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# Analysis of oil content of *Jatropha curcas* seeds under storage condition

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**Abstract**

*Jatropha curcas* has been recognized as an ideal plant for biodiesel. There are unlimited reasons to consider *Jatropha curcas* a better tree borne oilseed plants than any other as it grows well on arid soils and entail minimal investment. The present study evaluates the effect of seed storage on quality and quantity of oil content such that it can be used for oil extraction and ensures availability of biodiesel throughout the year. The seeds were collected and stored at four temperatures viz. -5°C, 0°C, 5°C and room temperature (open air condition) for 15 months of storage durations and evaluated at every three months interval. There was a significant decrease in oil content and oil quality with increase in storage duration. Although, the seed stored at temperature 5°C gave the highest quality and quantity attributes at all durations. The first 3 months of storage account for the least decline as in the initial oil content in Kernel weight basis (54.61%) and seed weight basis (36.12%), there was a only decrease of 4.67% and 4.97% respectively at 5°C whereas in other temperatures viz. -5°C, 0°C and room temperature (open air condition), there was a decline of 18.11, 14.48 and 9.06% in kernel weight basis and 18.36, 15.14 and 9.30% in seed weight basis respectively which accelerated with duration. Similarly, quality parameters *viz.* moisture content, acid value, iodine value, saponification value, refractive index (30°C), relative viscosity and specific gravity were initially as 7.59%, 1.42 mg KOH $g^{-1}$ oil, 108.61 g $I_2$ $100g^{-1}$ oil, 189.37 mg KOH $g^{-1}$ oil, 1.466, 21.30 and 0.911 respectively which change to 13.71 %, 1.74 mg KOH $g^{-1}$ oil, 107.95 g $I_2$ $100g^{-1}$ oil, 191.48 mg KOH $g^{-1}$ oil, 1.470, 23.45 and 0.918, respectively after 3 months of storage. Hence, change in quality and quantity parameters indicated the importance of proper seed storage on availability of bio-diesel throughout the year and economics in its processing *i.e.*, *transesterification*.

**Key words**

Acid value, Biodiesel, Future energy, *Jatropha curas*, Oil quality, Transesterification



## Introduction

In an era of globalized environment, energy self sufficiency is the basic tool to drive any nation on its way to economic development. With increasing pressure of population and increasing use of energy in different sectors, the energy demand in India is expected to grow approximately. 4.8 per cent/annum where it is known to produces only 30% of its annual crude oil requirement of 111 mt. With this ever increasing demand of energy in India, it is needed to look for some alternative fuel sources so that valuable foreign currency reserves can be saved for other development activities. Scientists are looking for an alternate source of fuel and research work is in progress on many biomass based alternate fuels such as alcohol, producer gas, biogas and plant oil fuel (Singh et al., 1997). Amongst these, plant oil fuel is considered comparatively better alternative fuel having number of advantages over others.

*Jatropha curcas* is recognized as most potential species for biodiesel production, since the seed contains high oil content (30-38%) and can be grown under different land-use situations Forson *et al.* (2004). It can be easily propagated by seeds or cuttings and start bearing within 2 to 3 years. Also, it can be commercially exploited in 4-5 years and lasts for about 50 years (Gubitz *et al.,* 1999). The huge plantation has already started and going on across the length and breadth of the country. The species is not grazed by cattle, can withstand extreme drought condition and above all has multipurpose use. It is commonly known as Ratanjyot and belongs to family Euphorbiaceae. It is believed to be a native of Mexico and Central America. The plant is reported to have been introduced in Asia by the Portuguese as an oil yielding plant (Heller, 1996). It is normally a small evergreen, nearly glabrous or softwooded shrub of 3 to 4 m height but can attain a height of 8-10 m under favourable conditions. It flowers during hot and rainy season. The fruit is a capsule of 2.5 to 5.0 cm in diameter; seed ovoid-oblong and becomes dull brownish black when matures after 2-4 months of flowering. Five year old plantation of *Jatropha curcas* yields 12 tons of seeds/ha/year (Jones and Miller, 1992), while 0.8-1.0 kg of seeds/meter of live fence can be obtained if it is planted for hedge (Henning, 1996). Depletion of fossil fuels in the near future will make us switch over to biodiesel. In order to provide regular supply of biodiesel throughout the year, the seeds are required to be stored in such a way that the oil content and quality is maintained without any much loss and also there is chance of storage of seeds in order to sell it at odd times to get extra benefit by the collectors which makes it extremely important to be considered. There is not much information on seed storage aspects especially, on oil content and oil quality. The seeds have been reported to be orthodox but are not expected to be stored as good as most orthodox seeds, under uncontrolled conditions because of high oil content, so the basic information needs to be generated. Keeping these in view the seed storage under various temperatures was taken up in the present investigation.

## Materials and Methods

The seeds of *Jatropha curcas* were collected from Baghaani range of Poanta Sahib forest division of Sirmour district in Himachal Pradesh, India during August, 2007. Five trees, approximately 3 to 4m height were randomly marked for seed collection on the basis of their phenotypic/morphological features. Matured capsules (brownish black coloured) were harvested from the marked trees by picking directly from the branches or beaten by stick and felled to the ground. Thereafter, seeds were packed in gunny bags and transported to the Department of Silviculture and Agroforestry, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan. The seeds were cleaned manually by removing pulp and then sun dried for a week, before subjecting to seed storage.

The seeds were stored in laboratory from August 2007 to October 2008 at four temperatures viz. -5º , 0º , 5º and room temperature (minimum 2.30-20.38 and maximum 17.45-29.06ºC) for 15 months, of storage duration. The stored seeds were evaluated for oil content and oil quality, at every three months interval *viz.*, fresh seeds, 3 months, in three replications.

Oil was extracted from the seeds using soxhlet extractor with petroleum ether (60-80ºC) for 6 hr without interruption following the method of Anonymous (1965) and calculated in percentage. The moisture content of seeds was determined by drying the seeds in an oven for 17±1 hr at 103ºC low constant temperature (Willan, 1985). The extracted oil was immediately analysed for acid value following the method of Thimmiah (1999), iodine value, saponification value and refractive index by AOAC (1995), relative viscosity and specific gravity by Ranganna (1997), respectively. All the data obtained was subjected to statistical analysis by the method of Gomez and Gomez (1984). Least significant difference at 1 % level was used to test the level of significance among the treatments.

## Results and Discussion

Oil yield forms the most important trait which will affect the overall commercial success of the efforts for *Jatropha curcas* cultivation and its use as an energy crop. The pre-storage oil content was recovered as 54.61% (kernel weight basis) and 36.12% (seed weight basis) as given in Table 1 which is remarkable for being used as biodiesel.

The oil content was found to decrease with increase in storage duration from 3 to 15 months as shown in Table 2 but seeds stored at temperature 5°C excelled other treatments by recording maximum oil content which found to decrease to only 39.26% (kernel weight basis) and 29.12% (seed weight basis) after 15 months of storage time. The reason for decrease in oil content may be due to membrane disruption caused by increase in acid level as indicated by increase in free fatty acid value (Table 3) and free radicals productivity by lipid (oil) peroxidation, as a result of which the cells were not able to retain their normal physical condition and functioning at different temperatures. Similar findings were reported by Kathiravan *et al.* (2008) who reported Seed germination, oil content, and dehydrogenase and peroxidase activities decreased as the storage period increased in *Jatropha curcas*.

Oil quality is as important as oil yield because if oil yield during storage is maintained and the quality degrades, the efforts would go in vain. The free fatty acids in the oil can be used as a guide in quality control of fuels. For biodiesel, free fatty acid is also important parameter to judge the quality since free fatty acid at high temperature is known to react with metals like zinc, lead, manganese, cobalt, tin etc. this could increase engine wear

**Table 1 :** Pre-storage chemical properties of *Jatropha curcas*

| | |
|---|---|
| Oil content (%) (Kernel weight basis) | 54.61 |
| Oil content (%) (Seed weight basis) | 36.12 |
| Moisture content (%) | 7.59 |
| Free fatty acid (mg KOH $g^{-1}$ oil) | 1.42 |
| Iodine value (g $I_2$ 100$g^{-1}$ oil) | 108.61 |
| Saponification value (mg KOH $g^{-1}$ oil) | 189.37 |
| Refractive index (30ºC) | 1.466 |
| Relative viscosity | 21.30 |
| Specific gravity | 0.911 |

(Adekunle and Oluwo, 2008). It appears to exceed its specified maximum before other deleterious fuel properties changes occurs, therefore, a conscientious programme of measuring is considered sufficient for monitoring bio-diesel stability (BIS. recorded 2005). An increased free fatty acid value was irrespective of any treatments (Table 3). The seed stored at 5°C recorded minimum free fatty acid content ranging 1.74- 2.93 mg KOH $g^{-1}$ at 5°C from 3 to 15 months while other treatments crossed 2.0 mg KOH $g^{-1}$ free fatty acid content in 3 months itself. Hence, 5°C excelled over other treatments because when oil with high free fatty acid content was used to produce biodiesel, it resulted in low yield and soap formation (Azhari *et al.*, 2008).

In general, the test was based on the breakdown of oil to fatty acids and glycerol as seed deterioration progressed. The seed oil quality declined as there was a concurrent increase in level of free fatty acid content from the pre-storage observation to storage due to lipid peroxidation. Elevated level of free fatty acid is toxic to cells and thus are known to be absent in healthy seed. So, increase in acid value showed increase of unhealthy seeds in sample. Neg and Anderson (2005) showed that storage time and storage temperature had a significant effect on free fatty acid content in oil of Quinoa (*Chenopedium quinoa)* seed. Seeds exposed to high temperature for longed period also affected the concentration of free fatty acid content in oil significantly (Azhari *et al.*, 2008).

Iodine value is the quality testing parameter which measures the unsaturation in the oil *i.e.,* it indicates the degree of unsaturation in the fatty acids of triacyglycerol. Hence, this value can be used to quantify the amount of double bonds present in the oil. During seed storage from 3 to 15 months (Table 3), there was decrease in iodine value irrespective of any treatment which was undesirable for oils to be used as bio-diesel, as decrease in iodine value can cause solidification of oil when used in any fuel engines. The seeds stored at 5°C excelled any other combinations as it recorded the maximum values ranging from 107.95-99.40 g $I^2$ $100g^{-1}$ within the range (90.8–112.5 g $I^2$ $100g^{-1}$ oil) given by Kaushik and Kumar (2005) and Shyam (2006). It is attributed that at 5°C, the unsaturated fatty acids were maximum which decreased with storage and seed deterioration process due to conversion of unsaturated fatty acid to saturated fatty acid. Similar findings were reported earlier by Nkafamiya *et al.* (2007) in *Adansonia digitata* and *Prosopsis africana* oils and Adekunle and Oluwo (2008) in *Cucumis melo* oil.

Similarly, moisture content (Table 4) is probably the most important factor in determination of seed storability, especially in

**Table 2 :** Effect of storage temperature with respect to storage duration on oil content and refractive index

| Storage temperature | oil content(%) (Kernel weight basis) | | | | | oil content (%)(Seed weight basis) | | | | | Refractive index (30°C) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Duration in months | | | | | Duration in months | | | | | Duration in months | | | | |
| | 3 | 6 | 9 | 12 | 15 | 3 | 6 | 9 | 12 | 15 | 3 | 6 | 9 | 12 | 15 |
| -5°C | 44.72 | 40.40 | 38.50 | 21.73 | 18.48 | 29.49 | 26.22 | 18.46 | 15.20 | 12.27 | 1.484 | 1.508 | 1.588 | 1.614 | 1.746 |
| | (38.30) | (36.41) | (30.43) | (26.35) | (24.37) | (31.10) | (29.33) | (24.47) | (21.98) | (19.75) | | | | | |
| 0°C | 46.48 | 42.58 | 39.17 | 33.67 | 24.79 | 30.65 | 27.68 | 26.02 | 24.29 | 17.39 | 1.480 | 1.495 | 1.534 | 1.555 | 1.695 |
| | (39.04) | (37.37) | (35.82) | (33.21) | (28.48) | (31.70) | (30.13) | (29.19) | (28.20) | (23.84) | | | | | |
| 5°C | 52.06 | 50.49 | 46.88 | 43.49 | 39.26 | 34.35 | 32.99 | 31.48 | 31.77 | 29.12 | 1.470 | 1.477 | 1.492 | 1.525 | 1.557 |
| | (41.34) | (40.70) | (39.19) | (37.77) | (35.87) | (33.58) | (32.90) | (32.11) | (32.28) | (30.88) | | | | | |
| Room Temp. | 49.66 | 47.39 | 41.62 | 36.21 | 30.61 | 32.76 | 30.91 | 27.76 | 26.22 | 22.11 | 1.477 | 1.491 | 1.507 | 1.538 | 1.638 |
| | (40.36) | (39.43) | (36.95) | (34.45) | (31.67) | (32.78) | (31.85) | (30.17) | (29.32) | (26.91) | | | | | |
| S Em±$CD_{0.01}$ | 0.58 | 0.33 | 0.60 | 0.25 | 0.25 | 0.47 | 0.26 | 0.49 | 0.21 | 0.21 | 0.002 | 0.002 | 0.005 | 0.004 | 0.008 |
| | 2.14 | 1.21 | 2.21 | 0.92 | 0.92 | 1.74 | 0.98 | 1.81 | 0.78 | 0.78 | 0.008 | 0.008 | 0.017 | 0.015 | 0.029 |

Figures in parentheses are arc sine transformed values

**Table 3.** Effect of storage temperature with respect to storage duration on free fatty acid value, iodine value and saponification value

| Storage temperature | Free fatty acid (mg KOH $g^{-1}$ oil) | | | | | Iodine value (g $I_2$ $100g^{-1}$ oil) | | | | | Saponification value (mg KOH $g^{-1}$ oil) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Duration in months | | | | | Duration in months | | | | | Duration in months | | | | |
| | 3 | 6 | 9 | 12 | 15 | 3 | 6 | 9 | 12 | 15 | 3 | 6 | 9 | 12 | 15 |
| -5°C | 2.83 | 3.48 | 4.07 | 5.23 | 5.55 | 104.65 | 103.55 | 101.51 | 98.19 | 95.11 | 202.51 | 204.48 | 206.25 | 209.27 | 214.20 |
| 0°C | 2.72 | 3.20 | 3.68 | 4.27 | 4.77 | 105.74 | 104.69 | 103.39 | 97.78 | 95.29 | 198.79 | 201.19 | 202.84 | 204.99 | 209.79 |
| 5°C | 1.74 | 2.12 | 2.40 | 2.67 | 2.93 | 107.95 | 107.09 | 105.02 | 103.41 | 99.40 | 191.48 | 193.24 | 194.76 | 197.21 | 201.44 |
| Room Temp. | 2.08 | 2.52 | 2.91 | 3.31 | 3.74 | 106.85 | 106.02 | 103.82 | 100.20 | 96.07 | 195.33 | 197.22 | 198.79 | 202.99 | 205.51 |
| S Em±$CD_{0.01}$ | 0.07 | 0.04 | 0.09 | 0.06 | 0.06 | 0.06 | 0.03 | 0.15 | 0.20 | 0.29 | 0.22 | 0.25 | 0.14 | 0.33 | 0.48 |
| | 0.26 | 0.16 | 0.34 | 0.24 | 0.23 | 0.23 | 0.19 | 0.55 | 0.74 | 1.13 | 0.83 | 1.00 | 0.40 | 1.19 | 1.68 |

**Table 4 :** Effect of storage temperature with respect to storage duration on moisture content, relative viscosity and specific gravity

| Storage Temperature | Moisture content (%) | | | | | Relative viscosity | | | | | Specific gravity | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Duration in months | | | | | Duration in months | | | | | Duration in months | | | | |
| | 3 | 6 | 9 | 12 | 15 | 3 | 6 | 9 | 12 | 15 | 3 | 6 | 9 | 12 | 15 |
| -5°C | 18.72 | 16.60 | 13.23 | 12.15 | 10.32 | 24.70 | 25.14 | 26.37 | 26.96 | 27.20 | 1.043 | 1.078 | 1.165 | 1.244 | 1.274 |
| | (4.32) | (4.07) | (3.64) | (3.48) | (3.21) | | | | | | | | | | |
| 0°C | 23.29 | 22.63 | 21.08 | 18.32 | 16.77 | 24.38 | 24.80 | 25.25 | 25.59 | 26.12 | 1.011 | 1.060 | 1.125 | 1.188 | 1.247 |
| | (4.82) | (4.75) | (4.59) | (4.28) | (4.09) | | | | | | | | | | |
| 5°C | 13.71 | 13.02 | 12.31 | 11.05 | 9.97 | 23.45 | 23.81 | 23.97 | 24.10 | 24.55 | 0.918 | 0.926 | 0.971 | 1.026 | 1.126 |
| | (3.70) | (3.61) | (3.50) | (3.32) | (3.16) | | | | | | | | | | |
| Room Temp. | 10.64 | 10.26 | 8.28 | 7.57 | 6.86 | 23.97 | 24.31 | 24.51 | 24.77 | 24.98 | 0.956 | 0.982 | 1.021 | 1.098 | 1.207 |
| | (3.26) | (3.20) | (2.88) | (2.75) | (2.61) | | | | | | | | | | |
| S Em±$CD_{0.01}$ | 0.57 | 0.03 | 0.06 | 0.03 | 0.02 | - | - | - | 0.38 | 0.41 | 0.029 | 0.017 | 0.033 | 0.018 | 0.019 |
| | 0.21 | 0.12 | 0.22 | 0.10 | 0.09 | NS | NS | NS | 1.39 | 1.52 | 0.107 | 0.061 | 0.120 | 0.065 | 0.070 |

Figures in parentheses are square root transformed values

orthodox seeds, as it corelates physiologically with other seed parameters. There was an increase in moisture content from 7.59% to 10.64% in open air condition while increase to 18.72%, 23.29% and 13.71% at -5°C, 0°C and 5°C respectively which later on a decreasing trend was seen from 3 months to 15 months irrespective of storage temperature. The increase in moisture content may be ascribed to absorption of moisture from the storage environment by the seeds. The decreasing trend may be due to high moisture percent the oxidation rate is also increased which must have accelerated aging of seeds and the chilling damage/ freezing injury as the seeds contained high moisture content. Similar findings were reported by Kathiravan *et al.* (2008). Sivakumar *et al.(*2006) also reported similar findings in storing *Aegel marmelos* seeds and suggested that storing under low temperature (0 to -5°C) was deleterious and recommended to store at low temperature about (4°C).

Saponification value is a measure of average molecular weight (or chain length) of all the fatty acids present. It allows comparison of average fatty acid chain length, along with other quality parameters *viz.*, refractive index (Table 2), viscosity and specific gravity (Table 4) were found to increase with increase in storage durations as 191.48 mg KOH $g^{-1}$ oil to 201.44 mg KOH $g^{-1}$ oil, 1.470-1.557, 23.45 to 24.55 and 0.918 to 1.126 respectively. The work can be supported by Ikhuoria and Maliki (2007) who used Refractive Index, Viscosity, Free fatty Acids, Saponification Values ,Iodine Value and Unsaponifiable Matter as quality parameter to compare Avocado pear oil and African pear oil and reported its alternative resource use as fats and oils.

From this study, it can be concluded that, storage period and storage temperatures influence oil yield and oil quality of *Jatropha curcas* seed. The oil content decreased with time duration irrespective of temperature treatment but 50C proved to the best among all temperatures viz. -5o , 0o , 5o and Room temperature (minimum 2.30-20.38 and maximum 17.45-29.060C )for oil quantity and quality. It is therefore important that investor, planning commercial production of biodiesel from *Jatropha* seeds as feedstock, do not have to store the seeds for long especially under open air condition.

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