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RESEARCH PAPER

Standardization of process parameter for maximum oil recovery from jatropha seed

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SUMMARY : The experiment was carried out to standardize process parameter for maximum oil recovery from jatropha using solvent extraction and expelling at laboratory scale. The grit size of 2 mm having flake thickness of 0.5 mm at pressure of 1.5 kg/cm^2 for 10 minutes of steam treatment and drying of steam treated flakes for 20 minutes at 65 ^{0}C temperature gave the maximum oil recovery of 98.22 per cent by solvent extraction and 73.37 per cent for mechanical expression method. The solvent and expelling experiment of jatropha without steam treatment having flake thickness 1.5 mm and grit size 3 mm showed that the oil recovery was 94.83 for solvent and 71.63 per cent for mechanical expression in a single pass.

KEY **W**ORDS : Oil recovery, Process parameter, Jatropha seed

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India, with a GDP of about USD 475 billion, is the fifth largest economy in the world (Anonymous 2011). Seventy two per cent of India's people live in rural areas and about 70 per cent earn their livelihood from agriculture. India's rate of economic development is affected, as it needs to import about 70 per cent of its petroleum demand. Wildly fluctuating world prices of oil have been a destabilizing element for the country's balance of payments situation, particularly in recent times. The current yearly consumption of diesel oil in India is approximately 40 million tonnes forming about 40 per cent of the total petroleum product consumption. As on today the total diesel fuel demand in India is 66.9 Million Metric Ton (Poonia and Jethoo, 2012). Therefore, attempts needs to be made to reduce reliance on imports and achieve better alternative sources of energy which are suitable and sustainable for the better health of the environment (Punia, 2007). In India, it is estimated that cost of biodiesel produced by trans-esterification of oil obtained from jatropha cultivation generates an income of Rs.2500/per ha in existing system of farming. Bio-diesel plant grown in 11 million ha of land can yield a revenue of approximately Rs.20000 crore a year and provide employment to cover 12 million people both for plantation and running of the extraction plant (Chandra *et al.*, 2006). Around 4-5 kg of jatropha seed is produced per plant and the fruiting starts in the second year onwards and continues unto 40-50 years (Anonymous, 2012).

Oil can be extracted mechanically with an oil press, an expeller, or even with a wooden mortar and pestle – a traditional method that originated models that an individual can build to power driven commercial presses. 72 per cent of oil is recovered by mechanically expelling. Higher percentage of oil can be extracted with solvents (up-to 99%), but solvent extraction is a complex operation. The solvent like ethane, propane, carbon dioxide, n-hexane etc. are mostly used for oil extraction, however, n-hexane is economical and convenient. The standardization of process for maximum oil recovery is not known. In this study the process and technology would be optimized for maximum oil recovery of jatropha using solvent extraction process at laboratory scale.

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EXPERIMENTAL METHODS

Oil expelling :

The single-feed double stage compression screw expeller was used for the oil expression from jatropha (Singh and Bargale, 2000). For experiment on oil expelling, the jatropha seed with and without any treatment was fed to the oil expeller. For optimization of process and parameters prior to expelling the seed was employed with different pretreatments to see the effect of pre-treatments on the oil recovery and to optimize the process. The different pre-treated seed taken for oil expelling are de-hulled and cracked seed, seed soaked in water for 30 min. and drying to 30 per cent M.C., de-hulled and cracked seed soaked in water for 30 min. and drying to 30 per cent M.C., seed treated with steam for 10 minutes at 2 kg/cm^2 pressure, de-hulled and cracked seed treated with steam for 10 minutes at 2 kg/cm^2 pressure and seed as a whole was taken as control. Each experiment was replicated three times. The oil was recovered in single pass. After the oil expelling experiments the residual oil content in the cake was analyzed using the soxhlet apparatus and the oil recovery was calculated as per the method adopted by Bargale *et al*. (2000).

Solvent extraction :

The experiment was carried out to standardize process parameter for maximum oil recovery from jatropha using solvent at laboratory scale. During this process the jatropha seed was fed in the multipurpose grain mill for grit making, cooking followed by flake making in flaker machine (Singh *et al.*, 1989). The flaked sample was taken for oil extraction using soxhlet apparatus The grits of size 1mm, 2 mm and 3 mm and flake thickness of 0.5 mm, 1 mm and 1.5 mm was prepared using above process and the sample was taken for oil extraction using the soxhlet apparatus with and with out steam treatments at different steam pressure of 1 kg/cm^2, 1.5 kg/cm^2, 2.0 kg/cm^2 given for different duration of 10min, 20 min, and 30 min. After steam treatment the flakes sample were dried in the mechanical tray dryer for 10-20 minutes at 50-60^{0}C prior to oil extraction using the soxhlet apparatus.

De-solventization :

The desolventization of jatropha oil obtained through solvent extraction was done by heating 200 ml of the jatropha oil at 60 ^{0}C, 70 ^{0}C, 80 ^{0}C for 15, 20, 25 minutes, respectively in distillation unit. The time and temperature for desolventization of jatropha was recorded.

Cost-economics :

The overall cost-economics was calculated considering cost, capacity and time of operation for solvent extraction as well as mechanical expression of oil from jatropha for its economic feasibility.

EXPERIMENTAL FINDINGS AND ANALYSIS

The results of the present study as well as relevant discussions have been presented under following sub heads:

Oil extraction :

The experiment was carried out to standardize process parameter for maximum oil recovery from jatropha using mechanical expelling and solvent at laboratory scale. The details of oil recovery from solvent extraction as well as mechanical expression from jatropha flakes are shown in Table 1. The experimentation showed that the grit size of 2 mm having flake thickness of 0.5 mm at pressure of 1.5 kg/cm^2 for 10 minutes of steam treatment and drying of steam treated flakes for 20 minutes at 60 ^{0}C temperature gave the maximum oil recovery of 98.22 per cent using solvent extraction and 73.37 per cent by use of mechanical expelling (Fig.1) whereas the grit size of 3 mm having flake thickness of 1.5 mm at pressure of 2 kg/cm^2 for 30 minutes of steam treatment and drying of steam treated flakes for 30 minutes at 60 ^{0}C temperature gave the oil recovery of 96.38 per cent and 72.89 per cent by using solvent and mechanical extraction, respectively followed by the grit size of 2 mm having flake thickness of 1 mm at pressure of 1 kg/cm^2 for 10 minutes of steam treatment and drying of steam treated flakes for 10 minutes at 60 ^{0}C temperature gave the maximum oil recovery of 97.62 per cent for solvent and 72.19 for mechanical expression. However, the grit size of 2 mm having flake thickness of 1 mm without steam pressure yields maximum oil recovery of 94.83 per cent and 71.63 per cent both for solvent extraction and mechanical expression from jatropha flakes (Fig. 2).

Table 1 : Maximum oil recoveries through solvent extraction and mechanical expression from jatropha flakes

Steam pressure kg/cm^2	Grit size (mm)	Flake thickness (mm)	Steam treatment time (min)	Oil recovery, % (solvent)	Oil recovery, % (mechanical)
1	2	1	10	97.62	72.19
1.5	2	0.5	10	98.22	73.37
2	3	1.5	30	96.38	72.89
Without steam	3	1.5	-	94.83	71.63

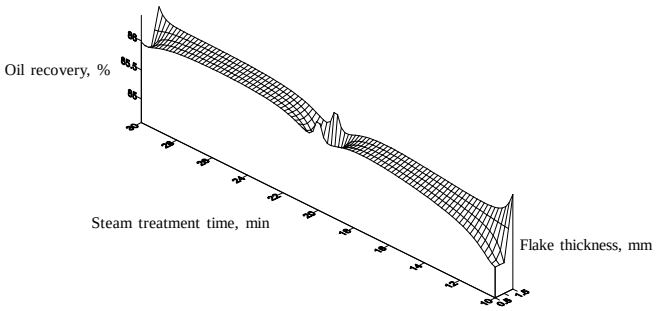

Fig.1: SSG for oil recovery through solvent extraction from jatropha flakes at 1.5 kg/cm² of steam pressure made from 2 mm grits

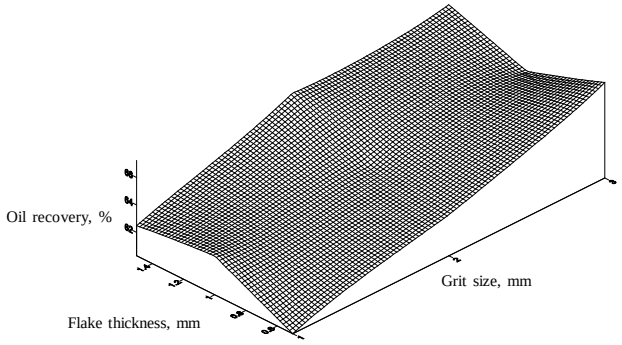

Fig. 2: SSG for oil recovery through solvent extraction from jatropha flakes without steam treatment

De-solventization :

De-solventization experiments were done to remove solvent (n-hexane) from extracted oil after solvent extraction process (Singh and Bargale, 1990). The findings of de-solventization showed that at heating temperature of 80 ^{0}C for 25 min, maximum solvent recovery of 2.1 per cent was achieved. The solvent recovery was reduced as the time and temperature of heating were reduced (Table 2).

Table 2 : Solvent recovery during desolventization of jatropha oil at various time and temperature combination

Heating temperature (^{0}C)	Heating time (min)	Solvent recovery (%)
60	15	0.2
	20	0.4
	25	0.8
70	15	1.0
	20	1.1
	25	1.2
80	15	1.8
	20	1.9
	25	2.1

Cost-economics :

The cost of raw jatropha oil recovered through mechanical expression was calculated as Rs. 23 per liter. Energy consumption for jatropha oil extraction using mechanical expression was 0.52 kWh/litre. Similarly, the cost of raw jatropha oil extracted using solvent extraction was calculated as Rs. 22 per liter. Energy consumption for jatropha oil extraction using solvent extraction method was 0.116 kWh/litre. Economic analysis indicates that to be viable a solvent extraction plant for jatropha oil should have a capacity not less than 100 t/day.

Conclusion :

The grit size of 2 mm having flake thickness of 0.5 mm at pressure of 1.5 kg/cm² for 10 minutes of steam treatment and drying of steam treated flakes for 20 minutes at 60 ^{0}C temperature gave the maximum oil recovery of 98.22 per cent using solvent extraction and 73.37 per cent by use of mechanical expelling in single pass. Steam treatment increased the oil recovery in both the method of solvent extraction and mechanical expression compared with untreated samples. Economic analysis indicates that to be viable a solvent extraction plant for jatropha oil should have a capacity not less than 100 t/day.

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