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Research Article

PERFORMANCE EVALUATION OF MANUALLY OPERATED TAMARIND BRIQUETTING MACHINE

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ABSTRACT

The objective of this study was to evaluate the performance of manually operated tamarind briquetting machine under different moisture levels of tamarind pulp and application of different 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 1.05 g/cm^3. It was also observed that the tamarind pulp, having moisture content 19.8 to 27.5% (wb) was suitable for briquetting. It was possible to obtain a final density (1.05 g/cm^3) of briquette at a constant pressure of 24.76 kPa at each stroke. The capacity of prototype of tamarind briquetting machine was found to be 40 number of briquettes per hour for 500 g briquette and 30 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.

Key Words: *Briquettes Density, Briquetting Machine, Processing, Tamarind and Value Addition*

INTRODUCTION

India is the world's largest producer of tamarind products. Out of 52 spices under the preview of Spices Board, India, tamarind is at the sixth position in terms of export. It is particularly abundant in the Indian state of Andra Pradesh, Karnataka, Tamil Nadu, Madhya Pradesh, Bihar, West Bengal and Chhattisgarh (Singh *et al.*, 2007). 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. To overcome such problem there is a need of developing tamarind briquettes by using manually operated tamarind briquetting machine. A manual 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.

MATERIALS AND METHODS

The performance of the manually 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 2012.

Performances Evaluation of Tamarind Briquetting Machine

Different moisture content tamarind pulps were taken for testing of tamarind briquetting machine. The machine was operated by 3 male and 3 female 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 by load cell which is fixed on pedal. Developed depth (cm) on pulp box due to applied force was measured with measuring scale after each stroke. Pressure was calculated by force applied by operators and area of pulp box. The Volume of the tamarind briquette was calculated by using the formula:

$$Volume = L_b \times B_b \times T_B \quad (1)$$

Where,
L_b = Length of the tamarind briquette, cm;
B_b = Breadth of the tamarind briquette, cm; and
T_b = Thickness of the tamarind briquette, cm
Density (g/cm^3) of the tamarind briquette was calculated by using the formula:

$$Density = \frac{M_b}{V_b} \quad (2)$$

Where,
M_b = Mass of the tamarind briquette, g; and
V_b = Volume of the tamarind briquette, cm^3
Compression ratio of the tamarind briquette was calculated by using the formula:

$$C_r = \frac{V_i}{V_f} \quad (3)$$

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

Breakeven Point Calculation

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

$$BEP = \frac{TFC}{SUP - VUP} \quad (4)$$

Where,
BEP = Breakeven 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

$$Payback\ period = \frac{Investment}{Annual\ \ cash\ inflow} \quad (5)$$

RESULTS AND DISCUSSION

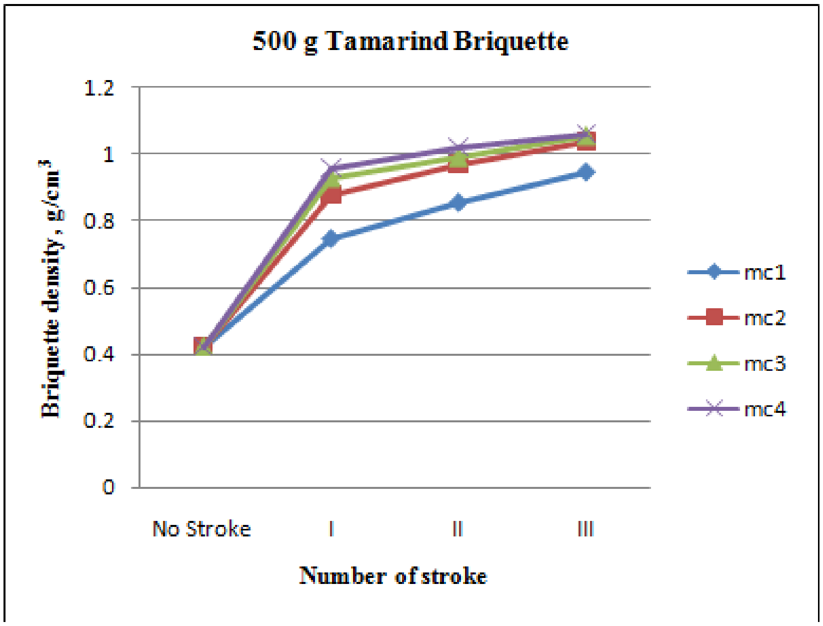
Briquetting of Tamarind by Hammering Action

Briquetting of tamarind by hammering action was carried out with the help of pulp box and a hammer. Putting the tamarind pulp on pulp box and hammering it continuously until the briquette developed. The capacity of manually tamarind briquetting by hammering action was found to be 18-22 number of briquette/h for 500 g briquette and 14-16 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 (wb) was 16.30 %, 19.80 %, 24.0 % and 27.50 %after completion of third stroke, the average density of briquettes was found to be 0.94, 1.03, 1.05, and 1.05g/cm^3 and compression ratio was calculated to be 2.24, 2.46, 2.50 and 2.50 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) 19.8 % to 27.5 % was better for briquetting.



(Note: mc1= 16.3% (wb), mc2= 19.8% (wb), mc3= 24.0%(wb)and mc4= 27.5% (wb))

Figure 1: Density of tamarind briquette at different stroke using tamarind pulp with different moisture content

Density of Tamarind Briquette by Applying Constant Pressure at Each Stroke

Figure 2 shows that the density of tamarind briquette by applying constant pressure on the area of pulp box 237.5cm^2 at each stroke. It was clearly observed that the density of tamarind briquette reduces gradually at different stroke with constant pressure. And the required number of stroke decreases, when the constant pressure applied by the operator at each stroke increases. It was also observed that it was possible to obtain a final density (1.05 g/cm^3) of briquette at a constant pressure of 24.76 kPa.

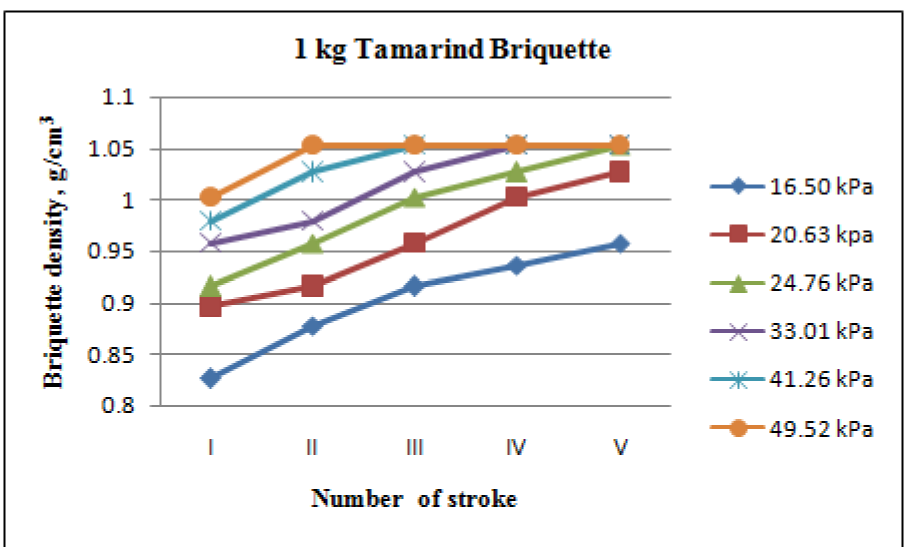


Figure 2: Density of tamarind briquette by applying constant pressure

Figure 3: A- Briquetting of tamarind in tamarind briquetting machine, B -Tamarind Briquette

Capacity of tamarind briquetting machine

The average capacity of tamarind briquetting machine was 40 number of briquettes per hour for 500 g briquette and 30 number of briquettes per hour for 1 kg briquette. It was observed that the capacity of tamarind briquetting machine was 82 % and 88% more than the capacity of briquetting by hammering action for 500 g and 1 kg briquettes respectively.

Statistical analysis for effect of pressure applied by operators

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

Table 1: ANOVA table for volume of tamarind briquettes

Source	Degrees of freedom	Sum of square	Mean Square	F Value	F Tab
Replication	2	0.013	0.006	7.70	-
Factor A (mc)	3	0.816	0.272	564.09*	2.68
Factor B(S)	2	1.281	0.64	1151.70*	3.07
AB (mc x S)	6	0.038	0.006	28.72*	2.17
Factor C(Op.)	5	0.181	0.036	72.10*	2.29
AC (mc x Op.)	15	0.025	0.004	4.54*	1.70
BC (S x Op.)	10	0.008	0.004	3.91*	1.94
ABC (mc x S x Op.)	30	0.015	0.003	1.58*	1.50
Error	142	0.083	0.001		
Total	215	2.461			

*(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

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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.0.95 per kg for 1 kg briquettes and Rs. 1.42 per kg for 500 g briquettes.

Table 2: Calculation of cost of briquetting per hour and per kg.

S. No.	Particular	Amount
1	Price of machine, Rs.	6000
2	Expected life, years	10
3	Annual use, h/y	150
4	Depreciation, Rs./h	3.60
5	Interest, Rs./h	2.20
6	Miscellaneous, Rs./h	0.60
A (4+5+6)	**Fixed cost, Rs./h**	**6.40**
7	Repair and Maintenance Cost, Rs./h	0.80
8	Operator charge, Rs./h	21.25
B (7+8)	**Variable cost, Rs./h**	**22.05**
A + B	**Cost of briquetting, Rs./h**	**28.45**
	For 500g briquettes, Rs./kg	**1.42**
	For 1kg briquettes, Rs./kg	**0.95**

Break-even Point

Figure 5 shows that the breakeven point of tamarind briquetting for 1 kg briquettes. The breakeven point was estimated to be 225 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 392 number of briquettes per year for 500 g briquettes. This may be achieved after 7.3 h of working.

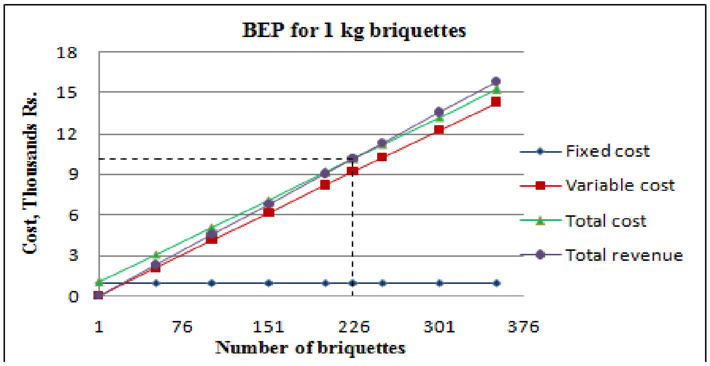

Figure 5: Break-even point for 1 kg briquettes

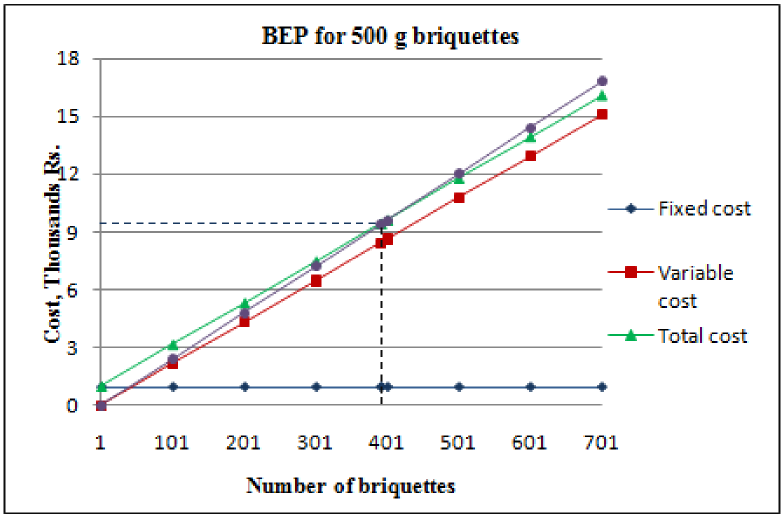

Figure 6: Break-even point for 500 g briquettes

Payback Period for Tamarind Briquetting Machine

The initial investment was estimated to be Rs. 6000. For 1 kg briquettes, total cost of production was estimated to be Rs. 183307.5 per year and total return was expected to be Rs. 202500. Hence the payback period was estimated to be 0.31 year.

For 500 g briquettes, total cost of production was estimated to be Rs. 129,307.5 per year and total return was expected to be Rs. 144000. Hence the payback period was estimated to be 0.41 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 1.05 g/cm^3 and 2.5:1 respectively. It was possible to obtain a final density (1.05 g/cm^3) of briquette at a constant pressure of 24.76 kPa at each stroke. And it was observed that the capacity of tamarind briquetting machine was 82 % and 88% more than the capacity of briquetting by hammering action for 500 g and 1 kg briquettes respectively.

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