Design and Fabrication of Power Operated Mango Stone Decorticator

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Abstract

The mango kernel inside mango stone is a soft and nutritive element. It is used in extraction of oil and as an additive in food processing industries. It is also used in ayurveda and allopathy because of its anticancer, antioxidant, antibacterial and antimicrobial properties. A mango stone decorticator for removal of nutritive kernel from mango stone was designed, fabricated and tested. The major components of the machine include hopper, spike tooth beater, concave, 2 hp motor, V-belt drive, collecting tray and frame. Before feeding, the mango stones are dried to moisture content of 15% to 20% for easy decortication. The dried mango stones are fed into the hopper and moves down to the decorticating chamber. The decorticating chamber consist of spike tooth beater which is rotated by 2 hp motor through belt drive. Thus, decortication takes place due to impact of spike tooth beater. And after decortication the kernel and the seed coat are collected in the collecting tray. The decorticating efficiency of decorticator at 12%, 14%, 16% moisture content found was 93%, 90% and 86%, respectively for Alphonso mango stone and 98.5%, 98% and 95% respectively for Totapuri mango stone. The kernel damage obtained from testing was 33.3% and 29.26% for Alphonso and Totapuri respectively. The output capacity of the power operated mango stone decorticator calculated was 34.48 kg/hr. This machine is compact, it is cost economical and best suited for small scale production.

Keywords: *Mango stone, Mango kernel, Decorticating efficiency and Mango stone decorticator.*

1. Introduction

Mango is a fruit which is indigenous to the Indian subcontinent, belonging to the genus Mangifera, consisting of numerous species of tropical fruiting trees in the flowering plant family Anacardiaceae (Karunanithi, et al., 2015). It is the main fruit of Asia and has developed its own importance all over the world. It is an important tropical fruit grown in India and it is the largest producer of mangoes with 44.14 per cent of the total world production (Shilpa Yatnatti, 2014). About 20 per cent of mango is processed for products such as puree, nectar, leather, canned slice and chutney, juices, ice cream, fruit bars, pies and also for direct consumption.
With the development of fruit processing industry, large quantities of guthalies are available at factory sites (Bhagwan Singh and Mittal J.P, 1982). The disposal of guthalies from factory premises to distant places for hygienic reasons, is a costly solution to the problems that is further aggravated by legal restrictions. At present the 40% to 60% peels and seeds are generated during processing and going as waste (Shilpa Yatnatti, et al., 2014).
Mango stone is a single flat oblong that can be fibrous or hairy on the surface, depending on the cultivar. Mango stone is composed of outer shell and inner kernel. It represents 20% to 60% of the whole fruit weight, depending upon the mango variety. The kernel inside the seed is 40% to 75% of whole seed (Ashoush and Gadallah, 2011).
However, mango stone is discarded due to the lack of awareness of their nutritional values. The kernel which has almost 20-50 times more nutritional value than the pulp. Mango kernel has 20-fold higher protein, 50-fold higher fat and 4-fold higher carbohydrates than mango pulp (Gordhan and Jasminkumar Kheni, 2018).
The kernel has nearly balanced quantities of protein, carbohydrates, oils, vitamins, minerals and therapeutic phytochemicals in sufficient quantities and it can be safely used for the production of food additives, replacing more expensive cereal constituents, livestock feeds etc. And it is utilized efficiently in different fields like phytochemicals and therapeutics and food processing industries (Gordhan and Jasminkumar Kheni, 2018).
In order to exploit the valuable components of mango stone, continuous mechanical equipment named power operated mango stone decorticator is designed, developed and evaluated for its performance. It is a unique and cost-effective invention and this is an effective substitute for the existing method of manually splitting up of the mango stone to obtain the mango seed kernel inside.

1.1 Problem statement

India ranks first among world's mango producing countries accounting for about 40% of the global production. In Tamil Nadu, mango is cultivated in about 125104 ha with the production of about 537780 tonnes. During processing large number of seeds (mango stones) are generated as waste and it leads to problem in disposing. At present the 40% to 60% peels and seeds are generated during processing and going as waste.

1.2 Justification

Mango fruit consumption was high at its peak period which resulted in environmental sanitation problem. Finding more useful application of kernel would be a way to reduce the environmental pollution. There is a lack of awareness about the nutritional value of mango kernel. It is rich in protein, carbohydrates and fat that can be further processed to get the valuable by product. In order to use this kernel in an efficient way we have designed a power operated mango stone decorticator which removes the kernel from the mango stone.

1.3 Objectives

To design and fabricate a power operated mango stone decorticator and to test the performance of the fabricated unit.

1.4 Advantages of mango stone kernel

a) The kernel is also used for medicinal purposes in moderation of anti-bacterial and anti-fungal activities. Therefore, the designed mango stone decorticator enhances the complete mechanization processes of mango products.

b) Mango seed powder can boost blood circulation and reduce bad cholesterol levels. This also helps to lower blood sugar and C-reactive protein levels.

c) Mango stones are useful as substitute for maize in finishing broiler diets. The kernel is also used for medicinal purposes in moderation of anti-bacterial and anti-fungal activities. Therefore, the designed mango stone decorticator enhances the complete mechanization processes of mango products.

d) Mango seed extract has high antioxidant capacity. Mango seed has high quality protein with all essential amino acids. Mango seed has lipid rich in unsaturated fatty acids, free of trans-fatty acids. Mango seed has great potential for use in the food industry.

e) Mango seed is also used in preparation of Ayurveda medicines such as Brihat Gangadhar churna, Pushyanuga churna and Ashokaristha.

1.5 Scope

a) This invention will brings a revolution in the mango industry to use the waste mango stone for productive purposes.

b) Post-harvest activities which improves the value and conditions of agricultural materials.

c) The equipment is easy to handle, maintenance and eco-friendly.

d) The by products from the mango (kernel) is useful for various products like cosmeceutical, pharmaceutical and in cancer treatment as anticancer property, protein powder in food processing etc.

2. Working procedure

The mango seeds are fed into the top of the hopper and it moves through the decorticating chamber through which the mango seeds are cut into pieces with the help of the spiked tooth beater, after that the outer seed coat and the kernel are moves down through the discharge tray and finally the shell and the kernel are collected together in a collecting tray.

Schematic diagram

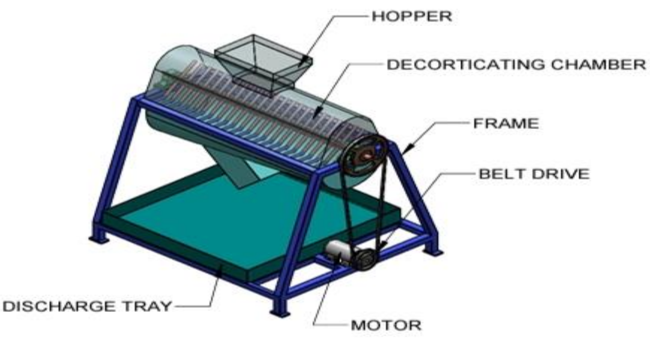

Figure1. schematic diagram of power operated mango stone decorticator

Physical properties of mango stone

Physical properties of mango stone were determined by doing experiments on moisture content, size, shape and geometric mean diameter.

2.1 Moisture content

The moisture content of mango stone was determined by using hot air oven method. The oven was set at the temperature of 105±1ºC for preheating. First of all, the weight of empty sample box was measured and it is taken as W_1. Then the weight of the sample box with mango stone was measured and it is taken as W_2. After the desired temperature was reached, the sample box with mango stone was kept inside the oven for 24 hrs. After 24 hrs the box was taken out and kept in the desiccator for 10-15 mins. After that, the weight of the sample box with sample was measured and taken as W_3. The moisture content of mango stone was determined by using the following formula (Bisen et al., 2016),

Moisture Content, % = $((W_2-W_3)/ (W_2-W_1)) \times 100$

Where,

W_1= Weight of the sample box.

W_2= Weight of the sample box with mango stone.

W_3= Weight of the sample box and mango stone after drying.

Table 1. Moisture content

S.No	Alphonso mango stone (%)	Totapuri mango stone (%)
1	32	39.3
2	28.83	41.4
3	25.85	41.6

The average moisture content of Alphonso and Totapuri mango stones were found as 26.97±5.01 and 40.76±1.03 respectively.

2.2 Size

The size of the mango stone is an important parameter that was consider in design of hopper and cutting mechanism of the decorticator. The total 15 number of mango stones were taken for each variety (Alphonso and Totapuri). The spatial dimension of mango stone was measured by using vernier caliper (Bisen et al., 2016).

Table 2. Spatial dimensions of Alphonso and Totapuri mango stone

S.No	Property	Alphonso	Totapuri
1	Length (mm)	95.5±5.67	124.8±7.44
2	Breadth (mm)	46.1±4.92	51.7±4.9
3	Thickness (mm)	16±5.76	22.1±5.15

From the table it is observed that, the Alphonso mango stone was shorter in length and breadth than Totapuri mango stone. The spatial dimension indicates that Totapuri mango stone is more oblong than Alphonso and thickness of Alphonso is greater than Totapuri.

Table 3. Spatial dimension of Alphonso and Totapuri mango kernel

S.No	Property	Alphonso	Totapuri
1	Length (mm)	48.2±1.6	56.2±3.05
2	Breadth (mm)	27.2 ±1.93	33.8 ± 3.96
3	Thickness (mm)	10.8±1.72	10.4±1.35

2.3 Geometric mean diameter

The size of mango stone is determined with the help of geometric mean of three dimensions (length, breadth and thickness). The total 15 number of mango stone at each variety were taken and their length, breath and thickness were determined with the help of vernier calliper and scale. The geometric mean diameter of mango stone was calculated by using the formula,

$D^g = (L \times B \times T)^{1/3}$

Where,

Dg = geometric mean diameter
L = length of the mango stone
B = breadth of the mango stone
T = thickness of the mango stone

Table 4. Geometric Mean Diameter

S.No	Property	Alphonso	Totapuri
1	Geometric Mean Diameter of mango stone (mm)	40.55±5.04	55.25±5.81
2	Geometric Mean Diameter of mango kernel (mm)	24.1±1.74	26.82±0.89

3. Testing and Results

3.1 Output capacity of decorticator

The output capacity of the power operated mango stone decorticator is calculated Output capacity (C) = W/t

C = Output capacity, kg/hr
W = weight of material fed into the decorticator, kg
W = 1kg
t = time taken for decortication, hr
t = 1.785 min = 0.029 hr
Output capacity (C) = 1 / 0.029
C = 34.48 kg/hr

3.2 Decorticating efficiency η = (1-Wu /W) × 100

Wu = weight of undecorticated material, g
W = weight of material fed into the machine, g

Table 5. Decorticating efficiency

S.no	Variety	Decorticating efficiency (%)
1	Alphonso	90
2	Totapuri	98

From the performance test results it is concluded that the Totapuri has the high decorticating efficiency of 98%.

Prototype model of power operated mango stone decorticator

Figure 2. Power operated mango stone decorticator

4. Conclusion

The power operated mango stone decorticator was tested and evaluated. The length, breadth, thickness and geometric mean diameter for mango stone of Alphonso were 95.5 ±5.67 mm, 46.1±5.92 mm, 16±5.76 mm and 40.55±5.04mm. The length, breadth, thickness and geometric mean diameter for mango stone of Totapuri were 124.8±7.44 mm, 51.7±4.9 mm, 22.1±5.15 mm and 55.25±5.8 mm. The length, breadth, thickness and geometric mean diameter for mango kernel of Alphonso were 48.2±1.6 mm, 27.2 ±1.93mm, 10.8 ±1.72 mm and 24.1±1.74 mm. The length, breadth, thickness and geometric mean diameter for mango kernel of Totapuri were 56.2±3.05 mm, 33.8± 3.96 mm, 10.4±1.35 mm and 26.82±0.89 mm .For small scale production considering unit weight of mango stone (kg) the output efficiency of Alphonso is 90 %, efficiency of Totapuri is 98% at nearly 14% moisture content. The kernel damage obtained from the testing was 33.3% and 29.26%. for Alphonso and Totapuri. The output capacity of the power operated mango stone decorticator calculated was 34.48kg/hr.

5. References

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