_{(\%)}$	1.306	5.540

3.5 The results of the Pearson's correlation coefficients among proximate qualities and anti-nutrients, and the minerals and anti-nutrients in the fruits of organically grown Corchorus

The result of the Pearson's correlation analysis showed that the organically produced *Corchorus* fruits among the proximate parameters and antinutrients showed that saponin and crude protein were positively and significantly related with tannin (r= 0.72*) (Table 5). Crude fibre was significantly and positively related with crude fat (r= 0.68*) and negatively correlated with phytate (r=-0.79**). Dry matter was significantly (p<0.05) and positively associated with carbohydrate (r=0.98*), oxalate (r=0.69*) and negatively related with saponin (-0.67*). Carbohydrate had a significant and positive relationship with oxalate (r= 0.65*) and negative relationship with tannin (r=0.85*) and saponin (r=-0.63*). Oxalate showed a very highly significant negative relationship (p<0.001) with saponin (r= -0.96***).

The results of the Pearson's correlation study among the minerals and antinutrients in the organically grown *Corchorus* fruits are shown in Table 6. Manganese had a significant and negative relationship with sodium (r=-0.80*) and potassium (r=-0.96*) and a positive relationship with phosphorous (r=0.78*). Potassium showed a significant (p<0.01) and negative relationship with manganese (r= -0.96**). Zinc showed a negative relationship with phosphorous (r= -0.75*) and manganese (r=-0.75*) and phytate (r= -0.80**). Iron showed a very highly significantly positive relationship with tannin (r= 0.94***). Magnesium showed a significant positive relationship with oxalate (r=0.74*) and a negative relationship with saponin (r= -0.69*).

The result has shown some significantly negative relationships among the nutritional traits and antinutrients such as: ash and tannin, saponin and carbohydrate and, fibre and phytate. Hence, increasing these nutritional traits through breeding concurrently lowers the antinutrients in *Corchorus* fruits. The positive correlations between the nutrient qualities and some of the anti-nutritional factors in the *Corchorus* fruits suggest the need for further research to screen other *Corchorus* germplasms for genotypes with increased proximate composition and reduced antinutrients. It further suggests the need for adequate processing in the fruits of the *Corchorus* accessions to ensure enhanced bioavailability of the nutrients. Since the measure of the genetic relationship between traits is indicated by the correlation coefficient's magnitude [2], the results of the correlations analyses in this study could be helpful in the choice of breeding strategy that will enhance genetic gains in the improvement of nutritional qualities of *Corchorus* fruits by future breeding programmes. The correlation results should therefore also be useful in developing crop and soil management practices for enhanced nutritional quality in *Corchorus* fruits. Hader [19] noted that various approaches to managing soil fertility have an impact on soil dynamics and plant metabolism, which leads to variations in plant composition and nutritional value.

Table 5. Pearson's Correlation coefficients among proximate qualities and antinutrients in the fresh fruits of the organically grown *Corchorus olitorius* accessions

	CP	Fat	Ash	DM	CB	Fib	Phy	Oxa	Tan	Sap
CP	1.00									
Fat	0.12	1.00								
Ash	-0.60	-0.51	1.00							
DM	-0.50	-0.46	0.58	1.00						
CB	-0.59	-0.47	0.61	0.98*	1.00					
Fib	0.02	0.68*	-0.62	-0.30	-0.34	1.00				
Phy	-0.10	-0.37	0.73*	0.40	0.40	-0.79**	1.00			
Oxa	-0.32	-0.12	0.07	0.69*	0.65*	0.35	-0.32	1.00		
Tan	0.72*	0.45	-0.69*	-0.79	-0.85*	0.49	-0.53	-0.28	1.00	
Sap	0.18	0.17	0.09	-0.67*	-0.63*	-0.30	0.35	-0.96***	0.27	1.00

******* Correlation is significant at the 0.001 level ****** Correlation is significant at the 0.01 level ***** Correlation is significant at the 0.05 CP = crude protein Fat = crude fat Ash= total ash DM = dry matter CB = carbohydrate Fib = crude fibre Phy = phytate Oxa = oxalate Tan = Tannin Sap = Saponin

Table 6. Pearson's Correlation coefficients among minerals and antinutrients in the fresh fruits of organically grown *Corchorus olitorius* accessions

	Na	K	Fe	Ca	Zn	Cu	Mg	Mn	P	Phy	Oxa	Tan	Sap
Na	1.00												
K	0.81	1.00											
Fe	0.31	0.37	1.00										
Ca	-0.47	-0.34	0.48	1.00									
Zn	0.61	0.56	0.11	0.06	1.00								
Cu	-0.33	-0.11	-0.45	0.27	0.47	1.00							
Mg	-0.22	-0.71*	-0.41	-0.11	-0.20	-0.02	1.00						
Mn	0.80**	-0.96**	-0.30	0.24	-0.75*	-0.09	0.66	1.00					
P	-0.40	-0.65*	0.22	0.17	-0.75*	-0.60	0.55	0.78*	1.00				
Phy	-0.43	-0.45	-0.59	-0.53	-0.80**	-0.26	0.37	0.61	0.46	1.00			
Oxa	0.11	-0.40	-0.02	0.24	0.36	0.09	0.74*	0.24	0.22	-0.32	1.00		
Tan	0.30	0.51	0.94***	0.39	0.08	-0.40	-0.61	-0.41	0.06	-0.53	-0.28	1.00	
Sap	0.10	0.52	0.02	-0.46	-0.31	-0.24	-0.69*	-0.34	-0.23	0.35	-0.96*	0.27	1.00

******* Correlation is significant at the 0.001 level ****** Correlation is significant at the 0.01 level ***** Correlation is significant at the 0.05 level. Na = sodium K= potassium Fe = iron Ca = calcium Zn = zinc Cu = Copper Mg = magnesium Mn = manganese P = phosphorus Phy = phytate Oxa = oxalate Tan = Tannin Sap = Saponin

3.6 The viscosity of the Corchorus fruits

The viscosity of the *Corchorus* fruits is shown in Table 7. The accessions differed significantly in their viscosities. Co-Ekiti (64.36 Pa-s) significantly ($p<0.05$) higher than the rest of the accessions in viscosity except Co-Oyo (63.67 Pa-s) while Co-Osun (36.07 Pa-s) was the least viscous. The viscosity of the *Corchorus* fruits has enormous potentials for human health, if fully exploited. Several studies using foods in different forms have found that increasing the viscosity of food reduces food in-take [11; 45] or suppresses appetite [28; 29]. Food viscosity increment may also slow the rate at which the stomach empties [30; 28; 24]. Since stomach distention is a major factor in how full you feel, the delayed gastric emptying may extend your feeling of satiety [20; 24]. Reduced food intake and satiety are key in preventing and managing over-weight and obesity in humans. The addition of *Corchorus* fruits to human dietary preparations and its consumption may help in addressing over-weight issues and preventing major chronic diseases, such as diabetes and cardiovascular diseases. According to reports, meals that are most viscous are the best at lowering post-prandial levels of glucose and insulin because they cause the stomach to take longer to empty and the small intestine's ability to absorb glucose to take longer [21; 20; 44]. The role of viscosity in reducing the glycemic index of foods in humans makes *Corchorus* fruit a promising vegetable that could help in the prevention and management of type-2 diabetes especially among the resource-poor.

Table 7. The viscosity (Pa-s) of the fresh fruits of the organically produced *Corchorus olitorius* accessions

Accession	Viscosity
Co-Ekiti	64.360
Co-Lagos	53.920
Co-Ondo	48.525
Co-Osun	36.065
Co-Oyo	63.665
Mean	53.307
$F\text{-}LSD_{(0.05)}$	0.948
$CV_{(\%)}$	0.692

4. 0 REFERENCES

[1] Abulude F.O. and Folorunso, R.A. 2003. Preliminary studies on nilipede; proximate composition, nutritionally valuable minerals and phytate contents. Global J Agric. Sci. 2:68-71
acute randomized controlled clinical trial. Croat Med. J. 49:772-82

[2] Agaba, R., Rubaihayo, P. Tukamhabwa, P., Mwanga, R.o.M, Tumwegamire, S., Ndirigwe, J., Heider, B. and Gruneberg, W. (2021). Genetic variation and response to selection for storage root dry matter and associated traits in a population of yam bean (*Pachyrhizus* spp.) interspecies crosses. Euphyti. 217(65):1-12.

[3] Akinyeye R.O., Oluwadahunsi, A. and Omoyeni, A. 2010. Proximate, minerals, anti-nutrients, phytochemical screening and amino acid composition of the leaves of *Pterocarpusmildbraedi*Harm. Electron. J. Environ, Agric. Food Chem. 9:1322-1333

[4] Amorim, E. L. C., Nascimento J. E., Monteiro J. M., PeixotoSobrinho T. J. S, Araújo T. A. S. and Albuquerque U. P. 2008. A simple and accurate procedure for the determination of tannin and flavonoid levels and some applications in ethnobotany and ethnopharmacology.Funct.Ecosys.Comm. 2(1):88-94

[5] AOAC (2005), Official method of Analysis (18th edition) Association of Official Analytical Chemists International. USA

[6] Baiyeri, S.O. and Samuel-Baiyeri, C.C.A. 2022. Evaluation of the minerals, proximate, viscosity and antinutrients of the fruits of *Corchorus olitorius* accessions. J. Austrian Soc. of Agric. Econs. 18(7): 1163-1171

[7] Bioversity International/IFAD 2021. How to do: promote neglected and underutilized species. https://www.ifad.org/documents/38714170/43559125/HTDN_NUS_3.pdf/297d93eb-330b-19a1-4804-c31d49e9fd37?t=1629384619783. Accessed on 19/08/2022

[8] Cominelli, E., Confalonieri, M., Carlessi, M., Cortinovis, G., Daminati, M., Porch, T. 2018. Phytic acid transport in *Phaseolus vulgaris*: a new low phytic acid mutant in the PvMRP1 gene and study of the PvMRPs promoters in two different plant systems. Plant Sci.270:1–12

[9] Dangour, A. D. Dodhia, S.K. Hayter, A. Allen, E., Lock, K. and Ricardo, U. 2009. Nutritional quality of organic foods: a system review. Am J Clin.Nutr.90:680-685

[10] De Baaj, J.H. F., Hoenderop, J.G. J. and Bindels, R.J. M**.** 2015. Magnesium in man: Implication for health and disease. Physiol. Rev.95:1-46

[11] de Wijk, R.A., Zijlstra, N., Mars, M., de Graaf, C., and Prinz, J.F. 2008. The effects of food viscosity on bite size, bite effort and food intake. Physiol. Behav. 95: 527–532

[12] Elinge, C. M., A., Muhammad, F. A., Atiku, A. U., Itodo, I. J., Peni, O., Sanni, M. 2012. Proximate, mineral and anti-nutrient composition of pumpkin (*Cucurbitapepo*L) seeds extract. Int. J. Plant Res. 2:146–150

[13] FAOSTAT (2013). Production, food, balance and land use data. Available online: http://www.fao.org/faostat/en/?#home (accessed on 18 May 2018)

[14] Food Standard Agency 2002.McCance and Widdowson's the composition of foods. 6th summary edition. Cambridge, United Kingdom: Royal Society of Chemistry foundation for Statistical computing, Vienna, Austria

[15] Geraldo, R., Santos, C.S., Pinto, E. and Vasconcelos, M.W. 2022. Widening the Perspectives for Legume Consumption: The Case of Bioactive Non-nutrients. Front. Plant Sci. 13:772054

[16] Ghane, S. G. Lokhande, V. H. Ahire, M. L. andNikam, T. D. 2010. "IndigoferaglandulosaWendl. (Barbada) a potential source of nutritious food: underutilized and neglected legume in India," Gen. Res. Crop Evol. (57)1:147–153

[17] Gutierrez, N., Avila, C. M., Moreno, M. T., and Torres, A. M. 2008. Development of SCAR markers linked to zt-2, one of the genes controlling absence of tannins in faba bean. Aust. J. Agric. Res.59:62–68

[18] Habtamu, F., G., Ratta, N.,Haki, G.D., Woldegiorgis, A. Z. and Beyene, F. 2015. Nutritional quality and health benefits of okra (Abelmoschus esculent. us): A review. J. Food Process Tech. 6:1–6

[19] Hader, T. 1986. The role of organic matter in the introduction of biofertilizers and biocontrolagens to soil. In: Chen Y, Avnimelech Y, eds. The role of organic matter in modern agriculture. Boston. MartinusNijhoff Publishers, pp 169-180.

[20] Jenkins, A.L., David J.A. Jenkins, D. J.A., Wolever, T.M.S., Rogovik, A. L., Jovanovski, E., Božikov, V., Rahelić, D., and Vuksan, V. 2008. Comparable postprandial glucose reductions with viscous fiber blend enriched biscuits in healthy subjects and patients with diabetes mellitus:

[21] Jenkins, D.J.A., Wolever, T.M.S., Leeds, A.R., Gassull, M.A., Haisman, P., Dilawari, J., Goff, D.V., Metz, G.L. and Alberti, K.G.M.M. 1978. Dietary fibres, fibre analagoues and glucose tolerance: importance of viscosity. Brit. Med. J. 1392-1394

[22] Johns, T. and Eyzaguirre, P. B. 2006. "Symposium on "wild gathered plants: basic nutrition, health and survival" Linking biodiversity, diet and health in policy and practice," *Proceedings of the Nutrition Society*, vol. 65, pp. 182–189

[23] Jones, K.L., Doran, S.M., Hveem, K., Bartholomeusz, F.D.L. and Morley, J.E. 1997. Relation between postprandial satiation and antral area in normal subjects.Am J ClinNutr 66: 127–132

[24] Juvonen, K.R., Purhonen, A.K., Salmenkallio-Marttila, M., Lahteenmaki, L. and Laaksonen, D.E. 2009. Viscosity of Oat Bran-Enriched Beverages Influences Gastrointestinal Hormonal Responses in Healthy Humans.J Nutr. 139: 461–466

[25] Kermanshah, A., P. Ziarati, J. Asgarpanah, and M. Qomi. 2014. Food values of two endemic wild *Almond* species from Iran. Int. J. Plant Anim. Environ. Sci. 4:380–388

[26] Kew Royal Botanical Garden, (2022). Available online: https://phys.org/news/2016-05-royal-botanical-gardens-world.html Accessed.13/09/2022

[27] Magbagbeola, J. A. Adetoso, . J. A. and Owolabi, O. A. 2010. "Neglected and underutilized species (NUS): a panacea for community focused development to poverty alleviation/ poverty reduction in Nigeria," J Econ. Int. Fin. 2(10): 208–211

[28] Marciani, L., Gowland, P.A., Spiller, R.C., Manoj, P. and Moore, R.J.2001. Effect of meal viscosity and nutrients on satiety, intragastric dilution, and emptying assessed by MRI. Am J Physiol-Gastroint Liver Physiol. 280: G1227–G1233

[29] Mattes, R.D. and Rothacker, D. 2001. Beverage viscosity is inversely related to postprandial hunger in humans. Physiol. Behav. 74:551–557

[30] Meyer, J.H., Gu, Y., Elashoff, J., Reedy, T. and Dressman, J. 1986. Effects of viscosity and fluid outflow on postcibal gastric emptying of solids.Am J Physiol. 250: G161–G164

ISSN: 18158129 E-ISSN: 18151027
Volume 19, Issue 05, May, 2023

[31] Mlitan, A. M., Sasi, M. S. and Alkherraz, A. M. 2014. Proximate and minor mineral content in some selected basil leaves of *Ocimumgratissimum*L, in Libya. Int. J. Chem. Eng. Appl. 5:8–17

[32] Obdoni, B.O. and Ochuko, P.O. 2001. Phytochemical studies and comparative efficacy of the crude extract of some homeostatic plants in Edo and Delta States of Nigeria. Global J. Pure Appl. Sci. 8.203-208

[33] Okaka, J. C. and A. N. O. Okaka. 2001. Food composition, spoilage and shelf life extension, ocjarc. Academic Publishers, Enugu, Nigeria. Pp. 54–56

[34] Padulosi, S. Eyzaquirre, P. and Hodgkin, T. (1999). Challenges and Strategies in Promoting Conservation and Use of Neglected andUnderutilized Crop Species, edited by J. Janick, ASHS Press, Alexandria, Va, USA, 1999

[35] Petroski, W., and Minich, D. M. 2020. Is there such a thing as “anti-nutrients”? A narrative review of perceived problematic plant compounds. Nutri.12:2929

[36] R Development Core Team, *R.* 2011. A Language and Environment for Statistical 1, R

[37] Samuel, F.O., Ayoola, P.B. and Ejoh, S.I. 2020. Nutrient, antinutrient and sensory evaluation of *Corchorus olitorius* fruit. Ife J. Agric. 32(1)*:*13-20

[38] Shi, L., Arntfield, S. D. and Nickerson, M. 2018. Changes in levels of phytic acid, lectins and oxalates during soaking and cooking of Canadian pulses.Food Res. Int.107:660–668

[39] Shills, M.E. and Young, V.R. 1988. Modern nutrition in health and disease.In:Nutrition. Nieman DC, Butterworth DE and Nieman CN (eds). Winc Brow Publishers.Dubugne, USA. pp. 276-282

[40] Sparvoli, F., Laureati, M., Pilu, R., Pagliarini, E., Toschi, I. and Giuberti, G. 2016. Exploitation of common bean flours with low antinutrient content for making nutritionally enhanced biscuits. Front. Plant Sci.7:928

[41] Umar, H.A., Adamu, R., Dahiru, D., and Nadro, M.S. 2007. Levels of anti-nutritional factors in some wild fruits of Northern Nigeria. Afr. J. Biotech. 6(16):1935-1938

[42] Wang, G.J., Tomasi, D., Backus, W., Wang, R., and Telang F. 2008. Gastric distention activates satiety circuitry in the human brain. Neuroimag. 39: 1824–1831

[43] Yusuf, A.A., Mofio, B.M. and Ahmed, A.B. 2007. Nutrient contents of pride of Barbados (*Caesalpiniapulcherrima* Linn.) seeds. Pak. J. Nutr. 6:117-121

[44] Zhu, Y., Hsu, W. H., Hollis, J.H. 2013. The impact of food viscosity on eating rate, subjective appetite, glycemic response and gastric emptying rate.Pl. One. 8(6):e67482

[45] Zijlstra, N., Mars, M., de Wijk, R.A., Westerterp-Plantenga, M.S. and de Graaf, C. 2008. The effect of viscosity on ad libitum food intake.Int. J Obes. 32: 676–683