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Performance evaluation of hydraulic operated tamarind briquetting machine

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Abstract
The objective of this study was to evaluate the performance of hydraulic operated tamarind briquetting machine under different moisture levels of tamarind pulp and application of constant pressure at each stroke. The test results indicated a satisfactory working of the prototype. The average density of briquettes varied from 0.94 to 1.07 g/cm3. It was also observed that the tamarind pulp, having moisture content 18.14 to 26.70.% (wb) was suitable for briquetting. It was possible to obtain a final density (1.03 & 1.14 g/cm3) for 500 & 1000 g/cm3of briquette at a constant pressure of 44057 kPa at each stroke. The capacity of prototype of tamarind briquetting machine was found to be 45 number of briquettes per hour for 500 g briquette and 35 number of briquettes per hour for 1 kg briquette. The breakeven point was estimated to be 225 number of briquettes per year for 1 kg briquettes and 392 number of briquettes per year for 500 g briquettes. The payback period is estimated to be 0.31 year for 1 kg briquettes and 0.41 year for 500 g briquettes.

Keywords: Briquettes Density, Briquetting Machine, Processing, Tamarind

Introduction
India is the world's largest producer of tamarind. Out of 52 spices under the preview of Spices Board, India, tamarind is at the fifth position in terms of exportin the year (2013-2014). The tree mostly grown wild, although it is cultivated to a limited extent. It is particularly abundant in the Indian state of Andhra Pradesh, Karnataka, Tamil Nadu, Madhya Pradesh, Bihar, West Bengal, Uttar Pradesh and Chhattisgarh. Tamarind is valued mostly for its fruit and pulp, which are used for a wide variety of domestic and industrial purposes. In Chhattisgarh, tamarind is produced in many small areas and collected by rural people in an unorganized manner after that they are selling it traditionally in local markets or to the middlemen. During selling of tamarind they come across many problems such as handling of large volumes which need significant space, consumer acceptability for its quality, high transportation cost, post-harvest losses and possibilities of mixing unwanted materials like dirt, stables etc. which deteriorate its quality. To overcome such problem there is a need of developing tamarind briquettes. A small pedal operated tamarind briquetting machine was developed It is more beneficial and easy to operate by the rural people, but its requires more labour and time. Hydraulic systems have been used in industry in a wide number of applications by virtue of their small size to power ratios and the ability to apply very large pressure and torque, to make it easier, safer and simple.A hydraulic briquetting machine is more beneficial as it don't need any fuel, electricity or animal power. A small light weight briquetting machine easy to operate by the non-technical rural people. Which ensure opportunities of providing livelihood to the rural community. Hence, keeping the above point in mind to design & modified theexisting pedal operated tamarind briquetting machine which was developed of IGKV Raipur which may be more to fulfill above problems for rural people by the application of hydraulic mechanism to reduces manual labour, time and which gives more uniform tamarind briquettes.

Materials and Methods
The performance of the Hydraulic operated tamarind briquetting machine was studied in the Department of Agricultural Processing and Food Engineering, Faculty of Agricultural Engineering, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) with tamarind pulp, during 2017.

Performances Evaluation of Tamarind Briquetting Machine
Different moisture content tamarind pulps were taken for testing of tamarind briquetting machine. The machine was operated by any operators. 3 replicas were done by each operator at a time. Counting the number of stroke while each briquetting process. During each stroke the force (kg) applied by operator was measured as constant.

Developed depth (cm) on pulp box due to applied force was measured with measuring scale after each stroke. Pressure was calculated as standard by detail specification of Vankos Hydraulic jack. The Volume of the tamarind briquette was calculated by using the formula:

$$\text{Volume} = L \times W \times T$$

Where,

L = Length of the tamarind pulp, cm;
W = Width of the tamarind pulp, cm; and
T = Thickness of the tamarind pulp, cm.

Density (g/cm3) of the tamarind briquette was calculated by using the formula:

$$\text{Density} = \frac{M}{V}$$

Where,

M = Mass of the tamarind pulp, g and
V = Volume of the tamarind pulp, cm^3.

Compression ratio of the tamarind briquette was calculated by using the formula:

$$\text{Compression ratio} = \frac{V_i}{V_f}$$

Where,

V_i = Initial volume of the tamarind block, (g/cm^3); and
V_f = Final volume of the tamarind block, (g/cm^3)

Statistical Analysis

Factorial randomized block design was used to determine the Analysis of Variances. The variable which was used under investigation is density of tamarind briquette at each stroke.

Economic Evaluation of Briquetting of Tamarind Break Even Point Calculation

Breakeven point (BEP) is the point at which total expenses and total revenues are equal. It was calculated by using following formula:

$$BEP = \frac{TFC}{SUP - VUCP}$$

Where,

BEP = Break even point (units of production),
TFC = Total fixed cost,Rs;
VUCP = Variable cost per unit production, Rs; and
SUP = Selling price per unit of production, Rs.

Payback period calculation

$$\text{Payback period} = \frac{\text{Investment}}{\text{Annual cash inflow}}$$

Results and Discussion

Briquetting of Tamarind by manually operated Tamarind Briquetting Machine

Briquetting of tamarind by manually operated Tamarind Briquetting Machine was carried out with the help of pulp box and a operator. Putting the tamarind pulp on pulp box and filling carefully then stand on a pedal and force as per the stroke required this procedure will done it continuously until the briquette developed. The capacity of manually operated tamarind briquetting was found to be 45 number of briquette/h for 500 g briquette and 35 number of briquette/h for 1 kg briquette.

Density of Tamarind Briquette at Different Stroke Using Different Moisture Content Tamarind Pulp

Figure 1 shows that the density of tamarind briquettes, having different moisture content, at different stroke. Tamarind pulp moisture content 21.10%, 18.14%, 15.10 % and 26.70 %. During testing the average density of briquettes was found to be 0.94, 0.90,8.92 and 1.07 $g/cm^3$and compression ratio was calculated to be 2.23, 2.15, 2.11 and 2.46 respectively.

It was observed that when the moisture content of tamarind pulp decreases, the hardness of the tamarind pulp increases. Hence the briquetting process made difficult. On other hand when the moisture content of tamarind pulp increases, the hardness of tamarind pulp decreases that will make briquetting process easier. It was also observed that the tamarind pulp, having moisture content (wb) 18.14 % to 26.70 % was better for briquetting.

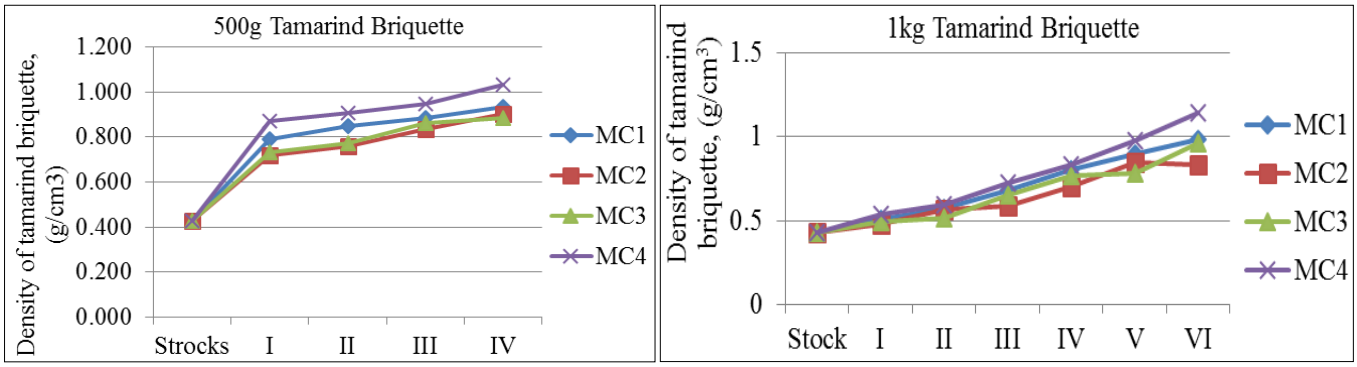

Fig 1, 2: Density of tamarind briquette at different stroke using tamarind pulp with different moisture content

Fig 3: A- Briquetting of tamarind in tamarind briquetting machine,

Fig 4: Tamarind briquettes

Capacity of Hydraulic Operated tamarind briquetting machine

The average capacity of tamarind briquetting machine was 45 number of briquettes per hour for 500 g briquette and 35 number of briquettes per hour for 1 kg briquette. It was observed that the capacity of hydraulic operated tamarind briquetting machine was 12.5 % and 16.77% more than the capacity ofmanually operated tamarind briquetting machine for 500 g and 1 kg briquettes respectively.

Statistical analysis

Density of tamarind briquettes after each stroke was analyzed statistically and ANOVA table is presented in Table 1.

Table 1: ANOVA table for density of tamarind briquettes (500g)

S.V	D.F.	SS	MSS	Com F value		Tab F value
Replication	2	0.00	0.00			
Main plot (S)	3	0.18	0.06	87.2*		8.9
Error (s)	6	0.00	0.00			
Sub plot (MC)	3	0.14	0.05	66.6*		8.6
SxMC	9	0.01	0.00	1.0*		2.9
Error (mc)	24	0.02	0.00			
Total	47	0.35				
				CD	CV,%	
Main plot				0.03	CV (s)	3.1
Sub plot				0.02	CV (mc)	3.1
Sub plot at same level of main plot				NS		
Main plot at same or different level of sub plot				NS	Mean	0.8

(Note: * indicates significance at 5% level of significance, mc indicates moisture content of tamarind pulp, S is number of stroke and Op. indicates the operator)

Table 2: ANOVA table for density of tamarind briquettes (1kg)

S.V	D.F.	SS	MSS	Com F value		Tab F value
Replication	2	0.0	0.0			
Main plot (S)	5	2.04	0.4	4031.8*		4.7
Error (s)	10	0.0	0.0			
Sub plot (MC)	3	0.2	0.1	575.9*		17.4
SxMC	15	0.1	0.01	63.2*		4.7
Error (mc)	36	0.0	0.0			
Total	71	2.3				
				CD	CV,%	
Main plot				0.01	CV (s)	1.4
Sub plot				0.01	CV (mc)	1.4
Sub plot at same level of main plot				0.02		
Main plot at same or different level of sub plot				0.02	Mean	0.7

(Note: * indicates significance at 5% level of significance, mc indicates moisture content of tamarind pulp, S is number of stroke and Op. indicates the operator)

It was observed that there was significant difference among the moisture content of tamarind pulp in respect of density of tamarind briquette. The effect of number of stroke was also analyzed and the differences were significant. The interaction effect of moisture content of tamarind pulp and number of stroke was also found significant in terms of density of tamarind briquette. The operators used for testing of tamarind briquetting machine were also statistically compared and it was also found significant. The combined effect of stroke, operator and moisture content of tamarind pulp was also analyzed and this interaction has significant in terms of density of tamarind briquette.

Economic Evaluation of Briquetting of Tamarind

The procedure for calculation of cost of briquetting is presented in Table 2. The cost of briquetting was calculated to be Rs 2.038 per kg for 1 kg briquettes and Rs. 1.585 per kg for 500 g briquettes

Table 3: Calculation of cost of briquetting per hour and per kg

S. No.	Particulars	Amount
1	Price of machine, Rs	32500
2	Expected life, years	10
3	Annual use, h/y	150
4	Depreciation, Rs/h	19.5
5	Interest, Rs/h	11.916
6	Miscellaneous, Rs/h	3.25
A (4+5+6)	Fixed cost, Rs/h	34.66
7	Repair and Maintenance Cost, Rs/h	5.42
	Operator charge, Rs/h	31.25
B (7+8)	Variable cost, Rs/h	36.66
A + B	Cost of briquetting, Rs /h	71.33
	For 500g briquettes, Rs/kg	1.585
	For 1kg briquettes, Rs/kg	2.038

Break-even Point

Figure 3 shows that the breakeven point of tamarind briquetting for 1 kg briquettes. The breakeven point was estimated to be 654 number of briquettes per year for 1 kg briquette. This may be achieved after 7.53 h of working. Figure 6 shows that the breakeven point of tamarind briquetting for 500 g briquettes. The breakeven point was estimated to be 1109 number of briquettes per year for 500 g briquettes. This may be achieved after 7.3 h of working.

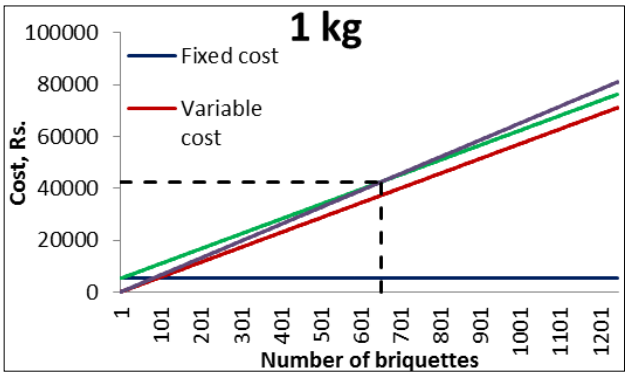

Fig 4: Breakeven point for 1 kg briquettes

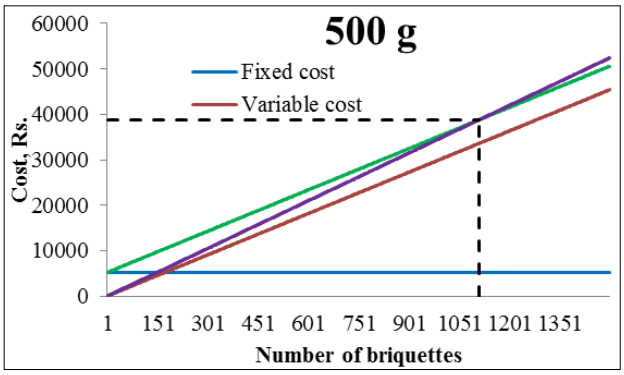

Fig 5: Breakeven point for 500 g briquettes

Payback Period for Tamarind Briquetting Machine

The initial investment was estimated to be Rs. 32500. For 1 kg briquettes, total cost of production was estimated to be Rs. 299499.9 per year and total return was expected to be Rs. 341250. Hence the payback period was estimated to be 0.78 year.

For 500 g briquettes, total cost of production was estimated to be Rs. 204624.9 per year and total return was expected to be Rs. 236250. Hence the payback period was estimated to be 1.027 year.

Conclusion

Performance of "Tamarind Briquetting Machine" was found to be satisfactory under the wide range of moisture content of tamarind pulp. The density and compression ratio of both type briquettes (500g and 1 kg) was found to be 1.03 &1.14 g/cm3 and 2.34:1 respectively. It was possible to obtain a final density (1.03 g/cm3) of briquette at a constant pressure of 44057 kPa at each stroke. And it was observed that the capacity of hydraulic tamarind briquetting machine was 12.5

% and 16.77% more than the capacity of manually operated tamarind briquetting machine for 500 g and 1 kg briquettes respectively.

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