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INFLUENCE OF STORAGE DURATION OF JATROPHA CURCAS SEED ON OIL YIELD AND FREE FATTY ACID CONTENT

J. O. Akowuah, A. Addo and F. Kemausuor
Department of Agricultural Engineering, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
E-Mail: akowuahjoe@yahoo.co.uk

ABSTRACT

Interest in biodiesel as an alternate fuel for diesel engines has increased in recent years. An important consideration in selection of feedstock for biodiesel production is the content of free fatty acid (FFA) in the oil. However, the FFA is affected by the storage duration and condition of the feedstock before extraction. This paper investigates the effect of storage period of *Jatropha* seeds on the oil yield and FFA content of the extracted oil. The study was carried out for a period of four (4) months. The FFA content and seed oil yield was determined before storage as control and regularly at monthly intervals. 50g of seed samples at an initial moisture content of 6.39% wb stored at room temperature and milled using a grinding machine to a particle size of 0.5mm. The Soxhlet extractor was used to extract the oil using petroleum ether as solvent. At average marginal moisture increase of 0.1% over the storage period, oil yield decreased significantly from 35.57% to 31.1%. Conversely, the FFA content (%) which is one of the critical parameters in the biodiesel production process also increased from 7.83% to 32.1%. The study concludes that, storage duration and improper handling of *Jatropha* seeds during storage have an effect on the quality *viz.* FFA content of the extracted crude oil for biodiesel production.

Keywords: *Jatropha curcas*, storage duration, oil yield, free fatty acid, moisture content.

INTRODUCTION

Interest in biodiesel as an alternative fuel for diesel engines has increased in recent years due to environmental concerns on emissions from petroleum based fuels. Biodiesel has therefore attracted extensive attention as a renewable, biodegradable and non-toxic fuel since the past decade (Stavarache *et al.*, 2007; Sarin *et al.*, 2007; and Tiwari *et al*., 2007).

A lot of research has exploited the viability of using various edible oils such as sunflower seed oil, soyabean oil, palm oil and palm kernel oil as feedstock for biodiesel. However, due to the tremendous demand for edible oil as food, Veljkovic´ *et al*., (2006), reported that, inedible vegetable oils have been identified as the best alternative source with *jatropha curcas* opined to be the best feedstock for biodiesel production due to its numerous advantages. Abidin *et al*., (2009) reports that, apart from non-competition with food as feedstock, biodiesel from *jatropha curcas* oil provides a commercially viable alternative to diesel as it has comparable desired physico-chemical and performance characteristics.

One of the important considerations in feedstock selection for biodiesel production is the content of free fatty acid (FFA) in the oil (Foidl *et al*., 1996; Tiwari *et al*., 2007). When oil with high FFA content is used to produce biodiesel, it results in low yield and soap formation (Azhari *et al*., 2008). Therefore, oil with low FFA content is often preferred for direct utilisation in the transesterification process during biodiesel production. The FFA and moisture content which depend on the quality of feedstock have significant effects on the transesterification of glycerides with alcohol as catalyst during the biodiesel production process (Goodrum, 2002). However, among other factors which cause the FFA to increase, is the storage time of the seeds to be used as feedstock.

Storage is done to maintain harvesting quality of product but not to improve it (Sisman and Delibas, 2004). Martini and Anon, (2005) reported that, storage condition of oil seeds before industrial extraction might influence the quality of the crude oil. Neg and Anderson (2005) also showed that storage time and storage temperature had significant effect on free fatty acid content in Quinoa (*Chenopedium quinoa*) seed oil. During storage, products, specially stored oils compositions can be influenced by several storage conditions. It is known that improper handling of crude *jatropha* oil (CJO) easily causes its moisture content to increase. Also, exposure of the seeds to high temperatures for long periods affects the concentration of the oil FFA which increases significantly (Azhari *et al*., 2008).

It seems temperature, moisture and the storage duration are the most important factors which affect stored product quality and quantity (Anderson and Lingnert, 1998; Chen and Ahn, 1998). However, (Azhari *et al*., 2008) reported that, in many instances, the quality of CJO for instance, deteriorates gradually due to improper handling of seeds and inappropriate storage condition. Therefore, for a successful biodiesel production process, understanding how to control the processes of transportation of seeds from farm through storage and processing the seeds for crude oil extraction are important. A survey of literature shows extensive work is being done in the areas of *jatropha* biodiesel production and its properties as well as engine performance testing. However, little work has been reported on the storage time of *jatropha* seeds which has a significant and direct effect on the yield and quality of seed oil extracted for biodiesel production. The objectives of this study were to carry out preliminary investigation into the influence of *jatropha curcas* seed storage duration and moisture on seed oil yield and FFA content.

MATERIALS AND METHODS

Collection of *jatropha* seeds

Matured dried *jatropha curcas* seeds were obtained from a *jatropha* farm in the Ahafo Ano South District of the Ashanti region of Ghana. The seeds were obtained from the same farm in order to maintain the genetic identity of the samples. The samples were sundried for 2 days and the moisture content was determined using standard hot air oven method at 105+1^{o}C for 24 hours (Pradhan *et al*., 2009). The moisture content of the seeds was 6.39%, which is a safe value for storage according to Zheng *et al*., (2005). The samples were stored under ambient conditions for duration of 4 months. The samples were analyzed for oil content, free fatty acid and moisture content.

Crude j*atropha* oil extraction

The oil content (dry basis) of the seeds was determined by Soxhlet extraction method. 100 g of the seeds was milled to 1- mm particle size using standard methods (ASTM E11) every 4 weeks. 50 g of the milled seeds was wrapped in extraction thimbles and the oil was extracted using a Soxhlet extractor with petroleum ether as the solvent. The solvent to solid ratio was 7:1 and the extraction was carried out for 8 hours at a temperature of 75°C. The petroleum ether in the solvent-oil mixture was evaporated using a rotary vacuum evaporator. The oil was then collected and weighed. The percentage oil yield was calculated using the expression (1):

$$Y = \left(\frac{M_o}{M_m}\right)\times 100 \quad (1)$$

Where, Y is the oil yield (%), M_o is the weight of oil expressed (g) and M_m is the weight of the sub-sample of milled *jatropha* seeds.

Determination of free fatty acid

The free fatty acid content of seed samples was determined using acid-base titration technique according to the method of the ASTM D 5555-95(2003). The free fatty acid content of the oil was determined before storage and at 4 weeks intervals during the storage period.

RESULTS AND DISCUSSIONS

Effect of seeds moisture content on oil yield

Table-1 shows the average ambient temperature (^{o}C), relative humidity (%) and seeds moisture content (%wb) during the storage period. The temperature ranged between 33.6 and 35.2^{o}C, whereas the humidity ranged between 71 and 75%.There was a marginal increase in moisture content of the seeds from 6.39 to 6.48 % during the storage period. This could be due to the relatively steady state of the relative humidity and a decrease in temperature of the ambient environment during the storage period.

Table-1. Seed moisture content, ambient temperature and humidity of the environment during storage period.

Storage period (days)	**Temperature** (^{o}C)	**Relative humidity** (%)	**Seed moisture content** (%wb)
0	33.6	75	6.39
30	35.2	71	6.41
60	34.3	74	6.47
90	33.8	74.3	6.48

Moisture content values are average over three replicates

It was observed that, there was no significant difference in the moisture content of the stored seeds at room conditions. The highest and least oil yield was recorded at 6.39% and 6.48% moisture content of the seeds respectively. However, a marginal increase 0.1% in moisture content after the storage period resulted in a percentage decrease 4.47% in oil yield.

Other researchers reported a similar trend. Farsaie, (1985) reported maximum oil recovery was obtained when sunflower seeds were expressed at 6% moisture content and increasing the moisture content to 14% decreased oil recovery by 16%. Bongiriwa *et al*., (1977) reported that, as the moisture content of groundnut increased up to 6%, the percentage oil removed increased and the yield decreased beyond 6% moisture content.

Kabutey *et al.*, (2010) who worked on screw press performance for oil extraction from *Jatropha curcas* seeds of different moisture content concluded that *jatropha* seeds with low moisture content produced greater amount of oil than seeds with high moisture content. The decrease in oil content of the seeds could be attributed to the marginal increase in the moisture content of the seeds which according to Sirisomboon and Kitchaiya (2008), affects the oil recovery process. This indicates that moisture has an effect on oil yield of stored seeds and increasing storage duration can adversely affect stocks which may be stored for several months before processing.

Effect of seed storage duration on oil content

From the results of the four months of storage in which the oil analyses of the seed samples were carried out, it can be inferred that, there is a significant effect of storage time on seed oil content of *jatropha curcas* seeds (Figure-1). The oil content of the seeds varied from maximum of 35.57% after one month of storage to minimum (after 4 months of storage) of 31.10%, respectively. The lowest oil percentage was recorded from the seed samples that stored longer.

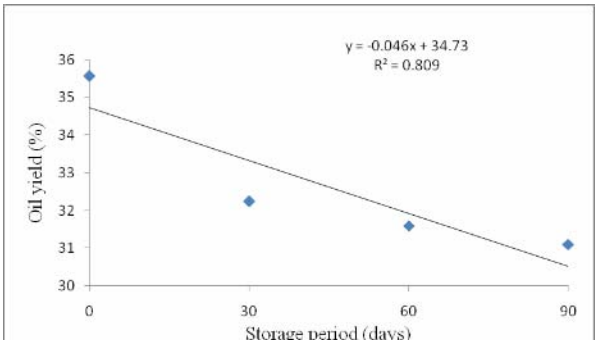

Figure 1: Effect of seed storage period on oil yield

The result observed in this study is in conformity with Sisman (2005), Sisman and Delibas (2004) who showed that during a period of three months storage of sunflower seeds, the percentage of seed oil gradually decreased with increasing storage time. Similar result was reported by Ghasemnezhad *et al*., (2007) in evening primrose. They showed that, as the storage time increased, they observed a corresponding rapid decrease of the oil percentage. The development of rancidity due to oxygen-dependent deterioration of lipids in vegetable oils has been recognised as the predominant cause of oil deterioration and reduction during storage (Ahmadkhan *et al*., 2000; Morello *et al*., 2004). Suriyong (2007) also reported that the ageing process naturally affects the quality of seeds during storage at various conditions, particularly the oil content which is sensitive to deterioration as a result of the oxidation processes - a reaction between unsaturated fatty acids and oxygen.

It is well established that, the rate of oxidation increases with increase in oxygen concentration and the duration of exposure (the length of storage time). The oxidation of oil requires the presence of atmospheric oxygen. The longer the storage time the higher the oxygen availability and vice versa. This might be a reason why the percentage of oil of stored seeds tends to reduce during storage. On the contrary, Ghasemnezhad and Honermeier (2009) reported that, the metabolism of seeds during storage to provide energy for its physiological activities could be another reason of the seed oil reduction during long storage duration.

Effect of seed storage duration and moisture content on free fatty acid content of oil

Deteriorative changes in oilseeds may be either oxidative or hydrolytic, resulting in the production of free fatty acids (FFA) (Christensen, 1974). In this study, the determination of the free fatty acid was very important to determine the degree of deterioration, as it evaluates the extent of hydrolysis. Osawa *et al*., (2007) reported that, the FFA determination is also a measurement intimately linked to the nature and quality of the feedstock, quality and degree of purity of the oil.

Fatty acid composition and the proportions of different fatty acids of oilseeds during storage are dependent on the degradation rate of different fatty acids, which convert to each other (Ahmadkhan and Shahidi, 2000). According to Ghasemnezhad and Honermeier (2009), fatty acid composition is the most important factor which determines oils susceptibility to oxidation. The risk of oxidation is high in *jatropha* seeds due to its high unsaturated fatty acids content, especially oleic fatty acids (Kartika 2010). Canakci (2007) also reported that the possible oxidation of the unsaturated fatty acids component in *jatropha* seeds occurred easily and it could lead to degradation of the oil.In this study, the profile of the fatty acid content of *jatropha curcas* seeds which was high in oleic acid was significantly influenced by storage time (Figure-2). The free fatty acid content of the seed oil increased linearly over the storage period. The increase ranged from 7.83% to 32.10 % for the first and last month of storage, respectively.

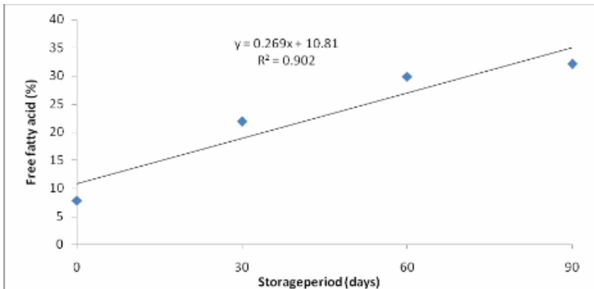

Figure 2: Influence of seed storage period on FFA content of oil

The increase in free fatty acid correlated with an increase in moisture content of the seeds over the storage period. This is in agreement with Berchmans and Hirata (2008) who reported that, free fatty acids have been found to increase due to the hydrolysis of triglycerides in the presence of moisture and oxygen. Ghasemnezhad and Honermeier (2009) also reported that, fatty acids in free forms are more susceptible to oxidation. This confirms that, increase of the free form of the oleic acid and its oxidation during storage could be the reason why the content of the fatty acid increased. Increase in the FFA content of the seeds could also be attributed to improper handling and storage of the seeds before the oil extraction process as reported by Kartika (2010). This is corroborated by Azhari *et al*., (2008), whose study concluded that, due to poor handling and storage of jatropha seeds, *jatropha* crude oil (JCO) had a higher value of FFA when compared to refined bleached deodorised palm oil (RBDPO) and crude palm oil (CPO) as shown in Table-2.

Table-2. The FFA content of JCO, RBDPO and CPO.

Oil	**FFA** (%)
Jatropha curcas oil	25.3
Refined bleached deodorized palm oil	0.031
Crude palm oil	6.1

Source: Azhari *et al*., (2008)

CONCLUSIONS

From this study, it can be concluded that, storage period and moisture content have an influence on the oil yield and free fatty acid content of *jatropha* seeds. The oil content of the seeds decreased from 35.57% to 31.10% during the storage period. However, the FFA content increased from 7.83% to 32.1% over the storage period. It is therefore important that investors, planning commercial production of biodiesel with *jatropha* seeds as feedstock, do not have to store the seeds for long especially under open air conditions as the oil yield and quality *viz*. FFA content are affected by storage time and improper storage condition.

REFERENCES

Abidin R., Sepidar S., Yunus Z. Z. and Azhari M. 2009. Extraction of Oil from *Jatropha* Seeds-Optimization and Kinetics. American Journal of Applied Sciences. 6(7): 1390-1395.

Ahmadkhan M. and Shahidi F. 2000. Oxidative stability of stripped and no stripped Borage and Evening primrose oils and their emulsions in water. Journal of the American Oil Chemistry Society. 77(9): 963-968.

American Standards for Testing of Materials (ASTM). 2003. D 189-01, D 240-02, D 4052-96, D 445-03, D 482-74,D 5555-95, D 6751-02, D 93-02a, D 95-990, D 97-02.

Anderson K. and Lingnert H. 1998. Influence of oxygen and copper concentration on lipid oxidation in rapeseed oil. Journal of the American Oil Chemists Society. 75(8): 1041-1046.

Azhari M. Faiz R. Yunus T.I Mohd. Ghazi and T.C.S Yaw. 2008. Reduction of free fatty acids in crude *jatropha curcas* oil via an esterification process. International Journal of Engineering and Technology. 5(2): 92-98.

Berchmans H.J. and Hirata S. 2008. Biodiesel production from crude *jatropha curcas* L. Seed oil with high content of free fatty acids. Bioresource. Technology. 79: 1716-1721.

Bongiriwar D. R., Pordwal-Desai S. R and Sreenivasan A. 1977. Studies on the defatting of peanuts and soybeans for ready-to-eat snack items. Indian Food Packer. 31(3): 61-76.

Canakci M. 2007. The potential of restaurant waste lipids as biodiesel feedstocks. Bioresource Technology. 98(1): 183-190.

Chen X.C. and Ahn D.U. 1998. Antioxidant activities of six natural phenolic against lipid oxidation induced by Fe^{+2} or ultraviolet light. Journal of the American Oil Chemists Society. 75(12): 1717-1721.

Christensen C.M. (Ed.). 1974. Storage of cereal grains and their products. American Association of Cereal Chemists Incorporated, Minnesota, USA.

Farsaie A. and Singh M. S. 1985. Energy models for Sunflower oil expression. Transactions of the American Society of Agricultural Engineers. 28: 275-279.

Foidl N., Foidl G., Sanchez M., Mittelbach M. and Hackel S. 1996. *Jatropha curcas* L. as a source for the production of biofuel in Nicaragua. Bioresource Technology. 58: 77-82.

Ghasemnezhad A. and Honermeier B. 2009. Influence of storage conditions on quality and viability of high and low oleic sunflower seeds. International Journal of Plant Production. 3(4): 39-48.

Goodrum J.W. 2002. Volatility and boiling points of biodiesel from vegetable oils and tallow. Biomass Bioenergy. 22: 205–211.

Kabutey A., Ceska Z. and Katedra M. 2010. Screw press performance for oil extraction from *Jatropha curcas* L. seeds of different moisture content. Scientia Agriculturae Bohemica. 41(4): 225-230.

Kartika I. A. 2010. Moisture sorption behavior of *jatropha* seeds at 20°C as a source of vegetable oil for biodiesel production. J. Tek. Ind. Pert. 19(3): 123-129.

Martini S. and Anon M.S. 2005. Storage of sunflower seed: variation on the wax content of the oil. European Journal of Lipid Science and Technology. 107: 74-79.

Morello J.R., Motilva M.J., Tovar M.J. and Romero M.P. 2004. Changes in commercial virgin olive oil (CV Arbequina) during storage with special emphasis on the phenolic fraction. Journal of Food Chemistry. 85: 357-364.

Neg S.C. and Anderson A. 2005. Lipid oxidation in Quinoa (*Chenopodium quinoa*) as determinated through accelerated aging. Journal of Environmental, Agriculture and Food Chemistry. 4(4): 1010-1020.

Osawa C.C., Gonçalves L.A.G. and Ragazzi S. 2007. Correlation between free fatty acids of vegetable oils evaluated by rapid tests and by the official method. Journal of Food Composition and Analysis. 20: 523-528.

Pradhan R. C., Naik S. N., Bhatnagar N. and Vijay V. K. 2009. Moisture-dependent physical properties of *jatropha* fruit. Industrial Crop and Products. 29: 341-347.

Sarin R., M. Sharma, S. Sinharay and R. K. Malhotra. 2007. *Jatropha*-palm biodiesel blend: An optimum mix for Asia. Fuel. 86: 1365-1371.

Sirisomboon P. and Kitchaiya P. 2008. Physical properties of *Jatropha curcas* L. kernels after heat treatment. Biosystems Engineering. 102(2): 244-250.

Sisman C. and Delibas L. 2004. Storing sunflower seed and quality losses during storage. Journal of Central European Agriculture. 4: 239-250.

Sisman C. 2005. Quality losses in temporary sunflower stores and influences of storage conditions on quality losses during storage. Journal of Central European Agriculture. 6: 143-150.

Stavarache C., M. Vintoru, Y. Maeda and H. Bandow. 2007. Ultrasonically driven continuous process for vegetable oil transesterification. Ultrasonic Sonochem 14: 413-417.

Suriyong S. 2007. Studies about mechanisms of oil seed deterioration under different storage conditions in oilseed rape (*Brassica napus* L.). Cuvillier Verlag Göttingen. p. 2.

Tiwari A. K., Kumar A. and Raheman H. 2007. Biodiesel production from jatropha oil (*Jatropha curcas*) with high free fatty acids: An optimized process. Biomass and Bioenergy. 31: 569-575.

Veljkovic V.B., Lakicevic S.H., Stamenkovic O.S., Todorovic Z.B. and Lazic K.L. 2006. Biodiesel production from tobacco (*Nicotiana tabacum* L.) seed oil with a high content of free fatty acids. Fuel. 85: 2671-2675.

Zheng Y., D.P. Wiesenborn, K. Tostenson and N. Kangas. 2005. Energy analysis in the screw pressing of whole and dehulled flaxseed. Journal of Food Engineering. 66(2): 193-202.