PHENOTYPIC TRAITS AND CHEMICAL PROPERTIES OF *JATROPHA CURCAS* SEEDS FROM NORTHERN GHANA

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Abstract

This study was carried out to examine the physical features, proximate composition and oil quality of *Jatropha curcas* seeds from Nyankpala and Bole in the Northern Region of Ghana. The unit mass of *J. curcas* seed and kernel, length, width, breadth, geometric and arithmetic mean diameter, volume, bulk density, solid density and sphericity were considered. The physical properties of *J. curcas* seed and kernel between the two provinces were significantly different ($p \leq 0.05$) with the exception of bulk density. The geometric features of seeds and kernel from Nyankapla were greater than those from Bole. Proximate composition of crude protein for Nyankpala and Bole was 21.67 ± 0.795 and 23.14 ± 0.781 respectively. Ether extract of *J. curcas* seeds from Bole (22.41± 2.98%) was significantly higher ($p<0.05$) than from Nyankapla (18.37± 2.14). Oil properties indicated stability and high saturation among the oil samples. The study reveals that variation in agro-climatic conditions of the two provinces influence the seed physical features. This finding will serve as useful data for the design and improvement of *J. curcas* seed and kernel processing machine and for the use of *J. curcas* seed meal as potential feed in animal husbandry.

Keywords: *Jatropha curcas*, physical properties, geometric features, feed

1.0 Introduction

The genus *Jatropha* belongs to the tribe *Joannesieae* in the *Euphorbiaceae* family and contains approximately 170 known species (Kumar and Sharma, 2008). *Jatropha (J.)* varieties which have been identified include *J. curcas*, *J. integerrima*, *J. gossypifolia* among others (Krishnan and Parama, 2009). *J. curcas* has been given the needed attention among the other varieties for its rich source of oil as biofuel (biodiesel) and medicinal properties (Krishnan and Parama, 2009). According to Salawu *et al.,* (2013), *J. curcas* seeds serve as an outstanding source of biofuel that can serve as substitute to fossil fuel, which is expected to be exhausted in the long term. Extracted oil from *J. curcas* is employed in making soap, cosmetic products (Becker and Makkar, 1998) and pesticides (Kuashik and Kumar, 2004). With the increasing demand for poultry and other livestock products, processed seeds, kernel and seed meals from *J. curcas* are anticipated to serve as feed sources for livestock production. *J. curcas* produces a trilocular ellipsoidal fruit. The fruits are green when unripe (Heller, 1996) and turn yellow when matured. Numerous research works on *J. curcas* seed and seed chemical characterization have been carried in most Jatropha cultivation zones (Martinez-Herrera *et al.*, 2006; Halilu *et al.*, 2011). Halilu *et al.* (2011) reported *J. curcas* seed weight to range from 0.28 - 0.80 g from Nigeria and 0.45- 0.72 g for seeds from Mexico (Martinez-Herrera *et al.*, 2006). *Jatropha curcas* fruit contain about 1 - 4 seeds and are black in colour and about 2 cm long and 1 cm thick (Heller, 1996). Ghosh and Singh (2011) indicated that *J. curcas* seed and seed composition varies widely with respect to province as well as agro-climatic zones.

In Ghana *J. curcas* is of growing interest in the Northern Region as a suitable area for its production and studies. Despite numerous documented physical properties of *J. curcas* seed in growing areas, inadequate data exist on the physico-chemical properties of *J. curcas* seed cultivated in Northern Region of Ghana. Physical and chemical characterization of the Ghanaian grown *J. curcas* seed is of importance to enhance efficient equipment design for oil extraction, seed handling and utilization of the seed's by-product. The aim of this study was to characterize the geometric and physico-chemical properties of seeds of *J. curcas* grown in two provinces (Bole and Nyankpala) within northern Ghana.

2.0 MATERIALS AND METHOD

2.1 Study area

Dried *J. curcas* seeds for the study were harvested from Nyankpala (A Guinea Savanna zone, Location Lat. 09° 25‘N, Long. 00° 58‘ W; average daily temperature 28.3 °C; annual rainfall of 1043 mm; average humidity of 58 %) and Bole (located on the coordinates: Lat. 9° 2’ N and Long. 2° 29’ W in the Northern Region of Ghana). *J. curcas* characterization and proximate analysis was conducted at the Spanish grant laboratory of the Department of Biotechnology, University for Development Studies.

2.2 Collection of *J. curcas* seeds

J. curcas seeds were collected in November and December 2013. The seeds were harvested from their fruit pulp, packaged in sterile plastic bags and stored under room temperature. Samples taken for analysis were kept for a week.

2.3 Morphological characterization of seeds and kernel of *J. curcas*

Two batches of 100 *J. curcas* seeds from each location were counted. Each seed in a batch was weighed using Sartorius CP224S analytical scale.

The length, width and breadth of each of 100 seeds were measured with a 1 mm precision calibre using Mitutoyo pair of callipers (Figure 1).

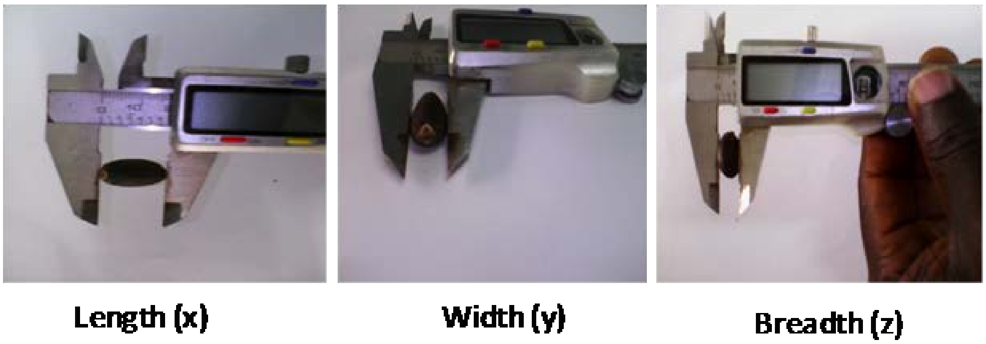

Figure 1: Three main dimensions of *J. curcas* seeds
Similar measurement were carried out for the kernels

2.3.1 Arithmetic mean diameter and geometric mean diameter

The arithmetic mean diameter (Da) and geometric mean diameter (Dg) of seeds and kernels were calculated from the geometrical dimensions as illustrated by Mohsenin (1980) and Bahnasawy (2007).

Arithmetic mean diameter (Da) = $\frac{x \times y \times z}{3}$ ……………………………...(1)

Geometric mean diameter (Dg) = $(x \times y \times z)^{1/3}$ …...…………...……..(2)

2.3.2 Sphericity, (Ø)

Sphericity, (Ø) of seeds and kernels was calculated based on the isoperimetric property of a sphere (Mohsenin, 1980).

Sphericity, (Ø) = $\sqrt[3]{(x \times y \times z)}/x$ ……………….…………….(3)

The higher the sphericity value for the seed, the closer is its shape to a sphere.

2.3.3 Volume of seed and kernel of *J. curcas*

The volume determination of seeds of *J. curcas* was based on that of (Mohsenin, 1980). The unit volume, Vu (cm^3) of seeds or kernels was determined based on the assumption that *J. curcas* seeds and kernels are similar to a scalene ellipsoid where x > y > z (Figure 2).

Figure 2: Three main dimensions of *J. curcas* seeds where x-axis is length, y-axis is width and z axis is breadth. Source: Karaj *et al.*, (2008).

The volume (Vu) of an ellipsoid was calculated using the Mohsenin (1980) formula

Volume (Vu) = $\frac{4}{3}\pi\ (x \cdot y \cdot z)$ ……………………………………………..(4)

2.3.4 Bulk density (ρb)

The bulk density is the ratio of the mass of the sample to its container volume. The bulk density of *J. curcas* seed was determined by weighing a filled measuring cylinder with known volume.

Bulk density = $\frac{Mass\ of\ seeds\ in\ cylinder}{Volume\ of\ measuring\ cylinder}$ ……………………………….(5)

2.3.5 Solid density

The solid density or true density is defined as the ratio of mass of the sample to its true volume (Mohsenin, 1980; Joshi et al., 1993). This was determined as:

Solid density = $\frac{mass\ of\ seed\ or\ kernel}{n \times Vu}$ ………………………………………(6)

Where n is number of seed/kernel in the sample

2.4 Proximate analysis of *J. curcas* seed

2.4.1 Moisture and volatilization content

Moisture and volatility test of *J. curcas* seed meal was carried out according to Nayak and Patel (2010), thus, five grams of defatted *J. curcas* seed was accurately weighed into a petri dish of known weight (wgt) and kept in hot-air oven maintained at 110 °C for 12 h. Samples were allowed to cool in a desiccator for 30 min and weighed. This was replicated thrice for each sample.

Moisture percentage was calculated as =

$$\frac{(\text{wgt of sample+dish before drying}) - (\text{wgt of sample+dish after drying})}{\text{wgt of sample taken}} \text{ X } 100 \ldots\ldots\ldots(7)$$

2.4.2 Ether extracts (oil percentage)

Dried and ground Jatropha samples (3 g) were weighed into clean empty thimbles. The thimbles were plugged with small cotton wool using disposal gloves. Clean extraction cups were weighed and their weights recorded. Then 50 ml petroleum ether was measured into each of the extraction cups in a fume cupboard. Thimbles were then carefully inserted into the condensers of Soxtec apparatus, using the thimble holder. The extraction cups were then placed into the Soxtec apparatus and the handle was carefully clamped down. Samples were allowed to boil at 150 ^{0}C for 45 min. After boiling the knobs on the service unit were moved to rinsing position to lift thimbles out of the solvent and rinsed for 30 min. The air button on the service unit was then pressed to open the evaporation valves on the Soxtec unit to evaporate last traces of solvent from the extraction cups in approximately 20 min. The oil was allowed to cool for 30 min in a dessicator, before the extraction cups with the oil were removed and weighed. Percentage (%) oil/fat was calculated using the formula

$$\text{Percentage Oil (\%)} = \frac{\text{weight of oil}}{\text{weight of sample}} \text{ X } 100\% \ldots\ldots\ldots(8)$$

Where Weight of oil/fat = W2-W1, with W1= weight of extraction cup, W2 = weight of extraction cup + oil

The crude protein, carbohydrate, and total ash contents were determined in accordance with the methods described by Chikpah and Demuyakor (2012).

3.0 RESULTS AND DISCUSSION

3.1 *Jatropha curcas* seed and kernel characterization

The length of seeds of *J. curcas* sampled from Nyankpala ranged between 1.5 - 2.3 cm, width between 0.9 – 1.3 cm, breadth between 0.6 – 1.0 cm whilst the length, width and breadth of Bole seeds ranged between 1.4 – 2 cm, 0.9 – 1.3 cm and 0.6 – 1.2 cm respectively (Table 1). *J. curcas* seed weight from Nyankpala and Bole ranged between 0.54 – 0.94 g and 0.51 – 0.99 g respectively. The maximum seed weight of 0.99 g and minimum seed weight of 0.51 g was obtained from Bole.

Table 1: Physical properties of *J. curcas* seeds (on dry matter basis) from Bole and Nyankpala

Means of treatments								
Parameter	Nyankpala				Bole			
Whole seed	N1	N2	Max	Min	B1	B2	Max	Min
Seed length (cm)	1.80	1.77	2.3	1.5	1.75	1.74	2	1.4
Seed width (cm)	1.13	1.12	1.3	0.9	1.09	1.14	1.3	0.9
Seed breadth (cm)	0.91	0.88	1.0	0.6	0.83	0.87	1.2	0.6
Arithmetic diameter (cm)	1.28	1.26	1.43	1.03	1.22	1.25	1.47	1.00
Geometric diameter (cm)	1.23	1.20	1.34	0.96	1.17	1.20	1.42	0.94
Seed weight (g)	0.78	0.77	0.94	0.54	0.78	0.75	0.99	0.51
Volume (cm^3)	7.75	7.33	10.05	3.77	6.66	7.31	12.1	3.52
Solid density (g/cm^3)	0.10	0.11	0.15	0.09	0.12	0.11	0.13	0.07
Sphericity	0.68	0.68	0.77	0.57	0.67	0.69	0.78	0.60

Geometric and arithmetic diameters of *J. curcas* seeds from Nyankapla were greater than seeds from Bole. The sphericity values of seeds from the two zones were almost the same (Table 1). The basic physical properties of analysed fraction of *J. curcas* kernel in terms of length, width, breadth weight, arithmetic diameter, geometric diameter and volume of samples from Nyankpala were greater than samples from Bole (Table 2). However the maximum and minimum kernel length and width were about the same. Kernel weight of *J. curcas* seed samples from Bole and Nyankpala contributed 65% and 64% of whole seed weight respectively whiles shell weight contributed 35% and 36% respectively (Table 2).

Table 2: Physical properties of *Jatropha curcas* kernel (on dry matter basis) from Bole and Nyankpala

Parameter	Nyankpalaa				Bole			
	N1	N2	Max	Min	B1	B2	Max	Min
Kernel length (cm)	1.50	1.50	1.7	1.2	1.34	1.38	1.7	1.2
Kernel width (cm)	0.91	0.91	1.0	0.6	0.80	0.84	1.0	0.6
Kernel breadth (cm)	0.74	0.74	0.9	0.4	0.63	0.68	1.0	0.5
Arithmetic diameter (cm)	1.05	1.05	1.20	0.83	0.92	0.97	1.17	0.83
Geometric diameter(cm)	0.99	0.99	1.15	0.75	0.88	0.92	1.14	0.77
Kernel weight (g)	0.50	0.49	0.61	0.32	0.51	0.48	0.65	0.31
Volume (cm^3)	4.22	4.23	6.41	1.76	2.86	3.35	6.28	1.91
Solid density g/cm^3	0.14	0.14	0.17	0.08	0.21	0.19	0.31	0.12
Sphericity	0.67	0.67	0.75	0.50	0.66	0.67	0.78	0.59
Shell weight (g)	0.28	0.28	0.28	0.26	0.27	0.27	0.27	0.25
% Kernel wgt of seed	64.1	63.6			65.4	64.0		
% Shell wgt of seed	35.9	36.4			34.6	36.0		

The mean values of *J. curcas* seed length, breadth and width from Nyankpala were 1.79, 0.89 and 1.13 cm respectively, whiles those from Bole were 1.79, 0.89 and 1.12 cm respectively (Table 3). There was significant difference between values obtained for both basic and complex geometric features of seed and kernel from Bole and those from Nyankpala (Tables 3 and 4). There was also significant difference ($P < 0.05$) between the weight of seeds from Bole and Nyankpala. Similar inference was made for kernel weight (Table 3).

Table 3: Comparison of basic physical properties of *J. curcas* seeds and kernel between two geographic sites (Nyankpala and Bole) in northern Ghana

	mean values ± standard deviation			
Parameter	**Nyankpala**	**Bole**	**p. Value**	**t-test**
Whole seeds				
Seed length (cm)	1.79 ± 0.11	1.75 ± 0.11	0.001	-3.57
Seed breadth (cm)	0.89 ± 0.07	0.85 ± 0.07	0.001	-5.10
Seed width (cm)	1.13 ± 0.07	1.12 ± 0.07	0.001	-1.69
Arithmetic diameter (cm)	1.27 ± 0.064	1.24 ± 0.064	0.001	- 2.26
Geometric diameter (cm)	1.22 ± 0.063	1.19 ± 0.063	0.001	- 4.59
Seed weight (g)	0.78 ± 0.07	0.76 ± 0.08	0.028	-3.01
Kernels				
Kernel length (cm)	1.50 ± 0.88	1.36 ± 0.09	0.001	-15.57
Kernel breadth(cm)	0.74 ± 0.09	0.66 ± 0.07	0.001	-9.82
Kernel width (cm)	0.91 ± 0.07	0.82 ± 0.08	0.001	10.87
Arithmetic diameter (cm)	1.05 ± 0.065	0.95 ± 0.066	0.001	- 4.80
Geometric diameter (cm)	0.99 ± 0.07	0.90 ± 0.068	0.001	-14.04
Kernel weight (g)	0.49 ± 0.05	0.49 ± 0.07	0.625	0.49

The mean bulk density of *J. curcas* seed from Nyankpala was higher than those from Bole; though there was no significant difference between the two samples. However, the bulk densities of their kernels were similar (Table 4). There was no significant difference between kernel bulk density of samples from Nyankpala and Bole. The mean solid density values of *J. curcas* seed of Nyankpala and Bole were similar but the solid density of seed and kernel from the two districts were significant different. Meanwhile the solid density of the seeds' kernel from Bole was higher than Nyankpala (Table 4). It was revealed that, kernel bulk density and solid density of *J. curcas* from Nyankpala and Bole were higher than their seeds.

Table 4: Complex geometric characteristics of *Jatropha curcas* seeds and kernels from Bole and Nyankpala districts in northern Ghana

Parameters	**Nyankpala**	**Bole**	**p. value**	
	Mean values ± standard deviation			
Seed				
100 seed weight (g)	77.71 ± 0.83	76.39 ± 1.65		
Volume of seed (cm^3)	7.54 ± 1.12	6.96 ± 1.21	0.001	- 4.64
Sphericity of seed	0.68 ± 0.031	0.68 ± 0.032	0.001	-0.62
Bulk density of seed (g/cm^3)	0.45 ± 0.01	0.43 ± 0.01	0.325	3.67
Solid density of seed (g/cm^3)	0.11 ± 0.01	0.11 ± 0.01	0.001	4.34
Kernel				
100 kernel weight (g)	49.34 ± 0.69	49.26 ± 1.65		
Volume of kernel (cm^3)	4.23 ± 0.83	3.10 ± 0.74	0.001	-14.15
Sphericity of Kernel	0.66 ± 0.036	0.67 ± 0.036	0.015	-0.97
Bulk density of kernel (g/cm^3)	0.48 ± 0.007	0.48 ± 0.007	0.273	9.78
Solid density of kernel (g/cm^3)	0.14 ± 0.01	0.20 ± 0.02	0.001	34.58

3.2 Physico-chemical characteristics of *Jatropha curcas* oil

Proximate composition of *J. curcas* seed from Bole and Nyankpala revealed significant differences in moisture and ash content (Table 5). The ether extract of the oil from the Bole seeds (22.41 ± 2.98%) was not significantly different from the extract from the Nyankpala seeds (18.36 ± 2.14 %): a similar trend was found in the crude protein (Table 5). The free fatty acid content of oil samples from Bole (8.25 ± 0.05%) was higher than ($p<0.05$) that from Nyankpala (3.44 ± 0.06%). The mean iodine value of oil samples extracted from the seeds from Bole and Nyankpala were 85.1 ± 2.13 mg/g and 85.0 ± 4.04 mg/g respectively; there were no significant differences ($p > 0.05$) between the samples from the two districts (Table 5). The peroxide (*Ip*) value of the seed oil from both districts was less than 8. However, peroxide value (*Ip*) of Bole samples (1.84 ± 0.06) was significantly lower ($p<0.05$) than the values of the Nyankapla samples (3.81 ± 0.19).

Table 5: Physico-chemical characteristics of *Jatropha curcas* whole seed and extracted oil from Bole and Nyankpala districts in northern Ghana

Samples	Nyankpala	Bole	P -value
Colour	Golden yellow	Golden yellow	
Moisture volatilities (%)	8.18 ± 0.214	6.83 ± 0.118	0.001
Ash (%)	1.87 ± 0.019	1.89 ± 0.004	0.043
Crude protein (%)	21.67 ± 0.795	23.14 ± 0.781	0.084
Ether extract %	18.37 ± 2.14	22.41 ± 2.98	0.129
% FFA as oleic acid	3.44 ± 0.06	8.25 ± 0.05	0.001
Iodine Value (mg/g)	85.1 ± 2.13	85.0 ± 4.04	0.977
Peroxide value (*Ip*) (meq/kg)	3.81 ± 0.19	1.84 ± 0.06	0.001

3.3 Correlation between physical parameters, proximate composition and oil quality of *J. curcas* seed

There was correlation between all physical parameters, proximate composition as well as oil quality. There was positive correlation between ether extract (oil content), weight of kernel, volume of seed and kernel (Table 6). This suggests that under similar conditions, the volume of whole seed or kernel of *J. curcas* is proportional to the amount of oil extracted. The correlation between ether extract and kernel weight was strong. This implies that higher percentage kernel weight will yield more oil. This is similar to the findings of Chikpah and Demuyakor (2014). According to Chikpah and Demuyakor (2014) oil yield from *J. curcas* kernel was higher than from the whole seed. The influence of moisture on free fatty acid in Jatropha oil was also positively correlated.

Table 6: Correlation in physico-chemical properties of *Jatropha curcas* seed from Bole

Ash	1	-												
Ether extract (oil)	2	0.2585	-											
FFA	3	-0.4424	-0.9807	-										
IV	4	-0.1516	-0.994	0.9535	-									
Kernel weight	5	-0.4915	0.7143	-0.5636	-0.7863	-								
Moisture	6	0.6749	-0.5384	0.3633	0.6271	-0.9744	-							
PV	7	-0.9949	-0.16	0.35	0.0515	0.5766	-0.7456	-						
Crude protein	8	-0.6186	-0.9189	0.9783	0.8704	-0.3802	0.1624	0.5365	-					
Seed weight	9	-0.9417	0.0817	0.1147	-0.1899	0.7559	-0.8839	0.9707	0.3181	-				
Sphericity kernel	10	0.9838	0.4275	-0.596	-0.3264	-0.3273	0.5316	-0.9608	-0.7495	-0.866	-			
Sphericity seed	11	0.9417	-0.0817	-0.1147	0.1899	-0.7559	0.8839	-0.9707	-0.3181	-1	0.866	-		
kernel volume	12	0.9562	0.53	-0.6856	-0.4344	-0.215	0.4292	-0.9219	-0.8215	-0.8018	0.9932	0.8018	-	
Seed volume	13	0.9945	0.3584	-0.5341	-0.2545	-0.3974	0.5937	-0.9789	-0.6977	-0.9011	0.9972	0.9011	0.9816	-
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**

IV = Iodine value, PV = Peroxide value, FFA = Free fatty acid

Also there was correlation between all measured physico-chemical properties of *J. curcas* sampled from Nyankpala (Table 7). Ether extract (oil), volume of seed and kernel, sphericity of kernel, kernel weight and seed weight was strongly correlated to each other. In addition, moisture content was strongly correlated to the amount of free fatty acid. Thus moisture in oil extracted or seed sample can cause the oil from the seed to be rancid, since moisture contributes to the hydrolysis of oil samples.

Table 7: Correlation in physico-chemical properties of *Jatropha curcas* seed from Nyankpala

Ash	1	-												
Ether extract	2	0.9854	-											
FFA	3	0.1273	0.2943	-										
IV	4	0.5383	0.3869	-0.7674	-									
Kernel weight	5	0.9177	0.8366	-0.2774	0.8288	-								
Moisture	6	0.3088	0.4663	0.9827	-0.6353	-0.0945	-							
PV	7	-0.0448	-0.2142	-0.9966	0.8178	0.3559	-0.964	-						
Protein	8	-0.0932	-0.2613	-0.9994	0.789	0.3101	-0.9758	0.9988	-					
Seed weight	9	0.9499	0.8829	-0.189	0.7746	0.9959	-0.0037	0.2696	0.2225	-				
Kernel sphericity	10	0.9972	0.9698	0.0524	0.6	0.9449	0.2366	0.0304	-0.0182	0.9707	-			
Seed sphericity	11	0.9972	0.9698	0.0524	0.6	0.9449	0.2366	0.0304	-0.0182	0.9707	1	-		
Kernel volume	12	0.9999	0.9835	0.1162	0.5476	0.922	0.2983	-0.0337	-0.0821	0.9534	0.9979	0.9979	-	
Seed volume	13	0.826	0.718	-0.4539	0.9196	0.982	-0.281	0.5261	0.4842	0.9608	0.866	0.866	0.8322	-
		1	2	3	4	5	6	7	8	9	10	11	12	13

IV = Iodine value, PV = Peroxide value, FFA = Free fatty acid

4.0 Discussion

4.1 Physical characterization of *Jatropha curcas* seed and kernel

In this study we characterized seeds and kernels of *J. curcas* from the district of Bole and Nyankpala. The geometric indices of the seeds and kernels of *J. curcas* from Bole and Nyankpala were statistically different. All geometric characterization of seeds and kernels of *J. curcas* from Nyankpala were greater than those from Bole. The physiological characteristics of *J. curcas* whole seeds sampled from the two districts had higher mean values compared to their respective kernel for all indices measured. The average weight of *J. curcas* seed from Nyankpala was greater than Bole samples. The difference in seed weight was as a result of variation in moisture content of the sampled seeds. This corroborates with the correlation between moisture content and seed weight. However, the seed weights were similar to earlier reports of Karaj *et al.* (2008). According to Karaj *et al.* (2008), Jatropha seeds could be grouped into four based on weight, 0.27 ± 0.055 g (group 1), 0.44 ± 0.042 g (group 2), 0.61 ± 0.060 g (group 3) and 0.78 ± 0.050 g (group 4). This suggests that seed samples weighed and used in this study could be placed in group four. Chikpah and Demuyakor (2012) reported that *J. curcas* seed from Nyankpala had an average weight of about 0.65 g, placing it in group three. The latter does not corroborate with the average weight of *J. curcas* seeds sampled for this study. Makkar *et al.* (1997) reported that the average Jatropha seed from Nyankpala weighed 0.571 g, which again is dissimilar to findings in this research. These suggest that variation exist among Jatropha seeds and corroborates with the findings of Karaj *et al.* (2008).

However, the average kernel weights from the two districts were similar. The kernel weights were similar to earlier reports of Karaj *et al.* (2008). In their finding, group four seeds of *J. curcas* had an average kernel weight of 0.49 ± 0.053 g. Kernel weights of Jatropha seed samples from Bole and Nyankpala contributed 65 % and 64 % of whole seed weight respectively. The seeds from Nyankpala had heavier shell weight than Bole thus the shell weight contributed 36 % and 35 % of the seed weight respectively. This implies that the weight of the shell of the seed significantly accounted for the weight difference among the seeds sampled. Since, the seeds sampled were of the same physiological age. In addition, variation in moisture content or influence of environmental condition contributed to the differences in seed weight. In the determination of physical, mechanical and chemical properties of seeds and kernels of *J. curcas*, Karaj *et al.* (2008) reported on higher mean values for *J. curcas* seeds when compared with those of kernels for all analyzed characteristics. This was observed in all the basic geometric characteristics of *J. curcas* seeds and kernels from Bole and Nyankpala. The kernel bulk density was greater than the seed bulk density with respect to each sample. Due to the small size or volume of the *J. curcas* kernel, more kernels were required to fill the 500 cm^3 cylinder compared to the large size or volume of the seeds. Solid density of both Nyankpala and Bole kernel was greater than their respective seed solid density. There was significant difference between solid densities of samples from Nyankpala and Bole. Significant difference in sphericity of seed and kernel were found between samples from Nyankpala and Bole; however the sphericity values of seeds within each zone were almost the same. Also, difference between sphericity values of the kernels from Nyankpala and Bole was statistically significant. The sphericity values of the seeds fractions were greater than their respective kernels which suggest that the seed were closer to the shape of a sphere than kernels. This result agrees with that of Karaj *et al.* (2008). The variation between geometric characteristics of *J. curcas* seeds and kernels sampled from Nyankpala and Bole might be as a result of agro-climatic discrepancy.

4.2 Physico-chemical characteristics of *Jatropha curcas* oil and defatted seed meal

Correlation between moisture content, seed weight and kernel weight from the two districts indicated an increase in weight of kernels and seeds result in decreasing moisture content. This implies that kernel and weight is dependent of moisture availability. Crude protein content of seeds from Bole and Nyankpala were similar to that reported by Chikpah and Demuyakor (2014). Oil samples were liquid at room temperature which implies that the oil samples were unsaturated. Free fatty acid content of oil from Nyankpala was lower than that from Bole. The iodine value is a measure of the average amount of unsaturation of fats and oils (Charlene *et al.,* 2004). The iodine values obtained indicated that oil samples extracted from *J. curcas* seed were unsaturated. The peroxide value (*Ip)* is the number that expresses in milli-equivalents to active oxygen the quantity of peroxide contained in 1000 grams of the substance (oil) (European Pharmacopoecia, 2005). Since peroxides are the first compounds formed during lipid oxidation, the value is an indication of the extent of oxidation during early stages of lipid deterioration and used as an index of freshness of the fat/oil. Oil having a peroxide value greater than 8.0 is considered to be rancid (Ravindran, 2008). The low peroxide value of oil samples from Nyankpala and Bole indicate that the samples were not rancid and indicate the oxidative stability of the oil. According to Eromosele *et al.* (1997), high iodine value and low peroxide value indicates that the seed oil upholds the good quality of semidrying oil purposes. The peroxide value of oil from Nyankpala was higher than its free fatty acid. This might probably be as a result of two acid pathways; oxidation pathways and those formed by hydrolysis (Sherwin, 1968). These two processes results in high peroxide value. Generally determination of FFA by titration does not differentiate between acids formed by oxidation and those formed by hydrolysis.

5.0 CONCLUSION

The physical or geometric characteristics of seed and kernel of seeds from Nyankpala were significantly different from those obtained from Bole with the exception of the bulk density of seed and kernel. The geometric features of samples from Nyankpala were greater than Bole. This suggests that variation exist in seed and kernel quality among *J. curcas* cultivation zones. The study also revealed that, strong correlation exists between the physical parameters of the seeds and their nutritional component. Knowledge about the correlation between *J. curcas* kernel, seed and oil yield is of importance during oil extraction.

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