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Cleaning Machine for Fruits and Vegetables: A Brief Literature Review

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Abstract: *It has been observed that washing of fruits and vegetables are mostly done manually which is more laborious and time-consuming work. It is necessary to clean fruits and vegetables after harvesting from dust, microbial load and pesticide residues. This article presents the previous study of design of fruits and vegetables cleaning machine. It is concluded that research focus should be towards development of flexible universal washing machine which will capable to do multi-produce washing. The cost and maintenance of fruits and vegetables washer would be economical which may be used by group of farmers, self-help groups and small-scale industries. As revealed by recent studies, the mechanical washing efficiency, microbial washing efficiency and bruising percentage of a crop washer to be considered in order to be able to design efficient and effective washers for fruits and vegetables.*

Keywords-fruits and vegetable cleaning machine, mechanical washing efficiency, microbial washing efficiency, bruising percentage.

1.0 INTRODUCTION

India's diverse climate conditions lead cultivated area of fruits stood at 7.05 million hectares while vegetables stood at 11.35 million hectares. It ranks second in fruits and vegetable production in the world, after China. As per National Horticulture Database (3rd Advance Estimates) published by National Horticulture Board, during 2021-22, India produced 107.24 million metric tonnes of fruits and 204.84 million metric tonnes of vegetables. The vast production base offers India tremendous opportunities for export. During 2022-23, India exported fresh fruits and vegetables worth Rs. 13185.30 crores which comprised Fresh Fruits worth Rs. 6,219.46 crores and vegetables worth Rs. 6,965.83 crores (www.Apeda.com). But India's share in global market is insignificant. It is 1.7% in vegetables and 0.5% in fruits. Lacks of post-harvest treatment are the one of major constraint in export of fruits and vegetables along with storage and packaging.

Cleaning of fruits and vegetables are important primary process in food process industry which reduces the surface microbial load while removing dust particles and residual pesticides. The consumptions of fresh fruits and vegetables are directly linked to reduce risk of chronic diseases and to enhance resistance against diseases (Van Duyn and Pivonka 2000). In addition to the pleasure of eating fruits and vegetables, provides various phytochemicals and antioxidants (Kalt 2005), phytoestrogens, and anti-inflammatory agents (Vincent et al. 2010) and other protective compounds (Kaur and Kapoor 2001; Slavin and Lloyd 2012). These aspects of health benefits led to the tremendous increased market for fresh cut and minimally processed fruits and vegetables. Fresh-cut products are preferred over processed one because of nutritional losses, desired sensory attributes such as colour and flavour and increased demand for 'natural-like' attributes (Kader 2002).

Normally many Indian farmers follow a traditional method of cleaning the carrots, radish in which the roots are washed manually by hands and feet. Proper cleaning of the fruits and vegetables are the subject of major concern to all the farmers, intermediaries and consumers, not only to control of post-harvest diseases, but also for prevention of food-borne illness to consumers. Fruits and vegetables should be cleaned with related methods and materials. So that there is need to design fruits and vegetable cleaner for the utilisation of every farmer in India which will be in affordable price.

This article presents the need of design and development of fruits and vegetables washer

2. METHODOLOGY

Google, Science Direct, Yahoo and Google Scholar search engines were consulted for relevant research articles, review articles, patent, report, thesis and other related materials up to August 2023, using combination of words as follows: "Vegetable crop washing, washer"; "Fruit crop washing machine"; "farm, agricultural produce washing, washer"; "farm, agricultural produce washing machine". This was done to be able to achieve this research's aim.

3. TECHNIQUES OF WASHING FRUITS AND VEGETABLES

Manual and mechanical methods are the two known ways of washing crops. Traditionally, there must be relative motion between crop surfaces and the cleaning object or between two crop surfaces in water. The water which is used for washing purpose must be potable.

3.1 Cabinet with Sprayer-Type

In this type of washer, only water jet cleaning action is use. Feeding and removal of washed crops are done manually. This washing method is observed to be too limited due to the fact that there is no relative motion among crops as well as between the crops and the containing/confining walls. It is ineffectual to leafy vegetables.

3.2 Stirrer-Type

As name indicates, it has stirrer, rotor, paddle or any similar tool to agitate the water in which crops to be washed are immersed. Sometimes, washing water and crops being washed are agitated together depending on the nature and properties of the crops.

3.3 Roller-Brush Type

Roller-brush washers have rollers incorporated with brushes mainly known for its scrubbing action for cleaning the surfaces under continuous water supply.

3.4 Rotary Barrel/Drum-Type

This is well known type, consists of a rotating barrel/drum. The crops inside rotating barrel/drum are cleaned under continuous supply of high-pressure water spray.

3.5 Conveyor-Type

The conveyor consists of belt, roller, chain etc. It is use for continuous flow operation. It usually finds application in food processing plants.

4.0 PERFORMANCE PARAMETERS

The performance of developed washing machine for fruits and vegetables are evaluated with following parameters.

4.1 Mechanical Washing Efficiency

Removal of soil by washing in mechanical washer is called mechanical washing efficiency.

$$Mechanical\ washing\ efficiency, \% = \frac{weight\ of\ produce\ before\ washing - weight\ of\ produce\ after\ washing}{weight\ of\ produce\ before\ washing}$$

4.2 The microbial washing efficiency

The surface microbial load in terms of total plate count (colony forming units, cfu) before and after washing of carrot was determined by serial dilution technique as enumerated by Ranganna (1986). The microbial washing efficiency was calculated as follows (Arora *et al.,* 2007)

$$Microbial\ washing\ efficiency, \% = \frac{initial\ microbial\ load - final\ microbialload}{initial\ microbial\ load}$$

4.3 Bruise index

Bruise index is a visual damage grading technique. Approximately, about 10% of the quantity of washed washer will be individually graded for assessing the number of surface injuries. The injuries were classified based on severity of damage e.g. scrapping, cut and breakage and multiplied by a scaling factor (Moden et al., 1989):

Bruise index = 0.5 (S1)+1 (S2)+1.5 (S3)+3(S4)+8(S5)+2(S6)

Where,

S1 = Scraping or surface abrasion (no depth)

S2 = Scraping depth between 0 to 5 mm

S3 = Scraping depth between 5.1 to 10 mm

S4 = Scraping depth between 10.1 to 20 mm

S5 = Scraping depth > 20 mm and

S6 = Broken tip 25 mm in diameter or larger

4.4 Optimum condition for washing

The optimum conditions for washing of selected raw material will be on the basis of microbial washing efficiency. The conditions of the mechanical washer, for microbial washing efficiency above 80%, will be selected as the optimum operating condition (Arora*et al*., 2007).

5.0 Review of Literature

All the review of literature are presented in Table I

Table I : Review of literature

SN	First Author Name	specific Technique for particular crop
1	Nikhil Kamalakar Deshmukh, *et al* (2023)	It is concluded that the domestic Ginger washer would make the heavier tasks much easier one and also prevents wastage of soil and human energy. By using the machine, farmer can start his own business.
2	Chatchaphon Ketviriyakit, *et al* (2022)	The galangal washing machine that replaces traditional washing with manual labor can reduce galangal production costs with a payback period of only 3 months. This machine can enhance the agricultural production of galangal farmers to increase income while also improving occupational health.
3	Mohammed Daniyal Shariff, et al (2022)	The pedal operated vegetable washer was tested for various vegetables like carrots, radish, potato and ginger and it was found that the overall washing efficiency was close to an average of 88.4%. The cost and maintenance is economical and can be used by small scale farmers.
4	Mirzaev *et al* (2021)	The calculated chain transmission is used in a two drum root crop washing machine. It revealed that efficiency of washing raw material is increased by increasing the path of the fruit passing and accordingly increasing the the time of contact interaction between the fruit and washing elements.
5	Md. Arun Amin and Md (2021)	A root crop washing machine was developed for carrot in Bangladesh. The capacity of the machine was 120 kg/batch with washing and cleaning efficiencies were about 98% and 99% respectively.

6	Emmanuel Olatunji Olutomilola (2021)	This review deals with the study of types of fruit and vegetable washer. It for researchers in this study area to note that mechanical washing efficiency, microbial washing efficiency, bruising percentage, retention/residence time, throughput capacity and performance index were performance parameters that are very crucial to detail/comprehensive evaluation of agricultural produce washers.
7	Joseph Chidiebere Igbo (2020)	This innovation was achieved by design, manufacturing process and proper material selection. It can be powered by either electric motor, internal combustion engine (ICE) or Tractor coupled. The machine cleaned root crops at a low time interval, irrespective of the source of power transmission.
8	Hossam El-Ghobashy, *et al* (2020)	A prototype small scale mechanical washer for potato was developed at Agricultural Engineering Research Institute, Dokki-Giza, Egypt. It operated successfully at the proper operating parameters of 4 min retention time, 20 rpm rotor drum speed and 36 kg batch load, which attained the proper washing efficiency, bruising percentage and microbial washing efficiency with values of 93.07, 5.33 and 85.8 %, respectively.
9	Pranita Joshi, *et al* (2020)	This review paper helps to study CAD modelling of vegetable cleaning machine.
10	Susendran T.S., *et al* (2019)	A rotary drum continues type mechanical washer was developed for washing turmeric rhizomes. It was used to perform mechanical washing of turmeric and its washing efficiency was evaluated.
11	Meshram Anjali (2018)	Design and development of a CAD model of vegetable cleaner machine made as per the company requirement base on sources available about vegetable cleaner machine.
12	Tehmena Rashid, et al (2018)	The trials was conducted in Pakistan and conclude that average washing efficiency for carrot was found 98% with washing capacity 2.75 t/hr. Further it recommended to achieve an efficient wash with lowest fuel consumption, the revaluation per minute of washing drum should be maintain between 20 to 21 rpm at 1500 speed of tractor.
13	S. A. Adegbite, *et al* (2018)	The washing machine was developed for tomato and orange in Nigeria with capacity ranged from 276.92 Kg/h to 320.00 kg/h for tomato, while that of orange ranged from 437.25 Kg/h to 517.99 Kg/h for orange. The washing efficiency for tomato ranged from 89.80 to 90.37% with a mean value of 89.73%while that of orange ranged from 86.28 to 92.17% with a mean value of 90.16%.
14	Narender, S. Mukes, *et al* (2018	Field test of carrot washing machine was conducted for carrot crop at Village Behbalpur, District Hisar (Haryana). It was found that optimum operating parameters of carrot washer were the average mechanical washing 75 and operating speed of rotor drum was 25 and the microbial washing efficiency, mechanical washing efficiency and bruising percentage was 90%, 75% and 7%, respectively.
15	Dawn C. P. *et al* (2013)	The manually operated vegetable washer for carrot and reddish was developed in Coimbator and tested by using various thickness of rubber and plastic matting. The trials revealed that 3.5 mm plastic matting gave better performance with washing efficiency (97% for carrot, 96% for reddish) and cleaning efficiency (91% for carrot, 90% for reddish)
16	Olotu, F.B., *et al* (2013)	A Continuous process multi-crop seed washer was designed and fabricated for melon and locust bean seeds at the National Centre for Agricultural Mechanization, (NCAM), Ilorin, Kwara StatC. Results obtained gave cleaning efficiencies of 80% and 89% for melon seeds and locust bean seeds respectively.
17	Kenghe R.N., *et al* (2015)	A prototype small scale mechanical fruit washer was designed, developed and tested for washing of potato. The washing efficiency of machine varied between 96.36 to 98.18.
18	Ravdeep Singh Ghuman, *et al* (2014)	It proposed design study of automatic root crop washer for vegetables like Radish, carrot and potatoes, etc. need to clean off from soil and clay particles after harvesting before transmitting them to Market.

19	Ichelle Choi, *et al* (2014)	The objective of this root crop washer design was to address the needs of the McGill Student-Run Ecological Garden by alleviating the processing impact of cleaning fresh root crop vegetables. Through design analysis, computer modelling and finally prototyping the conceptualized machine design was developed as an effective solution.
20	S Balasubramanian et al (2012)	It deals with study of physical properties of turmeric rhizomes which will be useful in the designing of polishers and other processing gadgets.
21	Magar A.P., Abuj M.D. et al (2010)	A prototype mechanical fruit washer (stirrer type) for Mango, Tomato and potato was developed at Dr. A.S. College of Agricultural Engg. And Technology, MPKV, Rahuri (MS). Author asses three different rotor speeds to evaluate performance index.
22	Jenelyn Antas Capito (2009)	The study tested and evaluated the performance of the AMDP Root Crop Washer-Peeler designed and fabricated at the Engineering Shop under the Institute of Agricultural Engineering. Three independent parameters, namely, the quantity (25, 50 and 75kg), drum speed (40, 50 and 60 rpm) and operating time (5, 10 and 15 minutes) were used to analyze the response parameters for experiment. The experimental results showed that the washer-peeler had peeling efficiency, cleaning efficiency, washing-peeling capacity, parenchyma recovery, cortex recovery, mechanical damage, noise level, and power consumption ranging from 45.6 – 95.4%, 87.6 – 94.4%, 46.8 – 792.0 kg/h, 41.3 – 82.5%, 53.2 – 82.2%, 19.0 – 61.2%, 90 – 94 db and 804.1 – 860.2 W, respectively.
23	J. A. Moos, D. D. Steele (2002)	The objective of this article is to chronicle the design, development, and performance of the mechanical carrot washing system. This study does not provide statistical comparisons of the mechanical versus manual washing systems i.e. comparisons based on quantitative measurements of percentage soil removal or other measurements.
24	Galizalyn B. Batara	The barrel potato washing machine has a maximum washing capacity of 6.82 kg/min and maximum cleaning efficiency of 93.82%. Meanwhile, the machine was able to obtain the minimum skinning damage of 3.51%.
25	Cross, Simon Rathangan, County Kildare (IE)	A root crop washer for beet having a washing drum rotating about a hori- zontal axis. Washing is achieved by partial im- mersion of the drum in water in a trough.

6.0 CONCLUSION

From all the review, it was found that washing of fruits and vegetables are important primary process in fruits and vegetable processing. It is concluded that research focus should be towards development of flexible universal washing machine which will capable to do multi-produce washing. The cost and maintenance of fruits and vegetables washer would be economical which may be used by group of farmers, self-help groups and small-scale industries. As revealed by recent studies, the mechanical washing efficiency, microbial washing efficiency and bruising percentage of a crop washer to be considered in order to be able to design efficient and effective washers for fruits and vegetables.

7.0 REFERENCES

1. S. A. Adegbite, S. K. Adeyemi, A. O. Komolafe, M. O. Salami, C. F. Nwaeche and A. A. Ogunbiyi, “Design and Development of Fruit Washer”, Journal of Scientific research and reports, vol.21(6), 2018, pp.1-11.

2. Md. Arun Amin and Md, Ayub Hossain,”Development and Evaluation of a Mechanical Carrot Washing Machine”, Agriculture Engineering International CIGR e- journal, vol 23 (3), 2021 pp. 111 to 119.

3. M. Arora, , V.K. Seghal, S.R. Sharma, “Quality Evaluation of Mechanically Washed and Polished Turmeric Rhizomes” Journal of Agricultural Engineering, 44(2), 2007pp. 39-43.

4. S. Balasubramanian, A.M. Mohite, K.K. Singh, T. John. Zachariah and T. Anand, “Physical Properties of Turmeric (Curcuma longa L.)” Journal of Spices and Aromatic Crops, Vol. 21 (2), 2012, pp.178–181.

5. K. Chatchaphon, R. Lakkana and J. Supalux, "Comparative Study of Manual Washing and Galangal Machine Washing: A Case Study of Uttaradit Province", Thailand, Proceedings of the International Conference on Industrial Engineering and Operations Management Istanbul, Turkey, March 2022, pp.7-10.

6. S.R. Cross, K. County, A Root Crop Washer, European Patent Application, Application no 93650016.4

7. C. P. Amborse and S. J. K. Annamalai, "Development of a Manually Operated Root Crop Washer", African Journal of Agricultural Research, vol. 8(24), 2013, pp. 3097-3101.

8. N. Deshmukh, D Ambalkar, D.S. Rayakar, "Domestic Ginger washer, Journal of Emerging Technologies and Innovative Research (JETIR)", vol. 10(2), 2023, pp. 174-183.

9. R.S. Ghuman, K. Rachit, S. Singla, P. Singh, H. Singh, "Designing and Fabrication of Automatic Root Crop Washer", IJRMET, vol 4, 2014, pp 222-224.

10. H. Ghobashy, Y. Shaban, S. Reheem and F. Gawad, "Development of a Small Scale Washing Machine for Root Crops", International Journal of Advance Research (IJAR), 8(05), 2020, pp. 35-43.

11. I. Choi, I. Han, K. Mohtashami, K. Walker "Design of a Small Scale Root Crop Washer", final Design Report submitted in McGill University – MacDonald Campus, 2014.

12. Jenelyn Antas Capito (2009) A thesis on Performance evaluation of amdp root crop washer-peeler at the faculty of agricultural and bio-process division institute of agricultural engineering college of engineering and agro-industrial technology university of the philippines los baños

13. J. Igbo, "The International Journal of Science & Technology", Vol 8 (10), 2020pp. 44-48.

14. P. Joshi, K.S. Zakiuddin, V.M. Sonde "Review on Design and Development of Vegetable Cleaning Machine", International Journal of Innovations in Engineering and Science, Vol 5 (10) 2020, pp. 20-24.

15. W. Kalt "Effects of Production and Processing Factors on Major Fruit And Vegetable Antioxidants" J Food Sci 70: 2005, pp.R11–R19

16. A.A. Kader "Quality parameters of fresh-cut fruit and vegetable products, Fresh-cut fruits and vegetables", Science, technology and market. CRC, Boca Raton, FL, 2002pp 11–20, Links.

17. C. Kaur, H.C. Kapoor () Antioxidants in fruits and vegetables—the millennium's health. International Journal Food Science Technology, vol 36, 2001, pp.703-725.

18. R.N. Kenghe, A.P. Magar and K.R. Kenghe, "Design, Development and Testing of Small Scale Mechanical Fruit Washer, International journal of trend in research and development, vol 2(4), 2015, pp. 168-171.

19. Magar A.P., Abuj M.D., Bastewad T.B. and Adagale P.V. (2010),Performance testing of stirrer type fruit washer,International Journal of Agricultural Engineering, Vol. 3, No 1, PN 89-93.

20. Anjali Meshram and S.R. Ikhar (), Design and Development of Turmeric Washer, International Journal for scientific research and Development, Volume 6 (3), 2018, pn 2321-0613.

21. Mirzaev and Mamasalieva, "Double Drum Root Crop Washer with Chain Transmission", E3S Web of Conferences 289, 07030Energy System Research, 2021, pp. 1-4.

22. J. Moos., D. Steele, D. Kirkpatrick , "Small–scale mechanical carrot washer for research sample preparation", Applied Engineering in Agriculture, Vol. 18(2), 2002, pp. 235–241.

23. Narender, S. Mukes, V. Rani, Anil Kumar, K. Verma and N. Karwasra () Performance Evaluation of Vegetable Washer for Carrot Crop, International Journal of Current Microbiology and Applied Sciences, vol. 7 (01), 2018, pp. 454-458.

24. F.B. Olotu, N.O. Oladip, Farounbi, A. J. and S.I. Obiakor, "Development of a Continuous Process Multi-crop Washing Machine", International Journal of Basic and Applied Sciences Vol. 3 (3). 2014. pn.96-100.

25. O.E. Olatunji "Washing of Agricultural Produce: a Review, ARPN Journal of Engineering and Applied Sciences, vol. 16 (12) 2021, pp. 1248-1259.

26. Ranganna, S., Hand book of Analysis and Quality control for fruit and vegetable products. Tata McGraw Hills Publication co. Ltd, New Delhi1, 986.

27. S.M. Daniyal, I. Rahman, M. Manish, P. Singh, M. Abhilash, "Design and Fabrication of Root Vegetable Washer", International Journal for Research in Applied Science & Engineering Technology, Vol.10(VII), 2022, pp. 1693-1697.

28. Slavin JL, Lloyd B, "Health Benefits of Fruits and Vegetables", Advance Nutrition 3: 2012, pp. 506–516.

29. T.S. Susendran, I.P. Sudagar, S Ganapathy and P. Aruna, "Design and Development of Turmeric Washer", International Journal of Agriculture Sciences, Volume 11 (10), 2019, pp. 8541-8544.

30. R. Tehmena, G. Siddique, Abdul Aleem, "Fabrication and performance evaluation of a tractor operated carrot washing machine", Scienece International (Lahore), 30 (2) 2018, pp. 329-332.

31. Van Duyn MAS, Pivonka E, "Overview of the health benefits of fruit and vegetable consumption for the dietetics professional": selected literature. J Am Diet Assoc 100, 2000, pp.1511–1521.

32. Vincent HK, Bourguignon CM, Taylor AG, "Relationship of the dietary phytochemical index to weight gain, oxidative stress and inflammation in overweight young adults". J Hum Nutr Diet, Vol 23, 2010, pp. 20–29.