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Research Paper :

Performance testing of stirrer type fruit washer

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ABSTRACT

A prototype of mechanical fruit washer was developed and evaluated for its performance. The effect of three different rotor speeds (1466, 1476 and 1486 rpm) and types (A,B,C) with 20 cm (110 lit) depth of water on capacity and performance index was evaluated. Mango, potato and tomato fruits were used for evaluation of washers. The higher washing efficiency (98.09%) was observed for rotor C at 1486 rpm for tomato washing. Highest capacity (833.17 kg/hr) was found with 98.09% washing efficiency at 1486 rpm for rotor C in case of tomato washing. Performance index at maximum efficiency (98.09%) found was 3.90. The cost of manual to mechanical washing for mango, potato and tomato was 4.26:1, 5.89:1 and 7.58:1, respectively. 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.

Key words : Fruit washer, Rotor speed, Capacity, Performance index, Efficiency

There are attractive opportunities for entrepreneurs in the field of fruit and vegetables processing. The installed capacity of fruit and vegetable processing industries has increased from 21 lakh tonnes in 1979 to 22 lakh tonnes in 2000. The production of processed fruits and vegetables in the country has increased from 9.8 lakh tonnes in 1999 to 9.9 lakh tonnes in 2000 (Rasul, 2002).

Fruits processing industry has been termed as a "sun rise industry" and several efforts have been made in last few years to give a big thrust to this sector. With liberalization of the economy in 1991 and globalization, it was felt that fruit processing industry would come of in a big way. India ranks second in the world production of fruits with a annual production of 45.49 million tonnes. The areas under fruit production has increased from a meagre 1.22 million hectare in 1961 to 3.79 million hectare in 2000-01 accounting for in an increase of 1.72% productivity per hectare has nearly doubled from the level of 5.52 to 10.28 t/ha. Presently the areas under fruits and vegetables production are 5.63 and 5.6 million hectares, respectively (Raganna, 2003).

Washing of fruits and vegetables is vital steps in any processing operation, which give attractive and chemical free fruits. At present washing of fruits is carried out manually which very tedious and time consuming. In view of this a prototype of mechanical fruit washer (stirrer type) was developed at Dr. A.S. College of Agricultural Engg. and Technology, Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra). The fruit washer was tested to mango, potato and tomato washing.

METHODOLOGY

The machine works on the principle of turbulent flow of water created by different rotors in the machine chamber. The fruits kept in washing tray would come in contact with the vortex created by water in the chamber and fruit get washed. The turbulence of water is available from the sides and bottom of tray, which effectively wash the fruit without any mechanical damage.

The fruit washing machine (stirrer type) (Fig.1) consisted mainly;

- Washing unit
- Body and lid
- Rotor assembly (Fig. 2)
- Main frame
- Power transmission unit and drive mechanism

Washing unit:

Washing unit consisted of washing tray. The tray was 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.

Body and lid:

The body of the washer was fabricated with 20 gauge G.I. sheet (1.2 mm). The overall body dimensions were 850 x 560 x 650 mm. The machine was covered

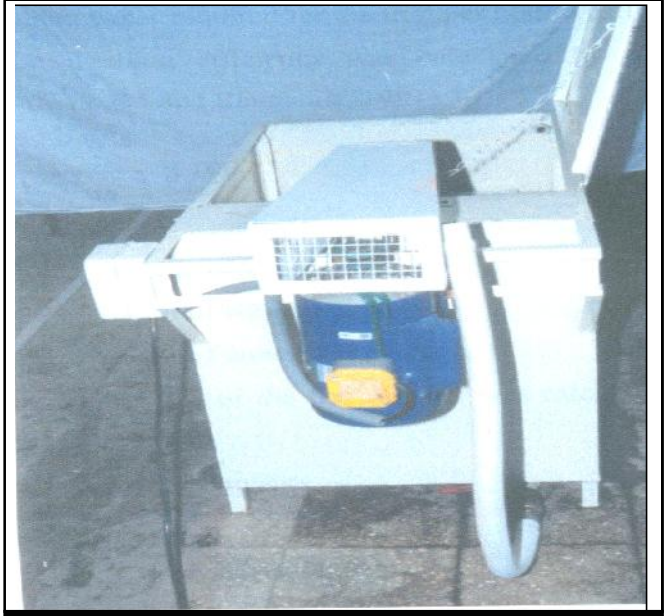

Fig. 1 : Mechanical fruit washer

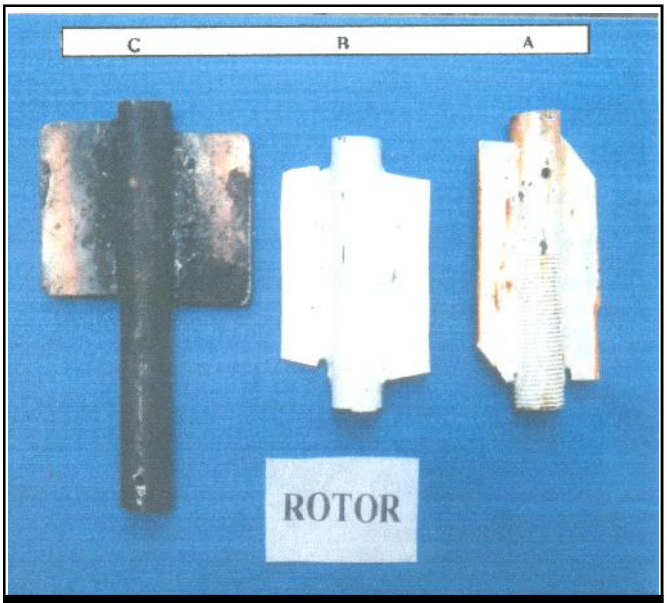

Fig. 2 : Rotor

with a lid made up of G.I. sheet of 1.2 mm thickness. The lid was kept close 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.

Rotor assembly:

The rotor assembly consisted of rotor blade, shaft and pulley. The various shape (Fig.2) of rotor was 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 (2 inch) arrangement at rated speed and created vortex in the water. The desired washing was achieved by the speed (rpm) of rotor.

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 main frame was 1000 mm x 560 mm x 750 mm. The main frame was kept on rigid platform at height of 100 mm from the ground.

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. The stirrer power assembly and motor shaft assembly or speed reduction unit including 1 HP single phase (1440 rpm) 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.

Experimental variables:

Three blades of different specifications were used for creating desired vertex in the water. The specifications of rotor blades were

–	Height	-	110 mm
	Width	-	65 mm
	Effective width	-	55 mm
–	Height	-	110 mm
	Width	-	75 mm
	Effective width	-	65 mm
–	Height	-	110 mm
	Width	-	100 mm
	Effective width	-	90 mm

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 following

equations (Dauthy, 1995 and Ranganna, 1991)

Ew = Ww / Wt x 100

where,
Ew = washing efficiency (%)
Ww = Weight of washed fruits (kg)
Wt = Weight of unwashed fruits (kg)

The performance index (P.I.) of the fruit washer was calculated by using the following equation

P.I. = (Efficiency x capacity) / Unit cost of operation

where,
Efficiency in per cent
Capacity in tons/hr.
Unit cost of operation in Rs. /tonnes.

RESULTS AND DISCUSSION

The findings of the present study as well as relevant discussion have been summarized under following heads:

Washing efficiency of mango fruit:

The washing efficiency of washer was tested for three speeds of 1466, 1476 and 1486 for three rotors at 20 cm water depth (110 lit water). It was observed from Table 1 that higher (97.07%) efficiency was observed for rotor C at 1486 rpm, followed by rotor B (96.59%) and rotor A (96.98%).It was observed during the trial that there was less vortex created by rotor A and rotor B, it may be due to its configuration. It was also observed that three to four times stirring was required for rotor A and rotor B after every minute. However, in case of rotor, stirring was not required in case of rotor C may be due to greater turbulence created by rotor C .

Washing efficiency of potato:

It was observed from the Table 1 that higher (98.18%) efficiency was recorded for rotor C at 1486 rpm. Lower efficiency (97.43%) was recorded for rotor B followed by rotor A (97%). It was also observed that there was no significant increase in efficiency for different rotor speeds in case of potato washing.

Washing efficiency of tomato:

The values obtained for washing of tomato are given in Table 1. It was observed from the table that higher efficiency (98.09%) was recorded for rotor C followed by rotor B (97.92%) and rotor A (98.07%). It was observed during the trial that no stirring was required for tomato, may due to sufficient vortex created by different rotors. The tomatos bouncing was found in the washing tray due to higher velocity of water and get washed without any mechanical damage. Similar results were reported by Sehgel and Arrora (2003) for washing of carrot in a rotary vegetable washing machine.

Capacity of machine for mango washing:

Capacity of machine for mango washing is given in Table 2. Capacity of machine was worked out for three rotors at different speed. It was observed from the table that higher capacity of 391.2 kg/hr, 396.69 kg/hr and 779.85 kg/hr was observed for rotor A, B and C, respectively at 1486 rpm speed. Maximum capacity (779.8 kg/hr) for mango washing was recorded at 1486 rpm for rotor C. It was noted that as speed increased the capacity of machine also increased. It was also observed that there was no specific increase in capacity of machine beyond 1486

Table1: Washing efficiency of mango, tomato and potato

Sr. No.	Sample used for washing	Speed of rotor(rpm)	Rotor A				Rotor B				Rotor C			
			Wt (g)	Ww (g)	Time (min)	Eff. = (Ww / Wt) x 100	Wt (g)	Ww (g)	Time (min)	Eff. = (Ww / Wt) x 100	Wt (g)	Ww (g)	Time (min)	Eff. = (Ww / Wt) x 100
1	Mango	1466	5375	5165	1.20	96.09	5349	5130	0.85	95.90	3.22	5115	0.71	96.11
2		1476	5347	5155	0.90	96.40	5302	5115	0.81	96.47	5320	5138	0.49	96.59
3		1486	5378	5216	0.80	96.98	5340	5157	0.78	96.59	5356	5199	0.40	97.07
1		1466	5356	5170	0.91	96.52	5346	5160	0.71	96.52	5320	5156	0.42	96.54
2	Potato	1476	5344	5150	0.75	96.36	5340	5148	0.69	96.40	5318	5135	0.39	96.54
3		1486	5340	5180	0.60	97.00	5340	5203	0.60	97.43	5300	5204	0.35	98.18
1		1466	4135	4040	0.45	97.70	4120	4035	0.55	97.93	4140	4030	0.35	97.34
2	Tomato	1476	4125	4036	0.42	97.84	4135	4031	0.51	97.24	4126	4029	0.31	97.64
3		1486	4110	4031	0.39	98.07	4115	4029	0.42	97.92	4105	4027	0.29	98.09

Table 2 : Effect of speed and type of rotor on capacity of mango, potato and tomato washing

Speed of rotor (rpm)	Rotor type	Capacity (kg/hr)		
		Mango	Potato	Tomato
1466	A	258.25	340.87	538.66
1476		343.66	412.00	576.57
1486		391.20	512.00	620.15
1466	B	362.11	436.05	440.18
1476		378.88	447.65	474.23
1486		396.69	520.03	575.57
1466	C	432.25	733.71	690.85
1476		629.14	790.00	779.80
1486		779.85	892.11	833.17

Table 3 : Performance index of washer for different rotor (A, B and C) speed for mango, potato and tomato washing

Speed (rpm)	Rotor type	Performance index		
		mango	tomato	potato
1466	A	0.92	1.46	2.10
1476		1.22	1.77	2.25
1486		1.40	2.21	2.42
1466	B	1.28	1.87	1.72
1476		1.35	1.94	1.84
1486		1.42	2.26	2.25
1466	C	1.54	3.16	2.68
1476		2.25	3.14	3.04
1486		2.80	3.90	3.26

rpm.

Capacity of machine for potato washing:

The results of capacity with respect rotor speed obtained are given in Table 2. Maximum capacity (892.11 kg/hr) was observed with 98.18 % washing efficiency for rotor C at 1486 rpm followed by 520.03 kg/hr, capacity with 97.43% washing efficiency at same rpm for rotor B and 512 kg/hr capacity with 97% washing efficiency at same rpm for rotor A. As rotor speed increased, efficiency did not show any significant increase.

Capacity of machine for tomato washing:

Higher (833.17 kg/hr) capacity with 98.09% washing efficiency was observed at 1486 rpm for rotor C. Capacity 575.57 kg/hr (97.91%) and 620.15kg/hr (98.07%) was recorded in rotor B and rotor A at 1486 rpm, respectively. Maximum efficiency of 98.9% and capacity 833.17 kg/hr was observed at 1486 rpm for rotor C among all the three fruits /vegetables tested for washing.

Performance index of washer:

Performance index of washer for mango, potato and tomato for different rotors at three speeds was calculated and presented in Table 3. It was observed that for tomato performance index was found higher (3.90) for rotor C at 1486 rpm followed by 3.26 and 2.80 for same rotor at same speed for potato and mango, respectively. It was observed that as speed increased performance index also increased and *vice versa*.

Cost of fruit washer:

The total cost of machine including motor was evaluated to be Rs.14, 650/-.

Conclusion:

- The washing efficiency of machine varied between 95.90% - 98.09% for mango, potato and tomato. The maximum washing efficiency of 98.09% was found in case of tomato (for rotor C at 1486 rpm).
- The capacity of machine varied between 258.25 kg/hr – 833.17kg/hr. The higher capacity (833.17 kg/hr) was seen in case of tomato.
- The performance index (PI) varied between o.92 – 3.90. The maximum performance index of 3.90 was found in case of rotor type C at speed of 1480 rpm.

The ratio of cost of manual washing to mechanical washing obtained was 4.26:1, 5.89:1 and 7.58:1 for mango, potato and tomato, respectively.

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