

## DEVELOPMENT AND PERFORMANCE EVALUATION OF CARROT WASHER

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Carrot washer is a machine which could find its use in agricultural fields. The root crops like carrot after harvesting have to be cleaned-off soil particles before their transportation from field to market in order to enhance market value. The washing of carrots is mainly carried out manually with the help of brooms and feet by using un-cleaned water of nearby source. Manual cleaning requires labor and it is time consuming due to sticky mud on the surface of carrot. Carrot washer is a machine which is very useful for cleaning purpose with a cleaning efficiency of 98%. It can also be used for the washing of other crops like potatoes; radish etc., after their harvesting and then these crops can be transported to the market. This is a low cost machine and every farmer in Pakistan can afford it. The objective of this paper is to discuss the design and details of this carrot washer. The machine has a wooden drum with a continuous pressurized water supply. Muddy carrots after harvesting are placed inside the drum through opening provided at the face of drum. The wooden drum rotates and rubs off foreign material from carrot surface; pressurized water is used to wash away the soil. The wastewater after washing falls down from the drum through slots provided at the circumference of drum. Hence carrot washer cleans the carrots and other root crops and makes them ready for marketing.

**Keywords:** Manual Cleaning; Carrots; Carrot Washer; Wooden Drum

### INTRODUCTION

Carrot (*Daucus carota*) is a root-crop which is rich in vitamin and used as a food, household vegetable and in salad. Maturity period of carrot is about 100-120 days and it is sown on an area of 33345 acres (13500 hectare) with a production of 235.9 thousand tons in Pakistan (GOP, 2011). As it is a root crop so after harvesting washing of carrots is very essential to get good market price (Shakeel *et al.*, 2013). After harvesting of root crops, immediate washing is necessary to avoid contamination due to drying of soil on crops in order to enhance quality of crop (Whitemore and Whalley, 2009; Aslam *et al.*, 2014). In Pakistan washing of carrots is mostly done manually which is laborious and time consuming due to sticky mud on its surface. Manual washing is done alongside the canals and water channels and it requires huge labor, it is expensive, time consuming and in-efficient. Henderson and Perry, (1980) reported that the manual washing is done by a huge amount of water moving at medium to high speed over the root crops. In some areas where canal water is not available, the washing of carrots is done with waste water and mud is removed with the help of feet. These methods of washing are immoral, unhygienic and also damage the carrots. Le Bohec, (1993) concluded that the conventional methods of washing of carrots tend to damage the crop. Fig.1 shows the conventional method of carrot washing which is

being practice in Pakistan. Ahmad *et al.*, (2012) reported that the washing procedure of the farmers is very poor at the farm level. These methods need to be improved for the greater market value of the crop. Murry and Judy, (1996) reported that there is a need of an efficient vegetable washer to remove the foreign material from the surface of the vegetables especially from root crops.



**Figure 1: Conventional Washing Method at Farm Level in Pakistan.**

## MATERIALS AND METHODS

According to demand of the root crop growers it was necessary to develop a machine which can help the farmers in washing of root crops at farm level. Therefore, Agricultural Mechanization Research Institute (AMRI), Multan has designed and developed two prototype machines for root crop growing community. These machines were tested many times in field and modifications were done to get best results. First prototype machine is operated with tractor P.T.O shaft and second is operated with 2 h.p electric motor. Fig 2 shows tractor operated carrot washer and fig 3 shows motor operated carrot washer. Both prototype machines were tested by washing of carrots. Tractor operated machine has washing drum of hexagonal shape which is made of iron strips. Carrots up to 0.5 ton can feed in the washing drum and feeding door is closed before rotation of drum. After one minute of continuous rotation of drum carrots are removed by opening the feeding door and collect the carrots on collector plate.



Figure 2: Tractor Operated Carrot Washer.



Figure 3: Motor Operated Carrot Washer.

In order to overcome the problems of tractor operated machine Institute decided to redesign new prototype machine which is capable to overcome all issues faced in tractor operated machine. A medium size electric operated prototype machine was design, developed (Fig.3) and tested for washing of carrots. The performance of machine was tested for washing efficiency and the capacity. The machine works on the principle of rubbing action provided by the brushes installed in the washing drum. The newly developed carrot washing machine mainly consists of, circular wooden drum, main frame, power transmission unit and drive assembly, water supply unit and drain water collector tank

**Circular Wooden Drum:** A circular wooden drum having 2438 mm length, 610 mm diameter and 23 wooden strips is used in this machine. Carrots are continuously fed in rotating wooden drum through the opening provided at one face of the drum and water is sprayed in the drum by a perforated pipe having diameter of 25 mm mounted on the top inside the washing drum. Three types of washing drums were fabricated and tested under different conditions to get better results.

D1 = Washing drum of 6ft diameter.

D2 = Washing drum of 8ft diameter.

D3 = Washing drum of 8ft diameter with cleaning brush inside the drum.

**Main Frame:** The main frame of carrot washer was rectangular in shape made by using 38x38x5 mm angle iron and 3 mm G.I sheet. The overall dimension of frame was 4000 x1066x1800 mm. Main frame of the machine have two wheel and one hitch for the purpose of easy transportation in the field.

**Power Transmission Unit and Drive Assembly:** Two phase motor having 900 rpm was use and power of motor was diverted to the wooden drum by V-belt. Fig 3 shows power transmission and drive assembly.

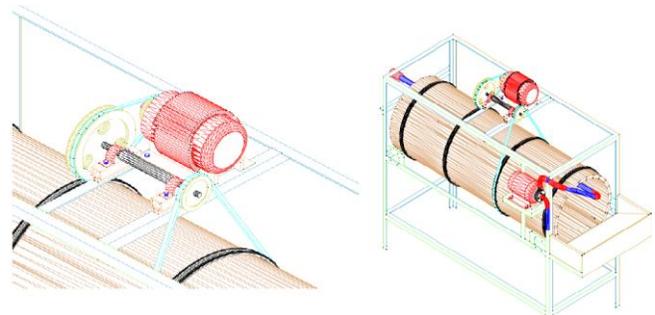
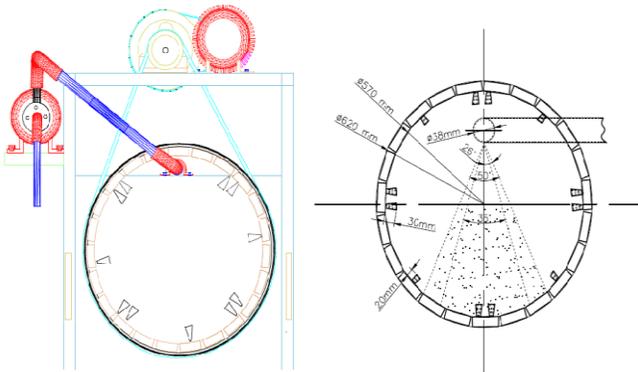


Figure 4. Power Transmission and Drive Assembly of Carrot Washer.

**Water Supply Unit:** Mono block pump having discharge of 1.5 liters/sec is used to supply water in the washing drum. Head of the pump is 70ft. The suction pipe of 37 mm and delivery pipe of 25 mm are attached with the pump. Pump is operated with electric motor having 2850 rpm. Perforated pipes are used to add fresh water with pressure and remove

floating produce after cleaning (Kitinoja and Kader, 2002). Fig 4 shows water supply unit and washing brushes with their exact position and spray angle inside the washing drum. The bruise index increased with increase in operating speed for washing root crops (Jayashree and Viswanathan, 2010). Vegetable washing by means of a spray washer is most effective method. Antony, (1987) concluded that those products that are heavily contaminated with soil should be thoroughly soaked in order to lose the soil and then pass it under sprays. In the case of plastic matting, washing efficiency was more for carrot and radish at 3.5 mm thickness compared to 1.5 mm thickness for the same produce. Fig 4 shows water supply unit and spray angle inside the drum.



**Figure 5: Water Supply Unit and Spray Angle inside the Drum.**

**Drain Water Collector Tank:** After washing of root crops (i.e. carrots) waste water falls down through spacing provided between the wooden strips of washing drum and collected in a collection tank present at the bottom of the machine. After collection the collected water is drained into the watercourse by the help of drained pipe. In this way water is saved and can be reused for agriculture purposes.

**Specifications:** The detailed specifications of the carrot washer are given in Table 1 and specification of the pump used in carrot washer is given in Table 2.

**Cleaning and Washing Efficiency:** Cleaning efficiency is the ratio of quantity of carrots washed effectively to the quantity of carrots supplied to the carrot washer for washing. It can also be determined by using following formula.

$$\text{Cleaning Efficiency} = \frac{\text{Quantity of carrots washed}}{\text{Total quantity of carrots in drum for washing}} \times 100$$

Washing efficiency is the ratio of the weight of carrots before washing to the weight of carrots after washing and it can be calculated by the following formula.

$$\text{Washing Efficiency} = \frac{\text{Weight of carrots before washing}}{\text{Weight of carrots after washing}} \times 100$$

## RESULTS AND DISCUSSION

The carrot washer was tested under different field conditions and data was collected carefully to check the performance of carrot washer. On the basis of these tests, suitable dimensions of the carrot washer were suggested. The results obtained at different field conditions are presented statistically in table 3. Table 3 consists of different types of washing drums having different lengths, slope, average cleaning capacity in kg/hr. and finally average cleaning efficiency of carrot washer at different slopes and lengths.

**Statistical Analysis of Obtained Data:** Statistical analysis of the data show that there was a significant difference in the performance of carrot washer under changing parameters. There was a significant difference in the cleaning capacity and cleaning efficiency of the carrot washers having washing drum of same length at different slope also there was a significant difference in the cleaning capacity and cleaning

**Table 1: Specifications of Motor Operated Carrot Washer**

Washing capacity	25 Mound/hour
Power of drive motor	2 h.p (Three phase) with 900 rpm
rpm of washing drum	40
Length of washing drum	2438 mm
Inner dia. Of drum	610 mm
Number of wooden strips used in drum	23
No. of transmission pulleys	2 (304 mm and 100 mm in dia.)
Number of supported rims	4 (dia. 660 mm)
Overall machine dimensions (L x W x H) mm	4000 x 1066 x 1800
Main material of machine (mm)	Angle iron (38 x 38 x 5) and M.S sheet 3 mm in thickness

**Table 2: Specifications of Pump**

Type of pump	Discharge (lit/sec)	Suction (mm)	Delivery (mm)	Power of motor attached with pump (hp)	RPM	Maximum Head (ft)
Mono block	1.5	37	25	0.5	2850	70

efficiency at same slope in washing drums of different length. Firstly, when the drum D1 was used its cleaning capacity was more at slope 2.25 % as shown in table 3 but cleaning efficiency was more at slope but cleaning efficiency was less, so D1 replaced with D2 but D2 also gave the same results as D1. Now we introduced cleaning brushes in D2 and named it as D3. On testing D3 at different slopes the results were excellent. At 0.75% slope the cleaning efficiency was maximum but cleaning capacity was less and at 2.25 % slope the cleaning capacity was maximum but cleaning efficiency was minimum. In this study our main concern was on cleaning efficiency so the recommended washing drum is D3 at slope 0.75 % as it gives maximum cleaning efficiency at this slope. All the statistical results are shown in table 3.

**Table 3: Performance of Machine at Different Slopes in Different Washing Drums**

Effects of slope and drum length	Parameters		
	Washing capacity of drum (kg h <sup>-1</sup> )	Cleaning efficiency (%)	
<b>Drum length (ft)</b>			
D1 = 6	1324 A*	74.2 C	
D2 = 8	1192 B	82.0 B	
D3 = 8 with brushes	1090 C	92.3 A	
HSD Value	0.8840	1.2392	
<b>Slope of drum (%)</b>			
S1 = 0.75	1138 C	87.9 A	
S2 = 1.50	1197 B	84.0 B	
S3 = 2.25	1272 A	76.7 C	
HSD Value	0.8840	1.2392	
<b>Interaction of drum length with slope</b>			
Drum length	Slope of drum		
6 ft	0.75	1249 d	78.7 e
	1.50	1326 b	75.0 f
	2.25	1398 a	69.0 g
8 ft	0.75	1115 g	87.0 c
	1.50	1193 e	83.0 d
	2.25	1269 c	76.0 ef
8 ft with brushes	0.75	1050 i	98.0 a
	1.50	1071 h	94.0 b
	2.25	1150 f	85.0 cd
HSD Value		2.112	2.960

\*Values followed by the same letter in the same column for each effect is not significantly different ( $P \leq 0.05$ ); significant values based on Tukey's test.

**Conclusion:** The cost of manual washing of carrots is estimated about Rs.5000 per acre while the operational cost

of this machine is about Rs. 2800 per acre. Manual washing also takes a lot of time but washing with carrot washer save time when we compare with manual washing. In conventional washing 80 hours are required per acre per person for washing of carrots. While the same work can be performing in 15 hours. In short, it can save about 65 hours per acre and also it is easy to operate and ensures safe handling of carrots. Besides of carrots it can also be used for the washing of other root crops.

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