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Design, Development and Testing of Small Scale Mechanical Fruit Washer

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Abstract: Fruits vegetables sample from field research must be cleaned prior to weighing, grading and processing for value addition. Soil and other foreign materials must be removed. The objective of this study was to develop a low–cost mechanical fruit and vegetable washer to reduce the labor and time requirements. A Prototype of mechanical fruit washer (50 kg capacity) was designed, developed and performance was evaluated. The effect of three different rotor speeds (1466, 1476 and 1486 rpm) and 20 cm (110 lit) effective depth of water on capacity and performance index was evaluated. Potato was used for performance evaluation of washer. The cost of manual to mechanical washing for potato was 5.89:1. The average cost of mechanical washing was Rs. 24.80 per tonne. The cost machine was Rs. 14,650/- including electric motor. The overall dimensions of machine were 1000 x 560 x 750 mm.

Keywords: Fruits, Vegetables, Cleaning, Washing, Processing.

I. INTRODUCTION

Washing of fruits and vegetables is vital step in any processing operation, which gives attractive and chemical free fruit. Washers may be continuous type or batch type. The batch type washer is recommended only for small plants or community installations. Presently the fruits are being washed by one or the combination of various washing methods by manually or mechanically.

Washing is an important primary process unit operation, which reduces the surface microbial load, while removing the field soil, dust and even residual pesticides, thus leading to the value addition of the produce at the farm level. Contamination of fruits and vegetables is generally due to unsanitary cultivation and marketing practices [1]. The estimation of level of microbial contamination of food allows the assessing of shelf life of food, which is important from the health and economic point of view [2]. The microorganisms involved with the food if pathogenic, can be critical from a public health point of view, because they can lead to health hazard [3].

Fruit washing is a mandatory processing step; it would be wise to eliminate spoiled fruit before washing in order to avoid the pollution of washing tools and / or equipment and the contamination of fruit during washing. Fruit washing can be carried out by immersion, by spray/showers or by combination of these two processes which is generally the best solution. Relatively very little information is available in research literature on small- scale fruit washer.

There are attractive opportunities for entrepreneurs in the field of fruit and vegetables processing in India. The installed capacity of fruit and vegetable processing industries has increased from 21 lakh tonnes in 1979 to 22 lakh tonnes in 2009. The production of processed fruits and vegetables in India has increased from 9.8 lakh tonnes in 1999 to 9.9 lakh tonnes in 2002 [4 . An attempt was made by [5] to develop a small-scale carrot washer for research sample purpose.

The primary motivations for development of a mechanical fruits and vegetables washer which can give improved fruits and vegetables quality, time and labor savings, and improved speed and efficiency of sample handling. This article presents the need and design considerations for a small–scale mechanical fruits and vegetables washer and its performance evaluation.

II. MATERIALS AND METHODS

A prototype of small- scale mechanical fruit washer was designed, developed (Fig.1) and tested for washing of potato. The performance of the machine was tested for washing efficiency and the capacity. The machine works on the principle of turbulent flow of water created by different rotors in the washing chamber. The potato kept in washing tray will come in contact with the vortex created by water in the chamber and get washed. The turbulence of water is available from the sides and bottom of tray, which effectively wash the potato without any mechanical damage.

The washing machine mainly consists of, 1.cleaning unit, 2.Body and lid, 3.rotor assembly, 4.main frame, 5.power transmission unit and drive mechanism and 6 guards.

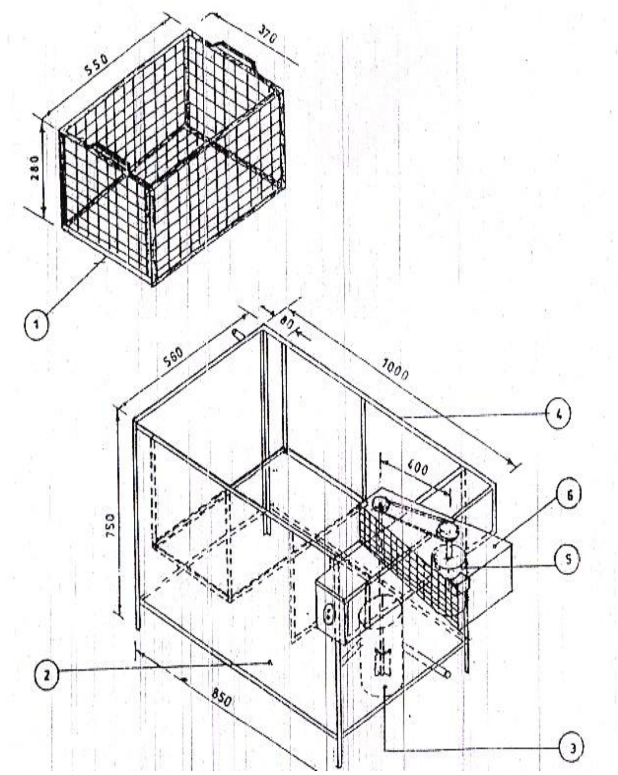

Figure: 1 Mechanical Fruit Washer

A) Cleaning Unit Cleaning unit consists of washing tray fabricated by using M.S. angle and iron netting, rectangular in shape. The overall dimension of tray was 280 x 370 x 550 mm. The tray was painted with special enamel paint to avoid rusting from water. The tray was fitted in the chamber by supporting frame at distance of 150 mm from the bottom. The tray was fitted exactly at the centre of chamber by keeping equal distance (100 mm) from all the four sides.

B) Body and Lid The body of the washer was fabricated with 20 gauge G.I. sheet (1.2 mm. The machine was covered with a lid made up of G.I. sheet of 1.2 mm thickness. The lid was kept closed while washing operation was conducted. The lid was operated while loading and unloading of trays. The inlet pipe (10 mm) for incoming water and outlet pipe (25 mm) for discharge of contaminated water was also fitted to the body of machine.

C) Rotor Assembly The rotor assembly consists of rotor blade, shaft and pulley. The various shapes of rotor were used for conducting the trials. The rotor was fitted at the end of vertical shaft by groove arrangement. The provision of replacement of rotor was made by key and pin arrangement. The shaft was rotated by pulley size 2 inch arrangement at rated speed and created vortex in the water. The desired washing was achieved by the speed (rpm) of rotor.

D) Main Frame The main frame of washer was made in rectangular shape by using 25 mm M.S. angle and G.I. Sheet. The overall dimension of mainframe was 1000 x 560 x 750 mm. The main frame was kept on rigid platform at height of 100 mm from the ground.

E) Power Transmission Mechanism and Drive Mechanism The power transmission unit frame was fabricated by using M.S. angle and fitted to the water chamber from outside in such a way that motor will fit vertically on the frame. The power transmission unit could be divided into two parts. Stirrer power assembly and motor shaft assembly or speed reduction unit including 1 HP single phase electric motor. The blade was fitted to the vertical shaft with the help of support and two bearing (No. 6204). Power was given from motor to shaft by V-belt and speed reduction was achieved with the help of pulley combination 3 x 2 inches. The motor pulley was 3 inches while shaft pulley was 2 inches.

F) Experimental Variables

Three blades of following specifications were fabricated and used for creating desired vortex in the washing chamber.

Rotor	Specifications, (mm)	
A	height	110
	width	65
	effective width	55
B	height	110
	width	75
	effective width	65
C	height	110
	width	100
	effective width	95

G) Experimental Technique The speed of rotor (1466, 1476 and 1486) was kept variable while conducting the trials. The optimum rotor speed and time was worked out. Minimum depth of water in the washer was kept 20 cm (0.11 m^3 volume). Minimum water required for the trial per hour was 110 lit.

The washing efficiency was calculated by using equation suggested by [6] and [7]. The performance index (PI) of the fruit washer was calculated by using the following equation.

$$\frac{\text{Efficiency x Capacity}}{\text{Unit cost of operation}} = \text{P.I} \qquad \dots (1)$$

where,

Efficiency in percent
Capacity in tonns/hr.
Unit cost of operation in Rs./tonnes.

H) Washing Material Potato (Cv. Kufri) was used for testing the performance of machine. For calculating washing efficiency known quantity of foreign material was added to sample and then effect was studied.

I) Measurement of Reynold's Number Osborne Reynolds in 1883 showed that transition from laminar to turbulent flow in tubes is not only a function of velocity but also of density, viscosity of fluid and the tube diameter. This dependency is summarized by dimensionless group known as Reynolds number. The instability of the fluid that leads to a turbulent flow is determined by ratio of the kinetic or inertia force (proportional to ρv^2) to the viscous force ($v\mu/d$).

$$Re= \frac{Inertia\ \ force\,(\rho v2\,)}{Viscous\ \ force\,(v\mu/d)} = \frac{pdv}{\mu} \quad \ldots (.2)$$

where,

P = Density of fluid in kg/m^3
v = Fluid velocity in m/s
μ = Dynamic viscosity in Pa s.
d = Diameter of the rotor

III. RESULTS AND DISCUSSION

A) Effect of Machine Parameter on Washing Efficiency Washing efficiency of potato was recorded by keeping the machine variable constant. It was observed that higher (98.18 %) efficiency was recorded for rotor C at 1486 rpm (Table 1). Lower efficiency (97.43 %) was recorded for rotor B followed by rotor A (97.00 %). It was also observed that there was no significant increase in efficiency for different rotor speeds in case of potato washing. Similar results were reported by [8] for washing of carrot in a rotary vegetable washing machine.

B) Capacity of Machine for Potato Washing Effect of speed of rotor on capacity of machine was studied and the data was given in Table 1. It was observed from the Table 1 that maximum capacity (892.11 kg hr^{-1}) was observed with 98.18 % washing efficiency for rotor C at 1486 rpm followed by 520.03 kg hr^{-1}, capacity with 97.43 % washing efficiency at same rpm for rotor B and 512.00 kg hr $^{-1}$ capacity with 97.00 % washing efficiency at same rpm for rotor A. As rotor speed increases capacity increases and efficiency does not show any significant increase.

Table 1: Effect of Speed and Type of Rotor on Capacity and Efficiency for Potato Washing

Speed (rpm)	Rotor type	Capacity(kg hr^{-1})	Efficiency (%)
1466		340.87	96.52
1476	A	412.00	96.36
1486		512.00	97.00
1466		436.05	96.52
1476	B	447.65	96.40
1486		520.03	97.43
1466		733.71	96.54
1476	C	790.00	96.55
1486		892.11	98.18

C) Performance Index of Washer Performance index of washer for potato for different rotors at three speeds was calculated it was observed that for potato performance index was found higher (3.26) for rotor C at 1486 rpm followed by 2.25 for rotor B and 2.42 for rotor A at same speed. It was observed that as speed increased performance index was found increased.

D) Cost Economics of Fruit Washer The manual and mechanical cost of washing for potato was worked out taking in to account the prevailing raw material as well as labour rates. It was observed that manual washing of potato needs Rs. 132 per ton, whereas, it was Rs. 22.41 per ton for mechanical washing. The ratio of cost for manual to mechanical washing obtained was found to be 5.89: 1. The cost of developed small-scale mechanical washer was found to be Rs. 14650/- including single phase electric motor.

CONCLUSIONS

Based on the designed mechanical fruit washer and the performance of potato washing following conclusions could be drawn.

1. A prototype of fruit washer was developed and tested. The machine consists of cleaning unit, body and lid, rotor assembly, main frame and power transmission unit. The overall dimensions of machine are 1000 x 560 x 750 mm and the cost of washer is Rs. 14,650/- (including 1 HP single phase, electric motor).
2. The capacity, efficiency and performance index of machine varied with respect to speed of rotor, depth of water and quantity of material to be washed.
3. The washing efficiency of machine varied between 96.36 to 98.18 % for all the rotor's used for potato washing.
4. The capacity of washing the fruit was varied between 340.87 kg hr^{-1} to 892.11 kg hr^{-1}. The higher (892.11 kg hr^{-1}) capacity with higher (98.18

%) washing efficiency was observed in case of potato washing at 1486 rpm for rotor C.

5. The performance index (PI) varied between 2.25 to 3.26. The maximum performance index of 3.26 was found in case of potato for rotor C at 1486 rpm.
6. The ratio of cost of manual to mechanical washing obtained for potato was 5.89:1

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