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# Development of Aonla Shredding cum Stone Extracting Machine

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**ABSTRACT**

**A continuous flow, power operated machine for production of aonla shreds as well as extraction of stone has been designed and developed. The machine consists of a hopper, a tapered roller, a drum chamber with concave sieve, a discharge chute and a power transmission system. The machine was tested at roller speed ranging from 200 to 400 revolutions per minute (RPM). At 330 RPM speed of roller, maximum aonla shreds (97-98 %) were recovered with minimal breakage of stone (6-7%). The machine could process 60-70 kg aonla per hour, which is 10 times more than the manual processing. The cost of processing of aonla using the developed machine is just Rs. 159 per tonne as compared to Rs. 833 per tonne for manual extraction.**

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## INTRODUCTION

Aonla (*Emblica officinalis*, Gaerin) is an important arid fruit crop. Its commercial cultivation can be seen mainly in Gujarat and Uttar Pradesh in India. The area under its cultivation is increasing now a days as the crop is becoming popular among farmers. Annual production of aonla in Gujarat is about 2000 tonnes and per tree production is about 400-500 kg at private farms. Average production of aonla per wild tree in forest is about 150 kg (Anon. 1991).

Aonla is a rich source of vitamin C. About 600 - 900 mg of vitamin C is found in 100 g of aonla pulp (Kikani *et al.* 1993). Due to this, aonla has a high demand in pharmaceutical and other allied industries i.e. Soap, Shampoo, Hairdye, Ink etc. Besides this, Chyavanprash, Squash, Jam, Candy, Triphala, Pickles, Mukhavas (Salted Dried Flakes) etc. are prepared from aonla. For all above preparation, stone is required to be removed, while for Mukhavas, Pickles, Triphala, and Candy, shreds are needed.

Traditionally, aonla shreds & stones are removed manually using knife. Manual process is time and labour consuming, tedious, unhygienic and uneconomical. It also causes injuries to the skin and hand while processing of aonla by labourers. Besides this, manual capacity of aonla processing is about 6 kg/h only. Non availability of adequate skilled labourers for this job in time is another problem. Dependence on human labour for aonla processing results in delay of separating seed from stone and increased cost of production.

The present study was undertaken with the objective to design & develop a suitable machine for aonla shredding and simultaneously stone removal from mature aonla fruits and to evaluate its performance.

## MATERIALS AND METHODS

A continuous flow type power operated machine was designed to handle about 100 kg mature aonla fruits per hour. The

machine consists of a hopper, a tapered roller, a drum chamber with concave sieve, a discharge chute, a power transmission system and framework. The complete machine except the framework is fabricated using food grade stainless steel (AISI 304) material. The overall dimensions of the machine are 1370 x 330 x 650 mm (Fig. 1).

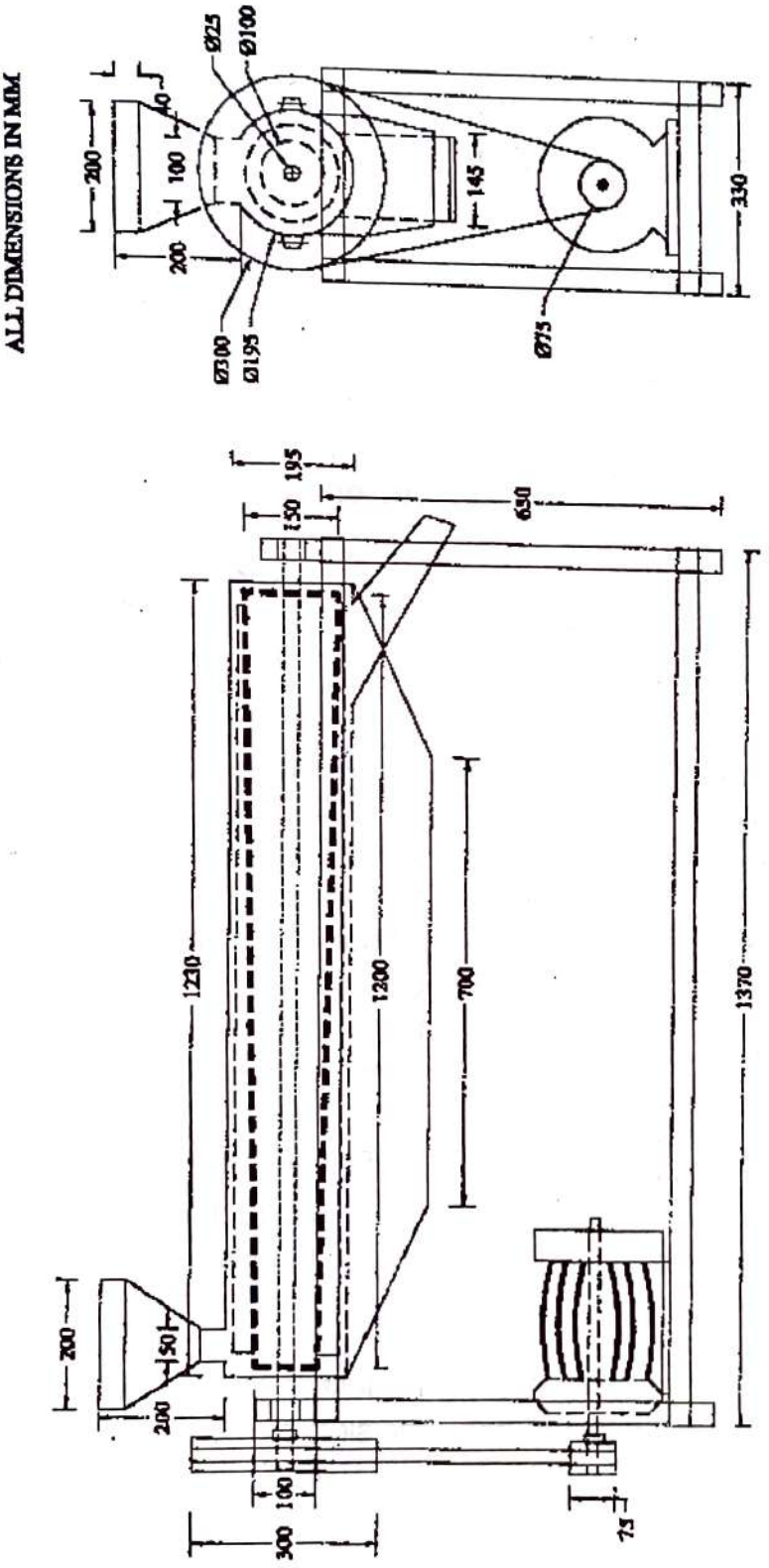


**Fig. 1 : Drawing of Aonla shredding cum stone extracting machine.**

The machine works on the principle of gradual scraping of the pulp from all around the fruit till the inner stone is free from pulp. Due consideration was also given to the fact that uniformly coarse size shreds are produced which will find direct use and the seeds inside the stone are undamaged to achieve maximum germination. The aonla fed to the machine is made to pass through the gradually reducing clearance between the roller and the stationary concave sieve, where it is continuously scraped and shredded while simultaneously conveying forward.

The hopper for feeding of aonla to the machine is fabricted from 1 mm thick S. S. sheet. The top and bottom cross sectional dimensions being 200 x 200 mm and 100 x 50 mm respectively. A free board of 40 mm height at the top and another 40 mm extension at bottom has been provided. The total height of the hopper is kept to be 200 mm.

The machine has a rotating taper roller fitted inside the drum chamber. The diameter of the roller at feed end is 100 mm and that at the discharge end is 150 mm. The length of the roller is 1200 mm inclusive of the end plates. The roller has been made from stainless steel round bars of 8 mm diameter and 1200 mm length. In all, thirty two such round bars are used. The bars have been welded with the end plates on both the sides in such a way that there is a forward angle of 8 degree from the feed end side. The forward twist has been provided to convey the material towards the discharge end. Two scrapers made up of 5 mm thick canvass belt have been fitted with bar no. 1 and bar no. 17, to scrap the material against the perforation of concave. The roller is mounted on a stainless steel shaft of 25 mm diameter and the shaft is fitted to the frame with the help of bearings.

The cylindrical drum chamber is made up of two equal halves namely, top cover and concave sieve. The top semi circular half (top cover) has a length of 1230 mm and radius of 97.5 mm and is made from 1 mm thick S. S. sheet and opening of 100 x 50 mm has been provided in the top cover near the feed end. There is a projection of 40 mm height at the opening; so as to push fit the feed hopper. The lower semi circular half is the concave sieve, having 1230 mm length and 97.5 mm radius, also made from 1 mm thick S. S. sheet.

The slit shape perforations of 25 x 4 mm size and 25 mm apart have been cut through out the concave in zigzag fashion. An opening of 110 x 65 mm has been provided at the discharge end of the concave for the discharge of the aonla stone and an inclined scoop has been welded there to guide the stones to a collecting pan kept below.

A trapezoidal shape discharge chute of 1230 x 195 mm top dimensions and 700 x 145 mm bottom dimensions is fitted below the concave. The sides of chute have smooth downward slope for easy flow of aonla shreds into the collecting pan, kept below the chute. The power is transmitted to the taper roller from a 3 phase, 1 HP, 1400 RPM electric motor through a set of pulleys and V-belt.

The structural frame of 1370 x 330 mm size is fabricated from M. S. angles. Four legs of 650 mm length have also been welded to support the complete machine. Pedestals and bearings have been fixed in the slots provided on each end of the frame, for mounting the central shaft. The schedule of quantities and rates of different items required for fabrication of the machine is given in Table-1.

## RESULTS AND DISCUSSION

Mature aonla fruits of 'Gujarat Aonla1' variety was used for evaluating the performance of the machine. The fruits fed to the drum chamber through hopper and pass into the space between taper roller and concave sieve. The machine was tested for different operating speeds (200-400 RPM) of the roller. The fruits got scraped continuously while the rotating roller against the projected perforations of the concave and the aonla shreds were obtained which pass down through openings in the sieve. The shreds were collected in a pan kept under the machine through the discharge chute. The aonla stones were conveyed forward in the machine while being scraped and were finally discharge separately at the other end in a container.

The performance of the machine was evaluated in terms of percentage of complete shredless stones recovered in single pass and the stone breakage (if any) by using following expressions :

$$\text{Shreds loss, (\%)} = \frac{\text{Wt. of shreds lost with stones}}{\text{Wt. of shreds recovered + Wt. of shreds lost with stones}} \times 100$$

$$\text{Breakage, (\%)} = \frac{\text{Wt. of broken stones}}{\text{Wt. of whole stones + Wt. of broken stones}} \times 100$$

*TABLE 1*

**Quantities and rates of material required for fabrication of aonla shredding cum stone extracting machine.**

| *Sr. No.* | *Item* | *Specifications* | *Quantity (kg)* | *Rate (Rs./kg)* | *Cost (Rs.)* |
|---|---|---|---|---|---|
| 1. | M. S. angle | 35 x 35 x 5 mm | 24.0 | 15 | 360 |
| 2. | S. S. angle | 25 x 25 x 3 mm | 2.5 | 110 | 275 |
| 3. | S. S. flat | 25 x 5 mm | 6.6 | 110 | 726 |
| 4. | S. S. sheet | 1829 x 1219 x 1 mm | 20.0 | 95 | 1900 |
| 5. | S. S. flange | 150 x 6 mm x 1 no. | 4.5 | 110 | 495 |
| | | 125 x 6 mm x 1 no. | | | |
| | | 102 x 6 mm x 1 no. | | | |
| 6. | S. S. round bar | 8 mm Ø | 14.0 | 110 | 1540 |
| 7. | S. S. round bar | 25 mm Ø | 6.0 | 110 | 660 |
| 8. | S. S. bush | 40 mm Od x 25 mm ID x 25 mm length x 2 nos. | 0.5 | 110 | 55 |
| 9. | C. I. pulley | Single B groove, 300 mm | 1 No. | 180 | 180 |
| 10. | C. I. pulley | Single B groove, 75 mm | 1 No. | 45 | 45 |
| 11. | V-belt | B-62 | 1 No. | 150 | 150 |
| 12. | Ball bearing | No. 6305 | 2 Nos. | 90 | 180 |
| 13. | Pedestal for bearing | No. 6305 | 2 Nos. | 125 | 250 |
| **Total Material cost** | | | | | **6816** |
| 14. | Fabrication charges | 30 % of material cost | | | 2045 |
| 15. | Electric motor | 3 phase, 1 HP, 1400 rpm | 1 No. | 1500 | 1500 |
| **Total cost of machine** | | | | **Rs.** | **10361** |
| | | | | **Say Rs.** | **10500** |

The extraction capacity of the machine was computed. Three replications were taken.

The performance data of the machine as a function of roller speed are presented in Table-2. The manchine extracted the stones clear of shreds completely in single pass for all the four speeds tested. The results indicate that as the speed of the roller is increased from 231 to 396 RPM, the total shreds loss reduced from 10.10 to 1.94%. But the corresponding breakage percentage of the stone increased from 4.38 to 10.74 %.

*TABLE 2*

**Performance of mechanical aonla shreds cum stone extracting machine.**

**Batch size + 5 kg aonla, Gujarat Aonla-1 variety**

| *Sr. No.* | *Speed of roller (RPM)* | *Capacity (kg/hour)* | *Shreds loss (%)* | *Breakage (%)* |
|---|---|---|---|---|
| 1. | 231 | 53.2 | 10.10 | 4.38 |
| 2. | 264 | 61.3 | 6.11 | 5.99 |
| 3. | 330 | 64.7 | 2.59 | 6.15 |
| 4. | 396 | 69.4 | 1.94 | 10.74 |

Above data are average of three replications.

The breakage of the stones increased abruptly to 10.74 % at 396 RPM speed of the roller. This shows that at high speed more stones were crushed. Therefore, the speed of 330 RPM, which resulted in comparatively lower shreds loss (2-3%) as well as less breakage of stone (6-7%), was considered to be the best.

However, the breakage of the stone caused in the machine did not harm the seeds, which are inside the stone. Some of the shreds loss obtained in the stone outlet could be recovered (1-2%) and hence the net shreds loss was less than 1%.

The economics of mechanical extraction of stone from aonla vis-a-vis the manual technique have been computed. The cost of the machine was calculated (Table-1). The details of various expenditures in terms of fixed cost, variable cost, etc. and the cost of extracting stone for both the mechanical method as well as manual method are given in Table-3.

The cost of the machine has been found to be about Rs. 10500, inclusive of the cost of electric motor. In manual extraction technique one labourer can extract only about 48 kg of aonla in 8 hour shift. Thus, the cost of stone extraction and shredding works out to be Rs. 833 per tonne. When the machine is used for the above work, it can process about 480 kg of aonla in 8 hour shift. Assuming 10 years useful life and 20 % salvage value, 12 % interest on investment, 10 % repair & maintenance cost, the total fixed cost comes out to be Rs. 3150. Similarly considering the actual consumption of electric power at the rate of 6 kWh per hour and the actual labour charges, the total variable cost works out to be Rs. 64 per day.

Considering the above values of fixed cost and variable cost, the cost of stone extraction and shredding aonla using the machine was found to be Rs. 159 per tonne. The above reveals that there will be net saving of Rs. 674 for processing of one tonne of aonla by the developed machine as compare to the traditional method.

TABLE 3

**Cost of aonla shredding cum stone extraction.**

| Sr. No. | Particulars | Specifications | Rate (Rs.) | Total Cost (Rs.) |
|---|---|---|---|---|
| I. | **Manual Extraction** | | | |
| | Labour charges | 1 No., Rs. 40 per 8 man hour | 40.00 | |
| | Capacity of stone extraction | Av. 48 kg per 8 man hour | | |
| | Cost of extraction per kg aonla | | 0.833 | |
| | Cost of extraction per tonne aonla | | | **833.00** |
| II. | **Mechanical Extraction** | | | |
| | Initial cost of the machine | | 10500.00 | |
| A. | **Fixed cost** | | | |
| | Depreciation of the machine | 10 years useful life, 20 % salvage value | 840.00 | |
| | Interest on investment | @ 12% on initial cost of m/c | 1260.00 | |
| | Repair and maintenance | @ 10 % of initial cost of m/c | 1050.00 | |
| | Total fixed cost | | 3150.00 | |
| | Fixed charges per day | | | **12.60** |
| B. | **Variable cost** | | | |
| | Electricity charges | @ 6 k Wh per 8 hours and Rs. 4 per kWh | 24.00 | |
| | Labour charges | 1 No. Rs. 40 per 8 man-hour | 40.00 | |
| | Total variable cost/day | | | **64.00** |
| | Total cost of extraction per day (8 hours) | **(A+B)** | | **76.60** |
| | Capacity of aonla stone extraction per day | 480 kg / 8 hours. | | |
| | Cost of extraction per kg aonla | | 0.159 | |
| | Cost of extraction per tonne aonla | | | **159.00** |
| **Pay back period** | | | **32 days** | |
| **Break even quantity** | | | **15.5 tonne handling of aonla** | |

The pay back period for the investment on the machine, comes to be about one month only. Therefore, the break-even quanity for the recovery of expenditure for mechanical extraction works to be about 15.5 tonnes of aonla.

There are various other benefits of using this machine, which can not be overlooked. The benefits include higher capacity of processing, better hygiene, superior quality product and elimination of possible health hazard. Thus, it can be concluded that for aonla shredding and stone extraction, the machine developed and described above is technically competent and economically viable. The comparative features of the machine vis-a-vis the manual extraction is briefly given in Table-4.

## Conclusions

The Aonla Shredding cum Stone Extracting Machine gave good quality aonla shreds and simultaneously remove stones

TABLE 4

**Comparative features of mechanical and manual aonla shredding cum stone extraction.**

| Sr. No. | Particulars | Mechanical extraction | Manual extraction |
|---|---|---|---|
| 1. | Cost of the machine | Rs. 10500 | Nil |
| 2. | Stone extraction rate | 60-70 kg per hour | 6 kg per man hour |
| 3. | Shreds recovery (%) | 97-98 | 90-92 |
| 4. | Whole stone recovery (%) | 93-94 | 100 |
| 5. | Cost of stone extraction | Rs. 159 / tonne | Rs. 833 / tonne |
| 6. | Break even quantity | 15.5 tonne | Nil |

from mature aonla. The machine could process 60-70 kg aonla per hour, which is 10 times more than the manual processing. The cost of processing of aonla using the developed machine is just Rs. 159 per tonne as compared to Rs. 833 per tonne for manual extraction. It could safeguard the hazardous effects of the labourer's hands and skin.

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