IJTA © Serials Publications
National Academy of Agricultural Science (NAAS) Rating : 3. 03

Development and Performance Evaluation of aTamarind Seed Expeller

Viresh Kumar Goud[1], R. Udhayakumar[2], Mohith Kumar G.V.[1] and Venkatachalapathy K.[1]*

Abstract: *A power operated seed expeller was developed and fabricated at Department of Agricultural Engineering, UAS, GKVK, Bengalurufor the study. This mainly consists of two different rollers, one with serrated surface and another with helical rings on the surface kept rotating in opposite direction moving in words. A hopper is provided above the main assembly to facilitate feeding of fruits. The rollers are driven by ½ HP single phase motor by means of V belt and step pulley arrangement. In addition, a handle is also provided for manual operation during power failure. The developed expeller performance was evaluated under different moisture content of tamarind fruits, fruit shapes, roller clearance and shaft speed. The operational parameters viz., moisture content (16.50%) of tamarind fruit with shaft speed of 200 rpm and 4.50mm clearance between the rollers showed higher seed expulsion rate with less damage occurred on pulp and seed. While considering the shape of the fruit, higher seed expulsion rate found in straight fruits (23.24kg/h) followed by curved fruits (22.83 kg/h) and mixed fruits (20.86 kg/h).*

Further evaluation, the power operated expeller was compared with handle operated and traditional method of seed expulsion for different shape of fruits with different moisture contents. The results showed that higher seed expulsion rate found when the straight fruits at 16.50 percent moisture content used in the traditional method (2.70kg/h), handle operated machine (10.15kg/h) with least pulp and seed damage. Hence, power operated seed expeller was found efficient when compared with other methods of seed expulsion.

The cost economics of power operated seed expeller was determined by considering fixed and variable cost. For evaluation purpose, it was compared with handle operated machine and traditional method of seed expulsion. The results showed that cost of operation for seed expulsion by using power operated machine was Rs. 1.55 /kg as compared to handle operated machine (Rs. 2.94/kg) and traditional method (7.38/kg).

Keywords: *Tamarind Seed Expeller, Pulp, Dehulling, Defibering.*

INTRODUCTION

Tamarind is an economically important multi-purpose spice which is grown both as domesticated spice in farm land and as wild in forest lands. Tamarind fruits can be processed in the variety of food products of commercial importance In Karnataka. Tamarind is grown extensively both in cultivated and rainfed conditions, with an area of 26177ha and producing 23559 tonns of pulp (Babu, *et. al.*, 2009)

Tamarind is native of dry Savannas of tropical Africa. Tamarind is one of the important and common trees of India. Though every part of it is useful, the fruit is most important component. The pulp is most important product for trade. India is the main producer with about 400000 MT of fruits. Among spices tamarind occupies sixth position in terms of export earnings. Tamarind fruit is composed of shell (15.25%), pulp (45-55%), seed (25-35%) and fibre (10-15%). Some of the countries shell

1 Department of Agricultural Engineering, University of Agricultural Sciences, GKVK, Bangalore
2 Professor of Agricultural Engineering, Gandhigram Rural Institute, Gandhigram, Tamilnadu
* *E-mail: vkgouda@gmail.com*

was used as feeding to the pigs. The pulp is often eaten fresh, directly from the pod, but it is also used in the preparation of many foods such as chutney, curries, preserves, confectioneries, juice and syrup. The fibre is used as a mat, scrubber and rope. The manual processing of dehulling, deseeding and defibring are labourious, unhygienic and time consuming.In order to minimize the use of human labour, which is scarcely available during peak harvesting season, a need was felt to develop a Tamarind seed expeller, which could make the process of seed expulsion less cumbersome, cheap and improve the expulsion efficiency.

MATERIALS AND METHODS

Assembly of Tamarind Seed Expeller Machine

The tamarind seed expeller machine was developed at Department of Agricultural Engineering, UAS, GKVK, Bengaluru and it mainly consists of two different rollers one with serrated surface and other helical rings. The serrated roller has a diameter of 110 mm and a length of 400 mm an MS flat measuring 300 mm length, width 15 mm and 3 mm thick is welded together all along the circumference of the roller in a serrated manner. 5 mm pitch between the two serrative is maintained. Another roller has a diameter of 110 mm and lengths of 400 mm helical rings are welded together all along with circumference of the roller. The pitch between the two rings maintained is 6 mm.

The clearance between the two rollers can be adjusted by shifting one roller and fixing it in desirable position by bolts and nuts. Rollers are rotating in opposite direction moving inwards. A hopper is provided above the main assembly to facilitate feeding of fruits. The rollers are driven by an ½ hp motor by means of a V-belt and pulley arrangement. To achieve the required rpm, a set of pulleys with different diameter are used (Figure 1). In addition, a handle is also provided for manual operation during electricity failure.

During the operation, the dehulled dried fruits are made to pass between the rollers at a fixed clearance. The fruits are fed between the rollers through the hopper, the fruits get crushed due to the slitting and pressing shearing action of the rollers and the seed gets expelled. Separated seeds drop below the machine due to gravity through sieve mesh and pulp is collected separately.

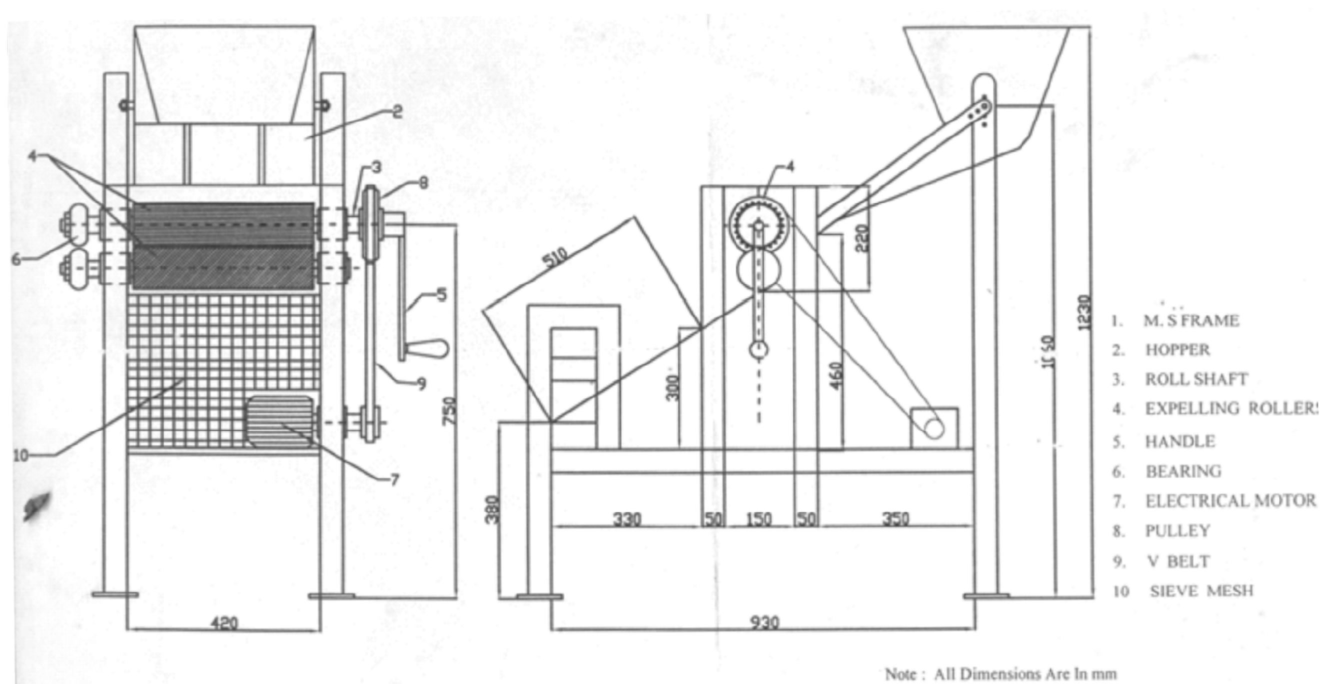

Figure 1: Development of tamarind seed expeller

Evaluation of Power Operated Tamarind Seed Expeller

The performance evaluation of a tamarind seed expulsion experiment were conducted using straight, curved and mixed fruits at different moisture content, clearances between the rollers and shaft speed. The shaft speed was measured by using a tachometer before starting the experiment. The shaft speed and roller clearance were recorded. The fruits were fed at uniform rate to avoid any blockage at the hopper outlet.

Two middle aged men labours were engaged, one for loading the dehulled tamarind fruit to feed hopper and other to pin drive the material between rotating roller and for collecting the fallen pulp. Time taken to expel seed from tamarind fruit at different moisture content, clearance and shaft speed was recorded. The weight of pulp, damaged seed and pulp were recorded. The weight of pulp, damaged seed and pulp were recorded separately for each treatment. Each treatment was replicated thrice. The damaged fruits and seeds were expressed in per cent by weight.

Statistical Aalysis

Fishers method of analysis of Completely Randomized Factorial Design (Sudar raj, *et. al.*, 1977) was adopted for the analysis of experimental data. Levels of significance used in 'F' test at (p = 0.05) were the reference for statistical conclusion, The results were described at this probability.

RESULTS AND DISCUSSION

Effect of Moisture Content, Fruit Shapes and Methods of Seed Expulsion

The tamarind seed expulsion varied significantly with the method of expulsion, moisture content and fruits shapes except at the interaction between methods of seed expulsion and fruit shapes, fruits shapes and moisture content as well as methods of seed expulsion, fruits shapes and moisture content are presented in Table 1. Among the methods of expulsion, the seed expulsion rate in tamarind fruit was highest with power operated machine (22.34 kg/h) which was statistically superior to handle operated machine (9.52 kg/h), both and of these were statistically superior to manual operation (2.44 kg/h)

Among the shapes of fruit, straight fruits resulted in highest rate of seed expulsion (12.05 kg/h), which was statistically identical to curved fruits (11.67 kg/h) and relatively lower seed expulsion was recorded with mixed fruits (10.57 kg/h). Among the varied moisture contents,

Table 1
Effect of moisture content, shapes of fruit on tamarind seed expulsion (kg/h) during different methods of seed expulsion

	Moisture Content (%) (w.b)											
	16.5				*17.5*				*18.5*			
Methods of Expulsion	*SF*	*CF*	*MF*	*Mean*	*SF*	*CF*	*MF*	*Mean*	*SF*	*CF*	*MF*	*Mean*
Manual	2.70	2.60	2.03	2.44	2.55	2.40	1.80	2.25	2.30	1.90	1.60	1.93
Handle operated	10.15	9.60	8.83	9.52	9.43	9.25	8.50	9.06	8.90	8.50	7.50	8.31
Power operated	23.34	22.83	20.86	22.34	21.50	19.00	18.16	19.56	16.00	14.68	13.83	14.83
Mean	12.06	11.67	10.57	11.43	11.16	10.21	9.49	10.28	9.06	8.36	7.64	8.35

SF - Straight fruits, CF - Curved fruits, MF - Mixed fruits

	A	*B*	*C*	*AB*	*AC*	*BC*	*ABC*
F Test	*	*	*	NS	*	NS	NS
S. Em±	0.43	0.43	0.43	0.74	0.74	0.74	2.21
CD at 5%	1.20	1.20	1.20	–	2.80	–	–

A - Different clearance, B - Fruit shapes, C - Moisture content of fruits, * - Significant, NS - Non-significant

16.50 per cent moisture resulted in significantly higher seed expulsion in tamarind (11.43 kg/h) which was statistically superior to 17.50 (10.28 kg/h) and 18.50 (8.35 kg/h) per cent moisture content.

Effect of Moisture Content and Fruit Shapes on Seed Expulsion Efficiency

The data pertaining to the seed expulsion efficiency of fruits as influenced by different moisture content and fruits shape in methods of expulsion are presented in Table 2. Among the methods of expulsion, the seed expulsion efficiency in tamarind fruit was highest with manual operation (100%), which was statistically superior to power operated machine (85.19%) and both of these were statistically superior to handle operated machine (83.58%).

Among the shapes of fruit, straight fruits resulted in highest seed expulsion efficiency (90.16%), which was statistically identical to curved fruits (89.6%) and relatively lower seed expulsion efficiency was recorded with mixed fruits (89.00%). Among the varied moisture contents, 16.50 per cent moisture content resulted in significantly higher seed expulsion efficiency in tamarind (89.58%) which was statistically superior to 17.50 (88.89 %) and 18.50 (87.14%) per cent moisture content.

Interaction between methods of seed expulsion and moisture content resulted in significant difference. The manual operation coupled with 16.50 per cent moisture content resulted in higher seed expulsion efficiency in tamarind (100%), which was statistically superior to power operated machine with 16.50 per cent moisture content (85.19%) and power operated with 17.50 and 18.50 per cent moisture content (84.08 and 81.36%, respectively). Similar trend was obtained with handle operated machine followed by manual operation.

Similar findings were also obtained with hand operated machine. However, 100 per cent efficiency was obtained in traditional method of seed expulsion. This might be attributed that labourers attended individual fruit and removed the all seeds present in the fruit. However, the time taken for separation was 9 times more as compared to power operated machine.

The seed expulsion efficiency was higher in power operated machine as compared to handle operated machine. Interaction between methods of seed expulsion efficiency and moisture content resulted in significant difference. This could happen due to ideal combination of moisture content, roller clearance and fruit shapes leads to effective expulsion of seeds from fruits. Straight fruits will

Table 2
Effect of moisture content, shapes of fruit on tamarind seed expulsion efficiency (%)during different methods of seed expulsion

	Moisture Content (%) (w.b)											
	16.5				*17.5*				*18.5*			
Methods of Expulsion	*SF*	*CF*	*MF*	*Mean*	*SF*	*CF*	*MF*	*Mean*	*SF*	*CF*	*MF*	*Mean*
Manual	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Handle operated	84.34	83.50	82.90	83.58	83.60	82.47	81.77	82.61	81.50	79.90	78.84	80.09
Power operated	86.17	85.30	84.10	85.19	85.24	83.74	83.27	84.08	83.24	81.05	79.80	81.36
Mean	90.16	89.60	89.0	89.58	89.61	88.73	88.34	88.89	88.25	86.98	86.21	87.14

SF - Straight fruits, CF - Curved fruits, MF - Mixed fruits

	A	*B*	*C*	*AB*	*AC*	*BC*	*ABC*
F Test	*	*	*	NS	*	NS	NS
S. Em±	0.11	0.11	0.11	0.20	0.20	0.20	0.61
CD at 5%	0.33	0.33	0.33	–	0.57	0.57	–

A - Different clearance, B - Fruit shapes, C - Moisture content of fruits, * - Significant, NS - Non-significant

have good roller contact because of their geometry to achieve expected shearing compared to mixed and curved fruits. Similar findings have been reported by Hiregouder (2000) in defibering of tamarind fruits.

Pulp Damage in Different Seed Expulsion Methods

The data concerning to pulp damage of tamarind fruits are presented in Table 3. Among the methods of expulsion, the pulp damage in tamarind fruit was highest with power operated machine (13.28%), which was statistically superior to handle operated machine (9.61%) and both of these were statistically superior to manual operation (3.41%)

Among the shapes of fruit, mixed fruits resulted in highest pulp damage (9.34%), which was statistically identical to curved fruits (8.72 %) and relatively lower pulp damage was recorded with straight fruits (8.24%). Among the varied moisture contents, 18.50 per cent moisture content resulted in significantly higher pulp damage in tamarind (8.76%), which was statistically superior to 17.50 (7.99%) and 16.50 (7.51%) per cent moisture content.

Interaction between methods of seed expulsion and moisture content resulted in significant difference. The power operated machine coupled with 18.50 per cent moisture content resulted in higher pulp damage in tamarind (13.28%), which was statistically superior to power operated machine with 17.50 per cent moisture (12.76%) and power operated with 16.50 per cent moisture (11.77%). Similar trend was obtained with handle operated machine followed by manual operation.

In the case of traditional method, mechanical damage to pulp was found less and negligible. This might be due to the attention given to individual fruit for seed separation when compared to the percentage of pulp damage found in more with power operated machine and hand operated machine. This might be due to high shaft speed causing shearing force resulted in more damage. Least damage was observed in straight fruits as compared to curved and mixed fruits. This might be attributed to the change in feeding angle of curved and mixed fruits leading to shearing action not taking place at the bulging portion of the fruit.

Table 3
Effect of moisture content, shapes of fruit on mechanical damage of pulp (%) during different methods of seed expulsion

	Moisture Content (%) (w.b)											
	16.5				*17.5*				*18.5*			
Methods of Expulsion	*SF*	*CF*	*MF*	*Mean*	*SF*	*CF*	*MF*	*Mean*	*SF*	*CF*	*MF*	*Mean*
Manual	2.10	2.66	3.16	2.64	2.37	2.83	3.33	2.84	3.07	3.34	3.84	3.41
Handle operated	8.00	8.17	8.16	8.11	8.16	8.34	8.66	8.39	9.0	9.67	10.16	9.61
Power operated	11.13	11.90	12.26	11.77	12.50	12.73	13.04	12.76	12.67	13.17	14.04	13.28
Mean	7.08	7.58	7.87	7.51	7.67	7.97	8.34	7.99	8.24	8.72	9.34	8.76

SF - Straight fruits, CF - Curved fruits, MF - Mixed fruits

	A	*B*	*C*	*AB*	*AC*	*BC*	*ABC*
F Test	*	*	*	NS	*	NS	NS
S. Em±	0.12	0.12	0.12	0.20	0.20	0.20	0.60
CD at 5%	0.34	0.34	0.34	–	0.60		–

A - Different clearance, B - Fruit shapes, C - Moisture content of fruits, * - Significant, NS - Non-significant

Seed Damage in Different Seed Expulsion Methods

The data on seed damage caused by different expulsion methods are presented in Table 4. Among the methods of expulsion, the seed damage in tamarind fruit was highest with power operated machine (10.29%), which was statistically superior to handle operated machine (8.61%) and both of these were statistically superior to manual operation (4.00%).

Among the shapes of fruit, mixed fruits resulted in highest seed damage (8.52), which was statistically identical to curved fruits (7.91%) and relatively lower seed damage was recorded with straight fruits (6.46%). Among the varied moisture contents, 18.50 per cent moisture content resulted in significantly higher seed damage in tamarind (7.63%) which was statistically superior to 17.50 (6.46%) and 16.50 (5.53%) per cent moisture content (Plate No. 4.3).

It was observed that as the moisture content of the fruit increases, the mechanical damage to seed also increases irrespective of methods of seed expulsion. However, at lower pulp moisture content, the seed damage was found negligible in all the methods. Least seed damage was observed in manual method of expulsion. It might be due to the force and careful manual beating caused lesser impact force. However more damage was noticed in power operated machine due of high speed of the shaft developing higher shear force resulted in seed damage.

Economics of Tamarind Seed Expeller

The economics of the developed tamarind seed expeller and the cost incurred was determined, taking into account of fixed, operational and variable cost. The cost incurred for developing the machine was Rs. 13,000 which include the motor cost, materials cost and fabricated cost. The total operational cost of the machine was Rs. 32.29 per hour, which includes the fixed cost and variable cost. The fixed cost consists of depreciation (10%), interest (18%) and cost of maintenance (2%). While the variable cost included the electricity charges at Rs. 3.71 per hour.

The cost of operation for separating seed was given below for power operated machine (at 200 rpm and 4.5 mm clearance), handle operated machine and traditional method for different types of fruit at 16.50 per cent moisture content.

Table 4
Effect of moisture content, shapes of fruit on seed damage (%) during different methods of seed expulsion

	Moisture Content (%) (w.b)											
	16.5				*17.5*				*18.5*			
Methods of Expulsion	*SF*	*CF*	*MF*	*Mean*	*SF*	*CF*	*MF*	*Mean*	*SF*	*CF*	*MF*	*Mean*
Manual	1.67	2.33	2.87	2.28	2.00	2.66	3.34	2.67	3.00	4.00	5.00	4.00
Handle operated	5.34	6.50	8.00	6.61	6.00	8.33	8.34	7.56	7.50	9.00	9.33	8.61
Power operated	6.43	7.56	9.16	7.72	7.40	9.83	10.30	9.18	8.90	10.73	11.23	10.29
Mean	4.48	5.46	6.67	5.53	5.13	6.94	7.32	6.46	6.46	7.91	8.52	7.63

SF - Straight fruits, CF - Curved fruits, MF - Mixed fruits

	A	*B*	*C*	*AB*	*AC*	*BC*	*ABC*
F Test	*	*	*	NS	*	NS	NS
S. Em±	0.13	0.13	0.13	0.24	0.24	0.24	0.72
CD at 5%	0.39	0.39	0.39	0.71	–	–	–

A - Different clearance, B - Fruit shapes, C - Moisture content of fruits, * - Significant, NS - Non-significant

Sl. No.	Types of fruit	Power operated machine (Rs./kg)	Handle operated machine (Rs./kg)	Traditional (Rs./kg)
1.	Straight fruits	1.38	2.56	5.55
2.	Curved fruits	1.41	2.70	6.81
3.	Mixed fruits	1.55	2.94	7.38

The seed expulsion rate was taken for mixed fruits at 16.50 per cent moisture content. It was observed that the cost of seed expulsion found cheaper in case of power operated machine (Rs 1.55/kg) compared with handle operated machine (Rs. 2.94/kg) and traditional method (Rs. 7.38/kg). This happened due to higher seed expulsion rate found in power operated machine compared to other methods.

CONCLUSION

The power operated expeller was compared with handle operated and traditional method of seed expulsion for different shape of fruits with different moisture contents. The results showed that higher seed expulsion rate was found when the straight fruits at 16.50 percent moisture content used in the traditional method (2.70kg/h), handle operated machine (10.15 kg/h) and power operated seed expeller (23.34 kg/h) with least pulp and seed damage. Hence, power operated seed expeller was found efficient when compared with other methods of seed expulsion.

The cost economics of power operated seed expeller was determined by considering fixed and variable cost. For evaluation purpose, it was compared with handle operated machine and traditional method of seed expulsion. The results showed that cost of operation for seed expulsion by using power operated machine was Rs. 1.55/kg as compared to handle operated machine (Rs. 2.94/kg) and traditional method (7.38/kg).

At present the post-harvest operations of tamarind fruit are highly expensive and the proposed power operated seed expeller will certainly come for farmers rescue in reducing the cost of operation, as well as in completing the operations timely

ACKNOWLEDGEMENT

This study was carried out as part of Ph. D research program. The authors are grateful to Gandhigram Rural Institute–Deemed University (MHRD-Govt. of India), Gandhigram and University of Agricultural Sciences, Bengaluru for providing required facilities for conducting research work.

References

Babu .C.K., (2009), A report on Post-harvest process of Tamarind, University of Agricultural Sciences, Bangalore.

Hiregoudar, S., (2000), Development and testing of a prototype tamarind defibering machine. UAS, Bangalore unpublished M.Sc. (Ag. Engg.) thesis.

Lewis, Y.S., (1970), Tamarind concentrate. *Ind. Food Packer.*

Shivanandam, V.N. (1980), Studies on systematic selection of productive types of tamarind (*Tamarindusindica L.*). M.Sc (Agri) thesis submitted to University of Agricultural Sciences, Bangalore.