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Design and fabrication of multiple root vegetable cleaning machine

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Abstract
Cleaning root vegetables is a time-consuming and labor-intensive task, which can decrease efficiency and increase costs in vegetable processing. Additionally, manual labor increases the risk of food contamination and reduces food safety. This work is carried out to design and fabricate a root vegetable cleaning machine that is energy-efficient, automated, and customizable to improve efficiency, safety, and sustainability in vegetable processing operations. Analyze the user needs and requirements, design and fabricate the machine using advanced technologies and customized solutions, and test and validate for cleaning efficiency, energy consumption, and food safety. The development of an energy-efficient, automated, and customizable root vegetable cleaning machine is crucial for improving efficiency, safety, and sustainability in vegetable processing. Future work should focus on improving automation, energy efficiency, customization, food safety, versatility, cost-effectiveness, user-friendly interface, remote monitoring, and integration with sustainability initiatives. Develop advanced technologies and customized solutions to meet the evolving needs and requirements of different users and markets in root vegetable cleaning machines. This will improve efficiency, safety, and sustainability in vegetable processing operations.

Keywords: Modeling, Autodesk, CAD software, mechanical washing efficiency

Introduction
Design and fabrication of a multiple root vegetable cleaning machine is a process of creating a device that can efficiently clean a variety of root vegetables, such as carrots, potatoes, and beets. The purpose of this machine is to improve the efficiency and productivity of vegetable cleaning, particularly in commercial or industrial settings where large quantities of vegetables need to be processed quickly. The design of the machine involves identifying the key features and functions required for effective cleaning, such as water spray nozzles, scrubbing brushes, and adjustable settings for different types of vegetables. The fabrication process involves using materials such as stainless steel or food-grade plastic to create the framework and components, and assembling them in a way that maximizes functionality and durability. The resulting machine should be able to handle a high volume of vegetables, while providing thorough cleaning to ensure that they are free of dirt, debris, and other contaminants. This can help to improve food safety and hygiene, reduce waste, and increase overall efficiency in vegetable processing operations. The multiple root vegetable cleaning machine can be used in various settings, such as in commercial kitchens, food processing plants, and farms. It is designed to handle a range of root vegetables, including potatoes, carrots, beets, and turnips, among others. The machine uses a combination of water, brushes, and other cleaning agents to remove dirt, debris, and other contaminants from the vegetables. Root vegetables are a category of vegetables that are grown for their roots, tubers, or bulbs, which are the edible parts of the plant. They are known for their unique flavors, nutritional value, and versatility in cooking. Some of the most common types of root vegetables include carrots, potatoes, beets, turnips, radishes, onions, and sweet potatoes, among others.

Root vegetables are a rich source of vitamins, minerals, and dietary fiber, making them an important component of a healthy diet. They are particularly high in vitamin C, vitamin A, and potassium, and are also low in fat and calories. In addition to their nutritional value, root vegetables are also prized for their ability to add flavor and texture to a wide range of dishes. Root vegetables have been cultivated for thousands of years and are a staple food in many cultures around the world. They are typically grown in cool climates and are often associated with fall and winter cooking. They can be roasted, baked, boiled, fried, mashed, or grated, and are used in a variety of dishes, including soups, stews, salads, casseroles, and side dishes.

Overall, root vegetables are a nutritious and versatile food group that offers a wide range of health benefits and culinary possibilities. Root vegetables are a diverse group of plants that have been cultivated for centuries and are enjoyed by people all over the world. They are known for their hardiness, versatility, and nutritional value, and are an important source of food for many communities. One of the defining characteristics of root vegetables is their ability to store nutrients in their roots, bulbs, or tubers. This allows them to survive in harsh conditions and provides them with the energy they need to grow and reproduce. Some root vegetables, such as carrots and sweet potatoes, are also able to synthesize their own sugars, making them a valuable source of carbohydrates. Root vegetables come in a wide range of shapes, sizes, and colors, and are often associated with fall and winter cooking. They can be eaten raw or cooked, and can be used in a variety of dishes, including soups, stews, roasts, and salads. In addition to their culinary uses, root vegetables are also prized for their nutritional value. They are a rich source of vitamins, minerals, and dietary fiber, and are particularly high in vitamin C, vitamin A, and potassium. Some root vegetables, such as beets and radishes, are also high in antioxidants, which are believed to have a number of health benefits. Despite their many benefits, root vegetables are often overlooked in modern diets, which tend to favor more processed and convenience foods. However, with their unique flavors and versatility, root vegetables are a valuable addition to any diet, and can help to promote overall health and wellness.

In recent years, there has been a growing interest in locally grown and organic foods, and root vegetables are no exception. Many farmers and small-scale producers are now specializing in the cultivation of heirloom and rare varieties of root vegetables, which offer unique flavors and nutritional profiles. This has led to a renewed appreciation for root vegetables and has helped to support sustainable agriculture and local food systems.In conclusion, root vegetables are a diverse and nutritious group of plants that offer a wide range of culinary possibilities and health benefits. With their rich history and cultural significance, as well as their potential for sustainable agriculture, root vegetables are a valuable and important part of our food system.

Materials and Methods

Fabrication of the machine involves using materials such as stainless steel, aluminum, or food- grade plastic to ensure durability and compliance with food safety standards. The machine must be easy to clean and maintain, with components that can be easily removed and replaced as needed. Safety features such as emergency stop buttons and protective guards should also be included to ensure the safety of operators.

Overall, the design and fabrication of a multiple root vegetable cleaning machine is a complex process that requires careful consideration of various factors such as functionality, durability, and compliance with food safety standards. When properly designed and constructed, this machine can improve the efficiency and productivity of vegetable processing operations, while ensuring that the final product is safe and free of contaminants.

In addition to improving the efficiency and productivity of vegetable cleaning, a multiple root vegetable cleaning machine can also offer several other benefits. These may include:

1. **Consistent cleaning:** The machine provides consistent cleaning to each vegetable, ensuring that they are thoroughly cleaned and free of contaminants. This can help to improve the quality of the final product.
2. **Increased throughput:** With the ability to handle a large volume of vegetables, the machine can help to increase throughput and reduce processing times.
3. **Reduced labor costs:** Automating the vegetable cleaning process can help to reduce labor costs, as fewer workers are needed to perform the task.
4. **Improved food safety:** By removing dirt, debris, and other contaminants from the vegetables, the machine can help to improve food safety and hygiene, reducing the risk of foodborne illness.
5. **Reduced Waste:** With more efficient cleaning, the machine can help to reduce waste by minimizing the number of vegetables that need to be discarded due to contamination.

The methodology that is being used to make this project complete and to work well. Many methodologies or findings from this field generated into journal for others to take advantages and improve as upcoming studies. The method is used to achieve the objective of the project that will accomplish a perfect result.

1. **Identifying the need of the product:** This step involves identifying the need for a root vegetable cleaning machine and understanding the problem it aims to solve. This could be done by analyzing the current methods of post-harvesting operations and identifying the gaps in the process that could be addressed by the use of a cleaning machine.
2. **Collection of data on several types of post-harvesting methods:** This step involves collecting information on different post-harvesting methods, including their advantages and disadvantages, to help in making informed decisions during the design process.
3. **Literature survey**: This step involves reviewing relevant literature on root vegetable cleaning machines to gain a better understanding of the current state-of-the-art in this field.
4. **Research on different root crop cleaning machines:** This step involves researching different types of root vegetable cleaning machines that are currently available in the market to identify their features, strengths, and weaknesses. This information can be used to guide the design process and to improve upon existing designs.
5. **Design and Drawing:** This step involves using the information gathered in the previous steps to come up with a preliminary design for the root vegetable cleaning machine. This design should take into consideration factors such as the size and type of vegetables to be cleaned, the required level of cleaning, and the materials to be used.
6. **Drawing the model in both 2D and 3D:** This step involves creating detailed 2D and 3D models of the root vegetable cleaning machine based on the preliminary design. These models will be used to guide the fabrication process.
7. **Analysis of design:** This step involves analyzing the design to identify any potential issues or areas for improvement. This could involve conducting simulations or experiments to test the performance of the machine under different conditions.
8. **Analyzing the various aspects of the model:** This step

involves analyzing various aspects of the model, such as the materials used, energy consumption, and maintenance requirements, to ensure that it meets the desired specifications and requirements.

9. **Optimization of design:** Based on the results of the analysis, the design can be optimized to improve its performance, efficiency, and effectiveness.
10. **Fabrication:** This step involves fabricating the root vegetable cleaning machine based on the final design. This could involve outsourcing the fabrication to a third-party or building the machine in-house.
11. **Fabrication of the final design:** This step involves building the root vegetable cleaning machine based on the final design. This could involve sourcing the required materials, assembling the various components, and testing the machine to ensure that it meets the desired specifications and requirements.
12. **Result:** The final step involves evaluating the performance of the root vegetable cleaning machine and determining whether it meets the desired specifications and requirements. This could involve conducting tests or trials on actual vegetables to ensure that the machine is effective and efficient.

The objective of designing and fabricating a multiple root vegetable cleaning machine is to automate the cleaning process of root vegetables, such as potatoes, carrots, beets, etc., in an efficient and hygienic manner. The machine should be able to remove dirt, debris, and other contaminants from the vegetables without damaging them, and should be easy to operate and maintain.

Some objectives for the machine might include

- **Customizable settings:** The machine should have adjustable settings that allow users to customize the cleaning process based on the type and condition of the vegetables being cleaned.
- **Easy maintenance:** The machine should be designed with easy-to-clean components that are durable and long-lasting.
- **Hygienic design:** The machine should be constructed from materials that are easy to sanitize and designed in a way that prevents the buildup of bacteria and other contaminants.
- **Efficient Cleaning:** The primary objective of a root vegetable washer is to effectively and efficiently clean root vegetables of dirt, debris, and other contaminants. This ensures that the vegetables are safe for consumption and meet the required quality standards.
- **Increased Productivity:** Root vegetable washers are designed to handle large quantities of vegetables in a shorter period of time. This increases productivity and reduces the time required for manual washing.
- **Consistency:** Root vegetable washers provide consistent cleaning results as they use a standardized process to clean the vegetables. This ensures that the quality of the cleaned vegetables remains constant, regardless of the operator.
- **Preservation of Quality:** Root vegetable washers are designed to clean vegetables without damaging them. This preserves the quality and appearance of the vegetables, making them more attractive to consumers.
- **Ease of Use:** Root vegetable washers are designed to be user-friendly, with simple controls and minimal maintenance requirements. This makes them easy to operate and maintain, even for those with limited experience.
- **Cost-Effective:** Root vegetable washers are a cost-effective alternative to manual washing, as they reduce the labor required for cleaning vegetables. This results in significant cost savings for farmers and processors.
- **Environmental Sustainability:** Root vegetable washers use less water compared to manual washing, reducing water consumption and promoting environmental sustainability.

Modeling and Analysis of the Vegetable Machine

After the 2D drawing of the model, the 3D modelling is done using AUTODESK FUSION- 360 with theoretical calculations to validate with design after validation A 3D drawing is a technical illustration that represents an object or a scene in three dimensions. It is created using computer-aided design (CAD) software, which allows engineers and designers to create detailed and realistic representations of the object or scene.In a 3D drawing, the object or scene is represented as a collection of three-dimensional geometric shapes, such as cubes, spheres, and cylinders. These shapes are positioned and scaled to create a realistic representation of the object or scene, complete with details such as surface textures, colors, and lighting as shown in Fig 1.

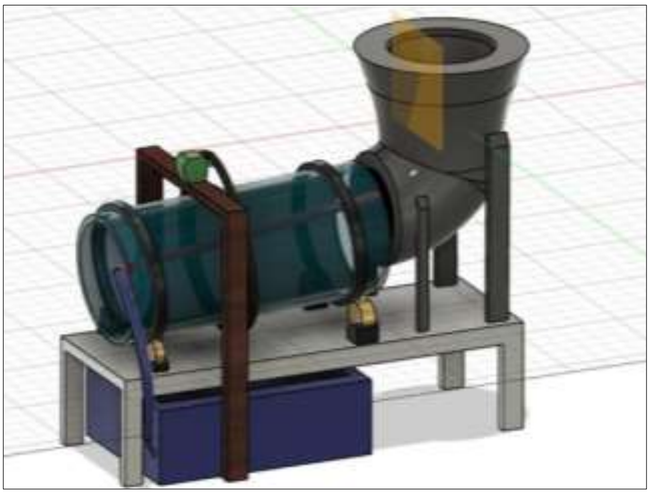

Fig 1: 3D assembly drawing of the Root cleaning machine

After the design of the model is according to the problem definition, the components used for machine design are assembled for following working condition. The mesh barrel is attached with brushes, so that the root crops pass between them and a motor to provide the necessary torque and speed requirements to facilitate the wash cycle. The operating speed of washing is comparatively low. Slower speeds tended to make it difficult for the unit to start and keep rotating, while faster speeds were not used to avoid root vegetables breakage. The brushes remove soil and foreign material sufficiently during the washing operation with sufficient water supply. The system could accommodate samples upto 20 kgs. The water requirement per batch is minimum. An operator needs to be present for sample loading, unloading and for operation of the washer using motor. After cleaning of root crops, the impurities cleaned from the vegetables moves through the drum with cleaned vegetables with presence of water. The theoretical calculation done before the fabrication of design will be validate after fabricated to avoid errors.

Design calculations

Design of drum

The volume of the drum can be found out by the formula,

Volume = Area*Length
V = Volume in mm^3,
A = Area in mm^2,
L = Length in mm,
D = Diameter of drum in mm. Here,
D = 41.3 cm= 413 mm
Radius =D/2=413/2=206.5mm L = 1.3 m= 1300 mm

By, using $A = \pi \times R^2$

$A = 3.141x(206.5)^2 = 134042.15\ mm^2$
As, V = A*L
$V = 134042.15\ mm^2 \times 1300\ mm$
$V = 174252607.922\ mm^3$ or $174252.607\ cm^3$

Calculation of frame

For the Calculation of the drum let us assume the whole frame structure to be a simply supported beam carrying a uniform load throughout its surface, the load distribution is mentioned accordingly.
Let us assume the Approximate Values for load as:
Mass of the Drum m_1 = 10.395 Kg =101.661 N
Maximum load of vegetables acceptable by drum m_2= 20 Kg = 196 N
Load due to Mass of Water, m_3= 150 Kg = 1470 N Total Load which is exerted on the frame uniformly, W = m1 + m2+ m3
W = 101.661+ 196 + 1470 = 1767.661 N

Bending moment

(B.M) = (w_l^2/8)

Where,
B.M = Bending moment N-mm, W = total weight on frame N, l = total length of frame, mm B.M = 56.597*10 N-mm

Power transmitted by motor and torque produced

1 HP = 746 Watts
1 RPM = 2 π/60 radians per second

Therefore, the power output of the motor in watts is

P = (1/4) x 746 = 186.5 W

The rotational speed of the motor in radians per second is

$\omega = (20 \times 2\pi)/60 = 2\pi/3$ radians per second

To find the torque produced by the motor, we can use the formula

$P = \tau \times \omega$

Where P is the power output in watts, τ is the torque produced in Newton-meters, and ω is the rotational speed in radians per second.
Rearranging the formula to solve for torque, we get: $\tau = P/\omega$
Substituting the values we have, we get:

$\tau = 186.5/(2\pi/3) = 111.7$ Nm

Therefore, the power transmitted by the motor is 186.5 watts and the torque produced is 111.7 Nm.

Flow of water through pump

Assuming a pump with half horsepower (0.5 HP), a head of 10 feet, and a pump efficiency of 0.5, the flow rate of water through the pump would be:

Q = (0.5 x 2178) / (10 x 62.4 x 0.5) = 8.78 GPM

Mechanical washing efficiency

$$\text{Mechanical washing efficiency} = \frac{\text{Weight of carrot before washing - Weight of carrot after washing}}{\text{Weight of carrot before washing}}$$

Mechanical washing efficiency = 20-19.5/20 = 0.025
= 0.025*100 = 2.5

Total mechanical efficiency achieved = 97.5%

Finite Element Analysis

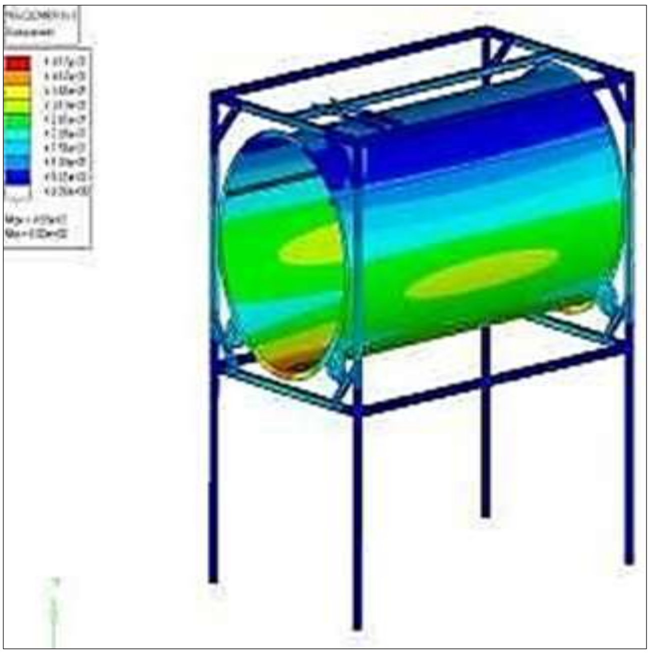

Fig 2: FEA model of Frame with drum

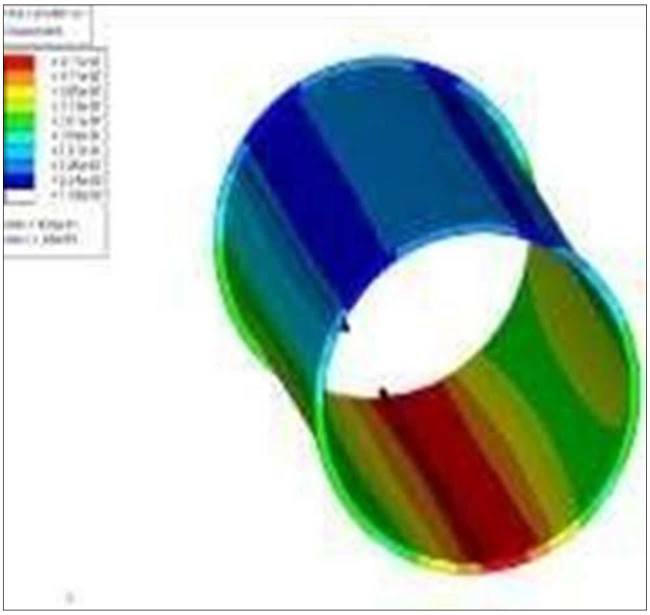

Fig 3: FEA model of drum

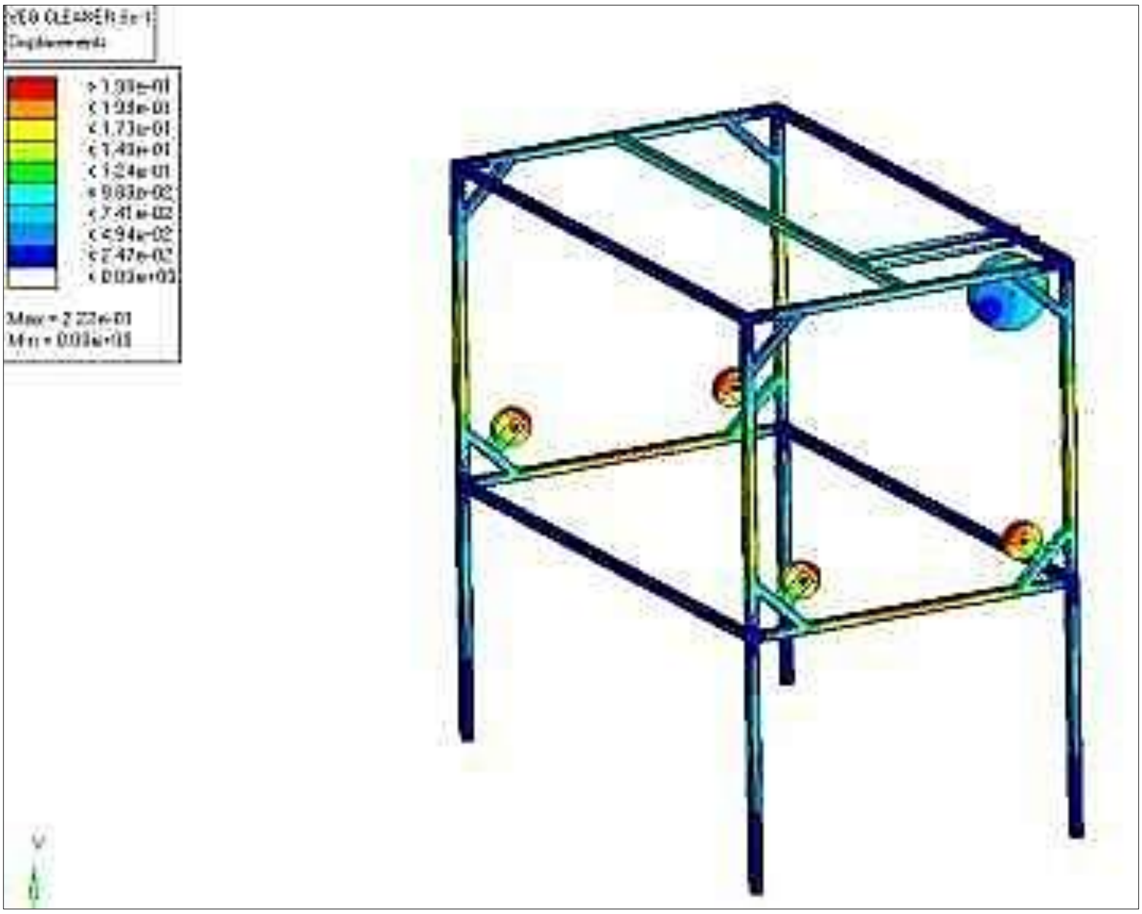

Fig 4: FEA of Frame

In above Figures FEA – model of vegetable cleaner machine is given. This is a maximum displacement pattern form in which maximum displacement is to be 0.46 mm. It is shown in the result format on the barrel

Maximum stress on mode

Fig 5: Max stress on mode

Fig 6: Max stress on drum

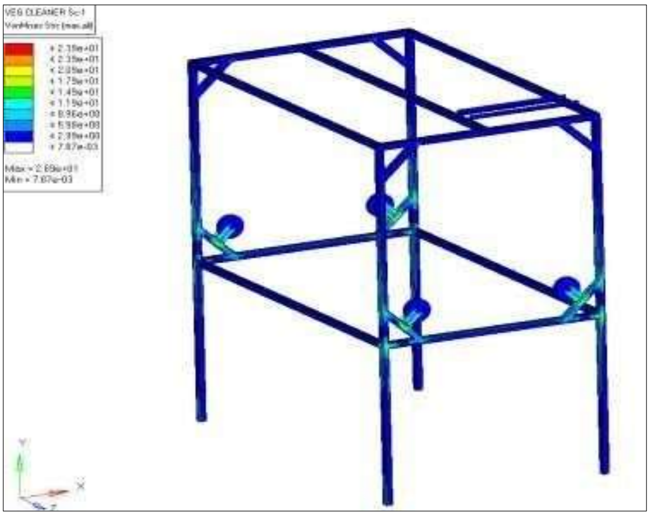

Fig 7: Max Stress on Frame

In above fig. 7 FEA – model of vegetable cleaner machine is shown in the figure 7 in which the maximum stress pattern is shown that should be 30.6 MPa. Maximum stress shows that barrel should be affected at this place. Blue pattern on the fig 7 means that the design would be safe

Results and Discussion

From the Linear Static Analysis 0.46 mm maximum displacement and 30.6 MPa. Maximum stresses were obtained. The tabular format of machine can be explained in below table as

Table 1: FEA results of the Model

Sl. No	Component	Frame	Drum
1	Material	SS304	SS304
2	Youngs modulus	210000 N/mm^2	210000 N/mm^2
3	Ultimate tensile strength	625 Mpa	625 Mpa
4	Co-efficient of linear expansion	0.00014571	0.00014571
5	Yield stress	215 N/mm^2	215 N/mm^2

From the table the linear static analysis and material properties of the vegetable cleaner machine is shown, the stresses obtained in the structure are within the limit of Yield stress (215MPa) of material. Steel material for frame and barrel having component material SS304 which is tough with the density 7850 Kg/m3 and it has a higher corrosion resistance than regular steel and is widely used.

Conclusions

The following are the conclusions drawn from the working model:

1. A root vegetable cleaning machine is designed to efficiently and effectively clean a variety of vegetables.
2. The machine is fabricated using materials like stainless steel and durable plastics to ensure resistance to corrosion and wear.
3. During the design and fabrication process, specific user needs and vegetable characteristics are carefully considered.
4. Performance testing is conducted to optimize cleaning efficiency, energy consumption, and durability under various operating conditions. Safety features like emergency stop buttons and guards are also incorporated to prevent injuries.
5. The design and fabrication of a root vegetable cleaning machine involve creating a reliable and effective system that streamlines vegetable processing and enhances food safety. It combines careful consideration of user requirements, the unique characteristics of vegetables, and the incorporation of features for improved cleaning efficiency and safety.

References

1. Tanwar, *et al.* Design and Fabrication of a Rotary Brush-Type Root Vegetable Washer. International Journal of Agriculture and Biology Engineering. 2021;14(2):82-89.
2. Olatunji SO, Afolayan OJ. Design and Fabrication of a Semi-Automatic Root Vegetable Washer. International Journal of Recent Technology and Engineering. 2019;8(3):2203-2209.
3. Olatunji SO, Afolayan OJ. Design and Fabrication of a Motorized Root Vegetable Washing and Scrubbing Machine. International Journal of Applied Engineering Research. 2019;14(7):1751-1757.
4. Afolayan OJ, Adeleke TM. Design and Development of a

Multiple Root Vegetable Washing Machine. Journal of Engineering Research. 2019;24(2):80-89.
5. Oyelami OB, Adeleke AA. Development and Evaluation of a Semi-Automated Root Vegetable Washing Machine. Journal of Engineering and Applied Sciences. 2018;13(7):2314-2321
6. Vadnere VP, Zad SR. Design and Fabrication of a Pedal Operated Root Vegetable Washer. Journal of Agriculture Engineering and Technology. 2018;10(2):47-56.
7. Olubanwo OA, Adeleke TM. Design and Fabrication of a Motorized Root Vegetable Washer. Journal of Mechanical Engineering Research and Developments. 2018;41(4):200-206.
8. Odia O, Anafi FO. Design and Fabrication of a Vegetable Washer for Small-Scale Farmers. Nigerian Journal of Technology. 2017;36(3):617-623.
9. Nwakaire NN, Ibeh CI. Design and Fabrication of a Manual Root Vegetable Washer. Journal of Engineering and Applied Sciences. 2017;12(7):1819-1825.
10. Adeyemi JA, Adenuga OA. Design and Fabrication of a Motorized Root Vegetable Washing Machine. Journal of Agricultural Engineering and Technology. 2017;25(2):1-10.