Studies on the Yield and Nutritional Properties of some Local Seeds: Effects of Drying Systems

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ABSTRACT

This study was undertaken in order to determine the oil yield and nutritional properties of oils extracted from the seeds of melon, Africa star apple, and tropical almond seeds. The oils were extracted from the corresponding seeds in a Soxhlet extractor with Hexane and analyzed for moisture content; oil yield; protein; vitamin A, D, E, and K; phenolic and flavonoid compounds; nitrogen; potassium; phosphorous; zinc; chloride; and magnesium.

The total flavonoid and phenolic compounds at drying temperatures of 50, 70, 90^{o}C, solar drying (80^{o}C), and no drying (i.e., control) from the Africa star apple seed oil were (7.12, 55.89), (8.89, 50.13), (8.94, 54.12), (8.38, 52.76), and (6.39, 51.13), respectively. The total flavonoid and phenolic compounds at drying temperatures of 50, 70, 90^{o}C, solar drying (80^{o}C) and no drying (i.e., control) from the tropical almond seeds were (8.56, 58.92), (8.54, 52.33), (8.40, 54.11), (8.38, 54.67), and (7.64, 59.64), respectively. The total flavonoid and phenolic compounds at drying temperatures of 50, 70, 90^{o}C, solar drying (80^{o}C), and no drying (i.e., control) from the melon seeds were (8.87, 61.22), (8.40, 60.83), (8.89, 62.36), (8.59, 60.13), and (8.36, 56.27). It is found that temperatures of the drying system affected the oil yield and also nutritional properties of the extracted oil. Oils could serve as feedstock for many industrial applications.

(Keywords: flavonoid, phenolic content, oil yield, hot air oven, drying methods, protein content, Soxhlet extractor)

INTRODUCTION

Nigeria, as a tropical country, has a wide variety of domestic plants that produce oil-bearing seeds of sufficient volume potential for industrial application, for example, edible seeds like soya bean, (Aluyor and Audu 2009) peanuts, and corn. According to Oderinde et al. (2009), Nigeria has one of the most extensive flora in continental Africa. Unfortunately, however, the vast majority of the seed oils have not been adequately characterized. Examples include Huracrepitans, (otherwise known as sandbox tree), neem, castor, rubber seed, et cetera Otoikhian (2008). Others are Melon, Tropical almond, and African star apple seeds.

Good nutrition is a basic human right. In order to have a healthy population that can promote development, the relation between food, nutrition and health should be reinforced. In developing countries, one of the ways of achieving this is through the exploitation of available local resources, in order to satisfy the needs of the increasing population. Knowledge of the nutritive value of local seeds local is necessary in order to encourage the increased cultivation and consumption of those that are highly nutritive. Several studies have been carried out including that of Teugwa et al. (1992) who determined the chemical composition of some local crops of the Far North Province of Cameroon ("Gniri/Follèré", "Gniri/Lalo" and "Gniri/Tasba", where "Gniri" is millet fufu were unbalanced due to excess carbohydrates and shortage of lipids, but with good levels of proteins, minerals and fibers.

The chemical and functional properties of the kernels and defatted cakes of Ricinodendronheudelotii and Tetracarpidium-conophorum, which are two underexploited oilseeds, largely consumed by the western and coastal populations of Cameroon were also analyzed. They showed that these oilseeds were good sources of lipids and proteins and that their defatted cakes could be used as protein

supplement in human nutrition. On the other hand the demand for drying is one of the most relevant and challenging processes of food industry, since a great number of food products are subjected to at least one drying step during its production (Wankhade et al., 2013).

Dehydration or drying of foods is described as any process that involves thermal removal of volatile substances to obtain a dry solid (Xiao et al., 2010). The main purposes of drying crops are to increase its shelf life, to better its quality, to simplify the handling, storage and transport of the products, and also to prepare the product for subsequent processes. Drying of Agricultural crops is done in most farms by sun-drying (Lasisi et al., 2013). This often results in contamination by insects and dust. Therefore, there is a need to introduce the use of different drying system. This study will therefore provide adequate information about a suitable drying method that will give the maximum nutrient retention of melon, tropical almond and African star apple seeds will also guide engineers in designing storage facilities for the seeds for various medicinal and nutritional uses.

Solar, open sun, hot air, and microwave drying are the mostly drying method used in drying theses seed, sun drying being the most common practice (Matazu and Haroun, 2014). These four drying systems (solar, open sun, hot air, microwave) utilize heat to remove water from food by evaporation. The removal of water by heat has been reported to affect the oil and nutrient contents of the seeds in various ways. It can either increase the concentration of some nutrients by making them more available or decrease the concentration of some nutrients (Hassan et al., 2007). This study is therefore carried out to establish the effect of these varying drying system on the oil and nutrition content of these seeds in order to determine the most suitable system that will not only increase their shelf life but also retain their nutrients adequately.

MATERIALS AND METHODS

The freshly harvested seed was sourced from the eastern part of Nigeria, Nsukka and Awka precisely during their various season of harvest. Materials used are: 1kg of different seeds, weighing balance, thermometer, solar over dryer, hot air oven dryer, Soxhlet extractor, beakers, chemical and reagents

Raw Material Preparation

The melon, Africa star apple, and tropical almond seeds undergo various processing in the course of its preparation for extraction. Some foreign materials and dirt which are separated by hand picking. The seeds were cracked to separate the shells from the kernel. The seeds were dried under the varying system to reduce its moisture content and manually grinded obtain a size of 2 mm sieve size in order to weaken or rupture the cell walls to release castor fat for extraction

Weighing and Drying of the Seeds

Different quantities of the seeds were weighed using electronic sensitive weighing balanced before drying, in order to calculate the moisture loss after drying. The samples been weighed are dried using different drying systems at varying temperatures.

Determination of Moisture Loss

The moisture loss (g) in the sample was determined by the measurement of the loss in weight due to drying at different temperature (Equation 1).

$$ML = (A - B) \quad \textbf{(1)}$$

Where, A is original weight of sample and B is weight of dried sample.

Oil Extraction from the Seed

The seed oil was obtained by extraction using (n-hexane) at 50-70-90°C in a Soxhlet extractor for the different seeds dried using hot air oven and at 90°C for seeds dried using solar dryer. Each milled sample is filled in a thimble. The round bottom flask is filled with the solvent (n-hexane) up to two-third of the flask. The reflux condenser was fitted to the top of the extractor and the water flow is turned on. The round bottom flask was placed in the heating mantle at the temperature as listed above for 3 hours.

After the extraction, the solvent was evaporated at 50 °C until the solvent evaporates.

Characterization of the Seeds Oil

Determination of oil yield in percentage (%): The percentage yield was calculated using the Equation (2):

$$Percentage\ yield\ of\ oil = \frac{Weight\ of\ oil\ (g)}{Weight\ of\ sample\ analyzed} \times 100 \quad \textbf{(2)}$$

Determination of Protein: The crude protein content was determined using the micro Kjedahl method.

Determination of Vitamin A: 1 g of each analysis oil was dissolved with 10 cm^3 of acetone in a 50 cm^3 conical flask and allowed to stand for 20 minutes and was shaken gently for every 4 minutes interval to extract the color substance in the sample. After agitation, the mixture was allowed to settle and was decanted to obtain a clear solution in a test tube. 5 cm^3 of hexane was added and shaken gently. Two distinct layers were observed. The upper layer was obtained by separation with a separating funnel and collected in a glass curvet and read off the absorbance at 453 nm in an Ultraviolet spectrophotometer.

Determination of Vitamin E: about 0.5 cm^3 of the oil sample was introduced into test tube with tight stopper and 0.5 cm^3 of anhydrous ethanol, Shaken for 1 minute. Also added was 3 cm^3 of xylene, the test plugged and shaken for 1 minute, centrifuged (1500 rpm for 1 minute). Measured 0.25ml of batophenanthio was introduced into the test tube. 1.5 cm^3 of extract (upper layer) was collected from the test tube mix, 0.25 cm^3 of $FeCl_3$ and 0.25ml of H_3PO_4 solutions were added, mixed and the absorbance at 539 nm was measured.

Determination of Vitamin K: about 1g of the oil sample was analyzed oil and then homogenized with 10 cm^3 of distilled water. 1 cm^3 of the supernatant pipette. 2 cm^3 of 0.04%, 2,4 dinitrophenylhyrazine was added in 1:5 hydrochloric acid was added, heated in boiling water for 45 minutes and cooled, diluted to 10 cm^3 with 1:30 ammonium hydroxide and the absorbance at 635 nm was measured.

Determination of Vitamin D: 1g of the oil sample was analyzed and then homogenized with 20 cm^3 ethanol. Centrifuge for 10 minutes at 300 rpm. 1 cm^3 of the supernatant was pipette and 0.5 cm^3 of 1% furfural was added. diluted to 2.5 cm^3 with ethanol and 1cm^3 of conc. H_2SO_4 added, mixed and after 2 minutes the absorbance at 525 nm was measured.

Determination of Minerals: about 5 g of oil sample was introduced into a conical flask for analysis. About 20 cm^3 of conc. HNO_3 and $HClO_4$ were mixed in a conical flask and digest on a hot plate at 130°C. The digestion was continued until the color appears clear, the silica became white and white fumes of $HClO_4$ appeared in the flask. The solution was mixed and made up to 50 cm^3 with distilled water, transferred to 250 cm^3 volumetric flask and diluted to mark with distilled water.

Determination of Nitrogen: The micro-Kjedahl method as described in Pearson (1976) was used in the determination of the nitrogen content.

Determination of Phosphorous by Ascorbic Acid Method: 2 cm^3 of the analysis oil was pipetted into a test tube. 1 cm^3 of ascorbic acid solution and 1 cm^3 of 2.57M ammonium molybdate reagents was added to the sample and mixed well. The well-mixed sample was boiled in a water bath for 5 minutes for the blue color to develop. The absorbance was read at 620 nm.

The phosphorus content was calculated using Equation (3):

$$Phosphorus = \frac{Absorbance\ of\ samples - Absorbance\ of\ blank \times D.F}{Slope} \quad \textbf{(3)}$$

Determination of Magnesium: Magnesium content was determined by AOAC (2000). 1 cm^3 of oil sample was pipette into 250 cm^3 conical flask with 25 cm^3 of distilled water, 25 cm^3 Ammonia – ammonium chloride buffer and a 2-3 drops of Erichrome black-T indicator; titrate against 0.01N EDTA. Equation (4) was used to calculate magnesium content (%).

$$Magnesium\ content\ (\%) = \frac{Volume\ of\ EDTA \times Weight\ of\ magnesium \times D.F}{100 \times Weigth\ of\ oil\ sample \times 10} \times 100 \quad \textbf{(4)}$$

Determination of Potassium: Potassium was determined by running the sample filtrate in a flame photometric with standard potassium according to the method described by AOAC (2000).

Determination of Zinc: Zinc content was determined according to the method described by Pearson (1976).

Determination of Chloride: 12.41g of sodium thiosulphate ($Na_2S_2O_4$ $5H_2O$) was dissolved in 1 liter of distilled water and 3 drops of chloroform added for preservation. Standard N/10 potassium iodide solution- Standard 10N of 16.6 g of potassium iodide in distilled water, concentrated HCL of specfic gravity 1.18 and Na_2HCO_3 were added. Starch paste was prepared with distilled water. 100 cm^3 was made with water and boiled by stirring and cooled.

Determination of Anti-Nutritional Factors

Total Phenolic Content: The concentration of phenolics was determined using spectrophotometric method. Folin-Ciocalteu assay method was used for the determination of the total phenol content. The reaction mixture consists of 1 cm^3 of oil sample and 9 cm^3 of distilled water was taken in a volumetric flask (25 ml). 1 cm^3 of Folin-Ciocalteu phenol reagent was treated to the mixture and shaken well. After 5 minutes, 10 cm^3 of 7% sodium carbonate (Na_2CO_3) solution was treated to the mixture. The volume was made up to 25 cm^3. A set of standard solutions of gallic acid (20, 40, 40, 60, 80, and 100 µg/ml) were prepared in the same manner as described earlier. Incubated for 90 min at room temperature and the absorbance for test and standard solutions were determined against the reagent blank at 550 nm with an Ultraviolet (UV)/Visible spectrophotometer. Total phenol content was expressed as mg of GAE/100g

Total Flavonoid Content: Total flavonoid content was measured by the aluminum chloride colorimetric assay. The reaction mixture consists of 1 cm^3 of analysis oil and 4 cm^3 of distilled water was taken in a 10 cm^3 volumetric flask. The flask was added 0.30 ml of 5% sodium nitrite and was treated and after 5 minutes, 0.3 cm^3 of 10% aluminum chloride was mixed. After 5 minutes, 2 cm^3 of 1M sodium hydroxide was treated and diluted to 10 cm^3 with distilled water. The absorbance for test and standard solutions were determined against the reagent blank at 510 nm with an UV/Visible spectrophotometer. The total flavonoid content was expressed in mg by 100 g.

RESULTS AND DISCUSSION

Results

Tables 1-3 present the values for oil and nutritional properties for tropical almond seeds, melon seeds and African star apple seeds at varying drying systems.

Discussion

Moisture Loss: From the Tables 1-3, the moisture loss for African star apple seeds were obtained and found to vary with drying temperatures- hot air oven (50, 70 and 90 °C), solar drying (80^{o}C) and open air drying.

Oil Yield: Increase in temperature of the dryer results in decrease in oil yield for all the seeds analyzed. The amount of oil yield in melon seeds is higher than that of Africa star apple seeds and tropical almond seeds. This could be due to genetic nature of the seeds. The optimum oil yield was obtained from the control sample at ambient temperature with the yield of 45.595%, 31.939%, and 26.241% for melon, tropical almond seeds and Africa star apple seeds respectively. The lowest oil yield for the same drying system was recorded at 90°C with the oil yield of 44.477%, 30.442%, and 24.966% for melon, tropical almond seeds and Africa star apple seeds respectively.

For African star apple, the oil yield of the seed vary from 25.498% to 26.241% indicating there is possibility of oil cell to break down and oil particles escape with the heat, however statistically, the value are not significantly different. The value of oil yield in this study is high compared to the values reported by Adejumo et al. (2012) and Agbede et al. (2011). This indicates that the seed may not be a good source of abundant oil. However, genetically modified breeds may be developed which could produce seeds with more oil yield.

Table 1: Oil and Nutritional Content of African Star Apple Seeds at Varying Drying Systems and Temperatures.

Properties	Hot Air Oven drying at 50°C	Hot Air Oven Drying at 70°C	Hot Air Oven Drying at 90°C	Solar Drying at 80°C	Control at Ambient Temperature
Moisture loss (g)	3.553	6.469	17.663	8.819	-
Oil yield (%)	25.498	25.450	24.966	25.690	26.241
Protein content (%)	0.550	0.544	0.494	0.481	0.444
Vitamin A (mg/g)	1.043	1.123	1.107	1.116	1.136
Vitamin D (mg/100g)	0.106	0.121	0.127	0.133	0.133
Vitamin K (mg/100g)	0.037	0.021	0.034	0.022	0.039
Vitamin E (mg/100g)	0.521	0.532	0.510	0.558	0.674
Nitrogen (%)	0.079	0.077	0.071	0.087	0.088
Zinc (mg/100g)	1.413	1.267	1.242	1.438	1.663
Magnesium (mg/100g)	37.920	37.574	33.866	38.550	37.839
Chloride (mg/100g)	0.056	0.051	0.057	0.036	0.023
Phosphorous (mg/100g)	131.110	123.606	123.584	129.641	137.770
Potassium (mg/100g)	76.580	77.691	72.425	76.961	83.640
Phenolic compound mg/100g	7.120	8.885	8.937	8.381	6.390
Flavonoid compound (mg/100g)	55.891	50.128	54.121	52.763	51.128

Table 2: Oil and Nutritional Content of Melon Seeds at Varying Drying Systems and Temperatures.

Properties	Hot Air Oven drying at 50°C	Hot Air Oven Drying at 70°C	Hot Air Oven Drying at 90°C	Solar Drying at 80°C	Control at Ambient Temperature
Moisture loss (g)	19.10	31.259	45.928	39.969	-
Oil yield (%)	44.972	44.864	44.477	44.977	45.595
Protein content (%)	0.544	0.550	0.450	0.556	0.569
Vitamin A (mg/g)	1.583	1.292	1.310	1.712	1.764
Vitamin D (mg/100g)	0.126	0.129	0.121	0.139	0.210
Vitamin K (mg/100g)	0.042	0.033	0.044	0.047	0.063
Vitamin E (mg/100g)	0.613	0.621	0.618	0.737	0.879
Nitrogen (%)	0.087	0.088	0.072	0.089	0.091
Zinc (mg/100g)	1.330	1.427	1.398	1.762	2.064
Magnesium (mg/100g)	35.064	32.129	30.642	34.912	36.647
Chloride (mg/100g)	0.026	0.016	0.025	0.021	0.057
Phosphorous (mg/100g)	131.660	132.261	133.991	131.647	138.647
Potassium (mg/100g)	75.690	83.421	84.420	83.330	84.420
Phenolic compound mg/100g	8.876	8.393	8.885	8.592	8.361
Flavonoid compound (mg/100g)	61.216	60.833	62.361	60.128	56.271

Table 3: Oil and Nutritional Content of Tropical Almond Seeds at Varying Drying Systems and Temperatures.

Properties	Hot Air Oven drying at 50°C	Hot Air Oven Drying at 70°C	Hot Air Oven Drying at 90°C	Solar Drying at 80°C	Control at Ambient Temperature
Moisture loss (g)	42.689	74.668	75.932	74.936	-
Oil yield (%)	31.041	30.995	30.442	31.220	31.939
Protein content (%)	0.475	0.462	0.437	0.475	0.494
Vitamin A (mg/g)	1.342	1.413	1.328	1.369	1.550
Vitamin D (mg/100g)	0.113	0.107	0.109	0.122	0.127
Vitamin K (mg/100g)	0.033	0.025	0.020	0.029	0.057
Vitamin E (mg/100g)	0.663	0.571	0.542	0.693	0.810
Nitrogen (%)	0.076	0.074	0.070	0.076	0.079
Zinc (mg/100g)	1.422	1.369	1.371	1.443	1.564
Magnesium (mg/100g)	31.423	30.646	31.129	31.227	33.330
Chloride (mg/100g)	0.030	0.039	0.041	0.038	0.024
Phosphorous (mg/100g)	141.392	140.016	136.761	140.391	147.220
Potassium (mg/100g)	71.112	70.327	70.047	760.428	75.676
Phenolic compound mg/100g	8.556	8.540	8.397	8.381	7.642
Flavonoid compound (mg/100g)	58.921	52.332	54.112	54.667	59.640

For melon, the amount of oil contain in this study is high compared to Yanty et al. (2008), they found out that melon contain lower contents of oil (25.0%). This difference arises from geographical conditions. De Melo et al. (2000) and De Mello et al. (2001) had earlier reported 30.83% and 32.3% in seeds of *Cucumis melo* hybrid and *Cucumis melo var. saccharinus* respectively. The highest

content (40%) was reported by Sorho et al (2006) in seeds *Cucumis amaris.*

Nutritional Properties of the African Star Apple Seed Oil

The nutritional properties results are presented in Table 1. The result showed that different levels of nutrient are contained in each seeds oil at varying drying temperature. For African star apple seed some of the nutrient properties are not really high compared to that of other seeds because of the genetic modification. The results for zinc are affected by the temperature as can be seen from the table. The zinc content is higher on the oil gotten from the control sample (open air drying) reading 1.663mg/100g and the lowest is that of oil gotten from the seed dried at 90°C using hot air oven dryer reading 1.242mg/100g. This shows that temperature has effect on the zinc content and this is applicable to the oil gotten from tropical almond and melon seed as well.

For chloride, the highest yield is that of the oil gotten from the seeds using hot air oven dryer at 90°C (0.057mg/100g) and lowest from oil gotten from the open air drying (0.023mg/100g). This is also the same for the entire oil sample and this show that temperature doesn't have effect on the chloride content.

For phosphorous, the highest yield is on the oil gotten from the open air drying (137.770mg/100g) and lowest yield is that of the oil gotten from the seeds dried using hot air oven dryer at 90°C (123.584mg/100g). These results agreed with Umelo (1997) who stated that *C. albidum* is an excellent source of vitamins, iron, and flavors to a diet.

Nutritional Properties of Tropical Almond Seed Oil

The nutritional properties results are presented in Table 3. The result showed that different levels of nutrient are contained in each seeds oil and the effect of temperature. For tropical almond seed the difference in the protein values are not significant as drying temperature doesn't affect the protein content. These values are low when compared to that of almond nut which is within the range 23.78–29.4% (Ezeokonkwo and Dodson, 2004; Omeje et al., 2008; Kimbonguila et al., 2010; Oliveira et al., 2000; Akpakpan and Akpabio, 2012).

It can be deduced from the results that an increase in temperature bring about a reduction in the vitamins content (i.e., vitamin D and K reading 0.5113 and 0.663 at 50°C and 0.57 and 0.810 for control sample). The reduction rate varies with the drying process for all the seeds. The decrease in the vitamin also varies with method of drying and nature of the vitamins.

From the results, temperature has effect on the zinc content Proximate analysis of the tropical almond shows that it is rich in protein (18.39–40.9%) and oil (43.36–63.65%). Similar studies have been done by Oliveira et al. (2000), Ezeokonkwo (2007), Biego et al. (2012), Monnet et al. (2012), and Atsu Barku et al. (2012). Ezeokonkwo and Dodson (2004) reported that the seed has essential amino acids that can support growth and a high dietary protein quality. Ezeokonkwo (2007) found out that the limiting amino acids in the tropical almond seed were tyrosine, lysine and methionine.

Nutritional Properties of Melon Seed Oil

The nutritional properties results are presented in Table 2. The result showed that nutritional properties of melon seed oil vary with drying temperature. The variation of protein content with drying temperature for the different systems is not significant. Increase in temperature bring about a reduction in the vitamins content (i.e., vitamin E and K reading 0.042 and 0.613 at 50°C and 0.063 and 0.879 for control sample). The reduction rate varies with the drying process for all the seeds. The decrease in the vitamin also varies with method of drying and nature of the vitamins.

Temperature has effect on the zinc content also. The mineral composition results of the seeds for potassium at lowest value reading 75.690mg/100g for hot air oven at 50°C. From the analysis, temperature doesn't have much effect on the value gotten from potassium as the value varies with changes in temperature. These results are not really in close agreement with those reported by Olaofe (1994) and Milovanovic (2005).

Manganese (Mn), copper (Cu), iron (Fe) and zinc (Zn) accounted for minor contents i.e. 1.59, 0.83,

4.90 and 4.65 mg/100g, respectively. Those percentages are comparable to those reported by Olaofe (1994) and Milovanovic (2005).

The presence of such chemical elements as K, Ca, Zn, Na and traces of nickel in foodstuffs was already reported for their important contribution to the maintenance of normal glucose levels and tolerance. These elements might contribute to the fight against the resistance to the release of insulin from the body. Only traces of cadmium (Cd), cobalt (Co) and nickel (Ni) were found.

CONCLUSION

Oil yield was successfully extracted from tropical almond seeds, melon seeds, and African star apple seeds with varying drying systems and various temperatures. The study showed that the oil was highest at 90^{o}C for melon (45.60%), tropical almond seeds at (31.94%) and African star apple seeds (26.24%). Also, the oil yield is influenced by the temperature and genetic nature of the seeds.

Most of the nutritional properties tested are highest for oil gotten from melon seeds. These seeds are good sources of some vital nutrients and are very rich in oil. Drying systems and temperatures had significant effect some of the nutritional properties of the oil gotten from the seeds.

The total flavonoid and phenolic compounds at drying temperatures of 50, 70, 90^{o}C, solar drying 80^{o}Cs and no drying (i.e., control) from the Africa star apple seed oil were (7.120, 55.89), (8.885, 50.13), (8.94, 54.12), (8.38, 52.76) and (6.390, 51.13), respectively.

The total flavonoid and phenolic compounds at drying temperatures of 50, 70, 90^{o}C, solar drying (80^{o}C) and no drying (i.e., control) from the tropical almond seeds (8.57, 58.92), (8.54, 52.33), (8.40, 54.11), (8.381, 54.68) and (7.64, 59.64).

The total flavonoid and phenolic compounds at drying temperatures of 50, 70, 90^{o}C, solar drying (80^{o}C) and no drying (i.e., control) from the melon seeds was (8.88, 61.22), (8.39, 60.83), (8.89, 62.36), (8.59, 60.13) and (8.36, 56.27).
The high oil and nutritional content of these seeds studied showed that they can be good feedstock for bio fuel production and rich source of valuable nutrient to man.

RECOMMENDATIONS

It is recommended that further study should be done to determine the physio-chemical properties of the oil from these seeds, in order to ascertain their suitability for biofuel purposes.

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