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Effect of Fermentation on Some Chemical and Nutritive Properties of Berlandier Nettle Spurge (*Jatropha cathartica*) and Physic Nut (*Jatropha curcas*) Seeds

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Abstract: The seeds of *Jatropha curcas* and *Jatropha carthatica* were subjected to traditional fermentation (a common way of producing local condiments in Nigeria) with the aim of improving the nutritional properties. The result of the study revealed that the raw seeds have high nutrient level (protein, carbohydrate, fat, crude fibre and minerals) and moderate anti-nutrient level. Fermentation increased the antinutrient content of the seeds as well as most of the minerals. Acid values for the oil of the fermented seeds were higher while unsaponifiables were appreciably reduced by fermentation.

Key words: Chemical properties, fermentation, *Jatropha* oils, *Jatropha* seeds, fermented seeds

Introduction

Several plants exist with very high nutritive value and yet remain unexploited for human and animal benefits. *Jatropha curcas* and *Jatropha cathartica* are amongst such plants. *Jatropha curcas* and *Jatropha cathatica* are perennial plants, which do not require much care and produce well for 30 to 40 years after establishment. They deserve as much attention as they can receive worldwide so that as many people as possible can benefit from their obvious advantages.

Fermentation has always been an important part of our lives: Foods can be spoiled by microbial fermentations, foods can be made by microbial fermentations and muscle cells use fermentation to provide us with quick responses. Fermentation could be called the staff of life because it gives us the basic food, bread. Fermentation has some benefits exclusive to foods, fermentation can produce important nutrients or eliminate antinutrients. Food can be preserved by fermentation, since fermentation uses up food energy and can make conditions unsuitable for undesirable microorganisms. Food flavouring condiments in Nigeria are prepared by traditional methods of uncontrolled solid substrate fermentation. In Africa, the art of fermentation is widespread including the processing of fruits and other carbohydrate sources to yield alcoholic and non-alcoholic beverages and the production of sour-tasting ogi- the fermented cereal products, which provide instant energy in breakfast and convalescent diets (Adewusi *et al*., 1991). Oil seeds such as African locust beans, melon seed, castor oil seed, mesquite bean and soybean are also fermented to give condiments. This study was carried out to determine the proximate and mineral compositions of the seed as well as chemical and physical parameters of the oil before and after fermentation an attempt to assess the possibility of using the seeds for the production of a local condiment.

Materials and Methods

Jatropha curcas seeds were collected around Fanibi in Akure town, Ondo state Nigeria while *Jatropha cathartica* seeds were collected at Iju in Ondo State, Nigeria. In both cases the plants are used as boundries and to demarcate farmlands and plots of land.

The seeds were de-husked and de-hulled to gain access to a cream-coloured endocarp, which is the sample material. The sample materials were sun dried and in each case divided into two parts. One part was fermented as whole seed, while the other part was blended to powder form with a high-speed blender. Both parts were stored in airtight polythene bags and kept in a refrigerator prior to analysis.

Fermentation: The traditional method of fermentation used in the production of a Nigerian local condiment *(ogiri*) was used. The microorganisms involved in the traditional fermentation were natural inoculants from the air and the leaves used. 300g of sun-dried seeds were sorted out to remove grit, dirt and decomposing seeds. The seeds were boiled for three hours. This softened the seeds and made it easy to remove hulls from the few seeds that still had them. The boiling was done such that the water just dried up in the cooking pot to avoid any nutrients leaching away. The boiled seeds were then transferred to *Ewe Iran* (*Sarcophynum brachystachys*) leaves and wrapped in a sack clothe and allowed to incubate for 72 hours at room temperature. After three days the fermented product was heated gently in a pot to bring an end to the fermentation. The resulting product having a characteristic fermented product smell like that of "*ogiri*" (a Nigerian local condiment) was transferred into an airtight polythene bag and stored in a refrigerator.

Table 1: Proximate composition (%) of Raw and Fermented *Jatropha* seeds (dry sample basis)

Composition	*J. curcas* (r)	*J. curcas* (f)	*J. cathartica* (r)	*J. cathartica* (f)
Amoisture	5.00^{b}±0.010	34.57^{c}±0.50	2.53^{a}±0.1040	4.03^{d}±0.550
Crude fat	46.24^{b}±0.37	43.23^{a}±0.31	47.13^{c}±0.120	42.64^{a}±0.63
Crude fibre	2.57^{b}±0.350	8.49^{c}±0.280	1.60^{a}±0.1800	12.55^{d}±0.30
Crude protein	29.40^{b}±1.04	26.94^{a}±0.37	38.5^{c}±0.4900	33.47d±0.19
Ash content	4.90^{a}±0.260	5.63^{b}±0.12	6.32^{c}±0.1700	7.53^{d}±0.350
Carbohydrate	16.89^{d}±0.91	15.71^{c}±0.10	6.45^{b}±0.5010	3.81^{a}±0.460

NB:A-Moisture content was determined on the wet sample. Values with different superscripts in the same row are significantly different while values with the same superscript in the same row are not significantly different (at 95% confidence level).

Table 2: Mineral content (mg/100g) of raw and fermented seeds of *jatropha* (Dry sample basis)

Element	*J. curcas* (r)	*J. curcas* (f)	*J. cathartica*(r)	*J. cathartica* (f)
Ca	525.11^{a}±11.480	604.29^{b}±9.7900	721.58^{c}±20.830	913.38^{d}±27.290
Na	93.05^{b}±2.22000	105.64^{c}±2.3100	85.56^{a}±1.15000	142.79^{d}±0.2300
K	1081.26^{b}±16.42	1365.13^{d}±25.66	987.48^{a}±2.2300	1205.46^{c}±0.160
Mg	1041.68^{a}±2.430	1352.29^{b}±23.75	1030.71^{a}±13.13	1540.83^{c}±51.99
Zn	46.91^{a}±0.90000	65.90^{b}±0.41000	47.22^{a}±0.24000	80.82^{c}±0.16000
Fe	4.63^{b}±0.210000	3.36^{a}±0.160000	3.39^{a}±0.520000	5.90^{c}±0.900000
Cu	nd	nd	nd	nd
Mn	8.32^{a}±0.320000	12.07^{a}±0.16000	36.31^{b}±5.74000	33.77^{b}±3.75000
Ni	nd	nd	nd	nd
P	2122.81^{a}±9.890	2210.09^{b}±10.09	2125.19^{a}±0.000	2203.56^{b}±1.830
Pb	0.20^{a}±0.010000	0.58^{c}±0.010000	0.19^{a}±0.020000	0.34^{b}±0.040000

nd: not detected. Values with different superscripts in the same row are significantly different while values with the same superscript in the same row are not significantly different (at 95% confidence level).

Sample analysis: The dried ground sample was extracted with petroleum ether (boiling point 40-60°C) using a soxhlet apparatus. Extracted oils from the samples before and after fermentation were stored in screw-capped bottles for further analysis. Moisture content was obtained by heating the samples to a constant weight in a thermostatically controlled oven at 100°C. The ash and crude fat contents were obtained using the methods described by Association of Official Analytical Chemists (1990). Protein was determined using the micro-Kjeldhal method (N x 6.25). The method of Pearson (1981) was used for the determination of crude fibre while carbohydrate was calculated by difference. The mineral composition was determined on aliquots of the solutions of the ash by established atomic absorption/emmision spectrophotometer model 200-A produced by Buck Scientific. Phosphorus was determined by calorimetric means using the Vanadomolybdate (yellow) Method (A.O.A.C, 1990). The phytate content was determined by the method of Wheeler and Ferrel (1971) based on the ability standard ferric chloride to precipitate phytate in dilute HCl extracts of the sample. The tannin content was determined using the method of Makkar (Makkar and Goodchild, 1996). The acid value, saponification value, unsaponifiable matter, Wijs iodine value, refractive index were determined as described by Pearson (1981). The refractive index at 28°C was determined using Abbe refractometer. The specific gravity was determined by finding the ratio of the density of oil to that of water using a relative density bottle and at room temperature.

Analysis of data: All data represent means of triplicate determinations and are expressed as mean ± standard deviation. A one way analysis of variance (ANOVA) and the Least Significance Difference (LSD) were carried out. Significance was accepted at p = 0.05.

Results and Discussion

Table 2 shows the proximate compositions of the raw and fermented seeds of *Jatropha curcas* and *Jatropha cathartica*. Moisture content of the raw seeds of *Jatropha curcas* and *Jatropha carthatica* are 5.00% and 2.53% respectively. There was an increase in moisture content of the fermented samples to 34.57% and 44.03% respectively. This obviously is due to water absorbed during boiling. The moisture content for the raw seeds of *Jatropha cathartica* is about half of that reported for *Jatropha curcas*, however both are obviously lower than the 10% moisture content limit recommended for storage stability of flours (http: //wantonfeed. com/grain /life.html). High crude fat values 46.24% and 47.13% were reported for the raw *Jatropha curcas* seeds and *Jatropha carthatica* seeds, however these values are not significantly different from each other. Decreases in crude fat values were observed for the fermented products; this may be due to the utilization of lipids by fermentation microbes to obtain energy for their activity when sugars were in short supply. This result is comparable to the work on the effect of fermentation on the nutrient content of locust bean (Eka, 1980). Crude fibre values surprisingly increased for the fermented samples for both *Jatropha curcas* and *Jatropha cathartica*. An increase in crude fibre from 2.57 to 8.49%

Table 3: Phytate and Tannin contents of the raw and fermented seeds of *Jatropha* curcas and *Jatropha cathartica*

	Phytate (mg/100g)	Tannin (mg/100g)
Jatropha curcas (raw)	3688.42^{b}±30.72	590.00^{b}±2.170
Jatropha curcas (fermented)	4794.94^{d}±0.000	1284.5^{d}±13.54
Jatropha cathartica (raw)	2945.96^{a}±60.48	412.92^{a}±2.010
Jatropha cathartica (fermented)	4099.21^{c}±16.28	1242.75^{c}±4.83

NB: Values with different superscripts in the same column are significantly different while values with the same superscript in the same column are not significantly different (at 95% confidence level).

was recorded for *Jatropha curcas* while an increase of 1.60 to 12.55% was recorded for *Jatropha carthatica*. This result compares favourably with the work of Eze and Ibe (2005) on the effect of fermentation on the nutritive value of B. Eurycoma "Achi" where an increase in fibre content from 4.35% to 7.14% for the fermented sample was reported. The reason for unexpected increase in fibre content for the fermented samples may be due to the activities of microorganisms. The fermentation process involves the conversion of materials to the perculiar needs of the microorganisms, which include the bacterial cell wall. The bacterial cell wall is made of peptidoglycan or murein, which is a polysaccharide like cellulose. As the microorganisms were not separated from the biomass, the increase in fibre could be due to such conversion of materials to peptidoglycan by the microorganisms (Eze and Ibe, 2005).

Decreases were also recorded in the fermented samples for the crude protein values from 29.4% to 26.94% for *Jatropha curcas* and 38.5% to 33.47 % for *Jatropha cathartica*. This result is similar to the work of Eze and Ibe (2005)., on the effect of fermentation on the nutritive value of B. Eurycoma "Achi" where a decrease in protein content from 3.35% to 2.29% was reported. The decrease in crude protein content of the fermented samples may be due to the fact that the activities of microorganisms may lead to breakdown of some amino acids with the liberation of ammonia. The same trend was reported by Achinewhu and also by Eze and Ibe (2005) who observed that fermentation of oil bean led to a reduction in the levels of some amino acids (Achinewhu, 1983; Eze and Ibe, 2005). Such reduction may also be attributed to degradation of these amino acids by fermentative microorganisms. Fermentation increased the ash content from 4.90 to 5.63% for *Jatropha curcas* and 6.32% to 7.53% for *Jatropha cathartica*. This increase may be due to contribution by fermentation microorganisms. The same trend was the observed by Eka (1980) on the effect of fermentation on the nutrient status of locust bean where an increase of about 30% in ash content was recorded after fermentation, it also agrees with the observation of Amoo (2003) on the effect of fermentation on the nutrient and mineral content of *Bauhinia reticulata*. Carbohydrate content also decreased on fermentation from 16.89 % to 15.71% and 6.45 to 3.81% for *Jatropha curcas* and *Jatropha cathartica* respectively, this is obviously due to the fact that they were used up as the source of energy during fermentation.

The results of the mineral analysis for the raw and fermented samples are shown on Table 2. These results show that fermentation increased the content of vital elements such as, Phosporus, Potassium, Calcium and Magnesium in both samples. This observed increase in mineral composition may be due to the contribution from fermentation microorganisms. Copper and nickel were not detected in any of the samples. The level of Calcium, Potassium, Sodium, Zinc and Magnesium are quite high while those of Lead, Manganese and Iron are much lower. The mineral content of the raw and fermented samples were quite higher than that recorded for raw coconut by Amoo (2004), while studying the effect of roasting on the chemical composition of coconut (*Cocus nucifera*) seed flour and oil and that reported for gourd (*Cucurbita maxima*) seed by Amoo *et al.* (2004). These values were also higher than what was reported for African Oil Bean (*Pentaclethra marcrophylla*) by Odoemelam (2005). The samples could therefore be referred to as good sources of Calcium, Magnesium, Potassium and Phosphorus. The presence of lead of more than 0.2mg/100g in the fermented seeds may limit their consumption, however high mineral content in the raw and fermented seeds could serve as a basis of adopting the seedcakes of *Jatropha curcas* and *Jatropha carthatica* as organic manures.

Table 3 gives the phytate and tannin contents of the raw and fermented seeds of *Jatropha curcas* and *Jatropha cartatica*. Phytate levels in the samples increased with fermentation, 3688.42 to 4794.94 for *Jatropha curcas* and from 2945.96 to 4099.21 for *Jatropha cathartica*. The result compares favorably with the work of Makkar *et al.* (1998) on the effect of roasting on the anti-nutrients and toxic factors of *Jatropha curcas* where it was reported that phytate levels were either similar or higher for the roasted seeds. It appears therefore that heat treatment increased phytate level in the seeds. Tannin content was also increased in the fermented seeds; from 590.00 to 1284.5mg/100g for *Jatropha curcas* and 412.92 to 1242.75mg/100g for *Jatropha cathartica*. Decreases in crude protein content and increases in crude fibre contents of the samples with fermentation may not be unconnected to increases in tannin content of the fermented seeds. This is because tannin in food depresses growth by decreasing protein quality and digestibility (Adeyeye and Fagbohun, 2005).

Table 4 gives the physicochemical properties of the oils extracted from *Jatropha curcas* and *Jatropha carthatica* seeds. Statistical test at 95% confidence level revealed that increases in acid value for the fermented samples 3.21 to 4.12 for *Jatropha curcas* and 7.19 to 8.18 for

Table 4: Physicochemical properties of oils extracted from the raw and fermented seeds of *Jatropha*

Parameter	*J. curcas* (r)	*J. curcas* (f)	*J. cathartica* (r)	*J. cathartica* (f)
AV mgKOH/g	3.21^{a}±0.2000	4.12^{b}±0.0100	7.19^{c}±0.1800	8.18^{d}±0.0100
FFA mg KOH/g	1.61^{a}±0.1000	2.06^{b}±0.0100	3.60^{c}±0.1000	4.09^{d}±0.0000
Iodine Value	98.37^{a}±0.740	166.40^{d}±0.72	123.82^{c}±0.79	115^{b}.85±1.02
S V mg/g	198.50^{d}±0.50	153.83^{a}±1.26	173.00^{b}±1.00	189.5^{c}±0.500
Unsap matter %	15.00^{b}±0.000	5.00^{a}±0.0000	31.33^{d}±0.580	18.83^{c}±1.040
Refractive Index	1.463^{a}±0.001	1.467^{c}±0.001	1.465^{b}±0.001	1.467^{c}±0.001
Specific Gravity	0.91^{c}±0.0000	0.90b±0.0000	0.90^{b}±0.0000	0.89^{a}±0.0000
Smoke point °C	120.00^{b}±0.00	119.33^{b}±0.60	125.00^{c}±0.00	93.50^{a}±1.320
Flash point °C	304.0^{b}±0.000	321.33^{c}±0.60	342.5^{d}±0.500	300.0^{a}±0.000
Fire Point °C	349.50^{b}±0.50	367.00^{c}±0.50	372.17^{d}±0.29	334.00^{a}±0.00

NB: Values with different superscripts in the same row are significantly different while values with the same superscript in the same row are not significantly different (at 95% confidence level).

Jatropha cathartica) were significant. The acid value and free fatty acid are used as indicator of the edibility of the oil. These two parameters determine the application of the oil for either edible or industrial utility. Acid value of the oil suitable for edible purposes should not exceed 4 mg KOH/g (Esuoso and Odetokun, 1995).

The results indicate that *Jatropha curcas* oil becomes less edible on fermentation. On the other hand, the oil of *Jatropha cathatica* obviously has higher acid value (7.19) and cannot be considered as edible oil both in the raw and fermented states. Iodine value increased significantly from 98.36 to 166.40 for *Jatropha curcas* but decreased 123.82 to 115.85 for *Jatropha cathartica*. The variation in the effect of fermentation on the two samples may be due to the difference in the types and levels of fatty acids present in them. The values obtained for the iodine values of both the raw and fermented samples are indicative of drying or semi-drying oils. The high degree of unsaturation also suggests that the oils may be used as a drying oil for the manufacture of cosmetics, oil paints and varnishes. High saponification values were recorded for both samples in the raw and fermented states, however an inverse trend occurred with fermentation when compared with Iodine value. There was a drop in Saponification value from 198.5 to 153.83 for *Jatropha curcas* whereas an increase in saponification value from 173.0 to 189.5 occurred for *Jatropha cathartica*. Again, this may not be unconnected to varying levels of the types of fatty acids present in the samples. High levels of unsaponifiable matter observed for *Jatropha curcas* (15%) and *Jatropha carthatica* (31%) suggests that they both contain higher hydrocarbons such as cholesterol, phytosterol and paraffin hydrocarbons, which are of low nutritional value (Pearson, 1981). However, fermentation was able to significantly reduce the level of unsaponifiable matter in the two samples by at least 41%.There was no significant change in smoke point for the oil from the fermented sample of *Jatropha curcas* whereas for *Jatropha cathartica* smoke point dropped from 125.0°C to 93.5°C with fermentation. Generally, the smoke points observed for oils from both the raw and fermented samples were below 190°C, which is the normal deep-frying temperature, hence these oils may not be suitable oils for frying. An increase in flash and fire points was recorded for the oil of *Jatropha curcas* on fermentation while the oil from the fermented sample of *Jatropa cathartica* gave a decrease in flash and fire points. The high flash points (ranging between 300°C and 342.5°C) of the oils from both the raw and fermented samples are well above the flash points of petroleum based diesel fuel (70°C) and that of biodiesel (150°C) and therefore suggest that *Jatropha curcas* and *Jatropha cathartica* seed oils will be safer than these fuels if used to run automobile engines.

Conclusion: Traditional fermentation significantly affects the observed properties of *Jatropha curcas* and *Jatropha cathartica*, however, in most cases fermentation did not improve the nutritional quality of the seeds. The seeds are good sources of carbohydrate, protein and oil and minerals. The oils have Iodine values indicative of drying or semi-drying oils rather than edible oils, although moderate fatty acid level and moderate Iodine value of *Jatropha curcas* oil could be assessed in the manufacture of margarine. The oil from *Jatropha carthatica* is high in fatty acids and is clearly not edible but may be used as a drying oil for the manufacture of cosmetics, oil paints and vanishes. High saponification values of the oils suggest that they will be very good for soap making. The seed cake could be a good substitute for animal manures due to high levels of Nitrogen, Phosphorus and Potassium (NPK) observed. High flash and fire points reveal that the extracted oils could be better substitutes for petroleum-based lubricants both from the economic point of view as well as the safety aspect.

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