Design & Development of a Semi-Automatic Cleaning, Disinfecting and Drying Machine for Fruits and Vegetables

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Abstract

The present work is introducing Batch-type Semi-Automatic Fruits/Vegetable Cleaning, Disinfection & Drying Machine designed to address the growing concern of foodborne illnesses and pesticide residues on fresh produce. The system contains two vital parts. One is a washer, and another is a dryer. Our innovative washer features a hinged tray submerged in water with two nozzles releasing ozone at 5 bar pressure, creating turbulence for optimal fruit/vegetable cleaning. Silver Hydrogen Peroxide enhances cleansing. Foot-operated pedal control facilitates easy operation, allowing for batch washing intervals. A butterfly valve efficiently drains used water after each cycle, ensuring hygiene and sustainability. The drying process involves manually transferring the tray from the washing chamber to the Dryer. A foot-operated pedal controls the flow of compressed air through nozzles and volume boosters, optimizing drying efficiency. Components include the tray for holding produce, foot-operated pedal for user control, and a network of nozzles and volume boosters for directing and regulating the airflow. A tray below collects residual water droplets, ensuring a comprehensive and effective drying process for fruits and vegetables. The distance between the dryer and the washer is such that the operator can easily pick up Tray from the washing chamber and place it on the dryer without moving any distance. The system employs an innovative three-stage process to ensure the hygiene and safety of fruits and vegetables. In the initial cleaning stage all the dirt, debris and surface contaminants will be removed by blowing air through the nozzles and the volume booster. This step is crucial in enhancing food safety and promoting public health. After completing the cleaning procedure, the washing procedure will be started. The nozzles will start a turbulence in the washer. Due to the turbulence the fruits or vegetables start to rotate, and a force will act on the fruits or vegetables tangentially. This force will remove the particles present on the surface of the fruits or vegetables. Then the washed fruits must be placed on the drier. With the help of airflow through the nozzles and volume booster of the dryer, the washed fruits will be dried.

Keywords: Cleaning, Disinfection, washer, Dryer

1. INTRODUCTION

In this research developed a special purpose machine which acts as a cleaning, disinfecting and drying machine. The main motive behind the development of this machine was because of the fact that Fruits and Vegetables are most important substances for the survival of humans on Earth. However, if they are not taken care it may result in heavy loss of such precious substances. It is also observed that around 25-30 % of fruits and vegetables have been lost due to development of micro-organisms. If this is not treated at the right time and by the right way it may lead to spreading of micro-organisms on other fruits and further lead to high percentage of wastage of fruits and vegetables. [1] To cope with this problem, we came up with a solution to reduce the wastage of fruits and vegetables by developing a Special Purpose Machine with inclusion of pneumatics systems, ozone in it. In order to make this machine more reliant and more user friendly we have implemented pneumatics to make this machine semi-automatic [2]. While keeping in mind that this machine is feasible for everyone, we have made sure that components used are affordable for local use, small industries etc. The machine consists of two different chambers having specific roles of drying and washing [3] which are explained in the subsequent sections. Stainless Steel and Mild Steel were used in construction of the chambers as well as the stands for holding purpose as they were found out to be the most suitable for this purpose [4].To maintain the quality of the produce it was very essential to choose the suitable chemical to be mixed with water so that the surface as well as the life of the produce will not be deteriorated. According to the research done we came up to the conclusion of using Silver Hydrogen Peroxide as a cleansing agent. [5]. Also added Ozone for washing purpose as there is evidence showing ozone improves taste and appearance of fresh salad for the RTE market while controlling food borne pathogens [6]. It reduces bacteria which lead to food spoilage increases shelf life and shipping distance. The chemical oxidizing action of ozone can breakdown toxic chemicals such as pesticides on food making

them biodegradable [7].

1.1Microbial World

Microbes: An Inevitable Type of Life. Microbes are tiny organisms that bear resemblance to the ubiquitous bacteria, fungi, viruses, protozoa, and algae found everywhere on Earth. Most of these microbes are the beginning and end of complex food chains that are necessary for all other life forms to survive and exist. Trillions of cells in the human body are made up of bacteria, fungi, viruses, and other microbes; some are mutualistic, others are commensal, and some are infectious agents. Because of this, they are crucial to both humans and other living things. The human body has over 100 trillion cells in total, of which about 10% are bacteria rather than actual cells.

1.2 Bacteria

Based on their form, bacteria are classified as unicellular prokaryotic organisms in the medical field. Spiral/curved, bacilli/cylindrical/rod-shaped, and cocci/spherical are the three forms of bacteria. Gram-positive and Gram-negative bacteria may be divided into two main groups according to the quantity of peptidoglycan in their cell walls. While it is well known that Salmonella species, Escherichia coli O157:H7, Proteus mirabilis, and other Gram-negative bacteria may cause a wide range of ailments, Bacillus cereus, Clostridium botulinum, and Clostridium perfringens are frequent Gram-positive bacteria that can produce intoxications when consumed in food. Among the numerous other bacteria that cause infections and food spoilage are Acinetobacter, Alcaligenes, Aeromonas, Flavobacterium, Arcobacter, Lactococcus, Pseudomonas, Serratia, Shigella, Listeria, Yersinia, Campylobacter, Citrobacter, Vibrio Enterobacter, Micrococcus, Enterococcus, Penicilliums, Corynebacterium, Staphylococcus, and Weisell.

1.3 Fungi

Yeast and moulds belong to the kingdom of fungi. Food Molds are multicellular filamentous organisms that have a fuzzy or cottony texture on their surface. Molds grow very well on most grains and corns when stored in damp environments; they need minimal moisture to exist and may thrive in temperatures between 25 and 30 0 C and low pH levels. Meals like cheese may be matured and a variety of other meals and food items can be produced with the use of Molds like the Camembert and Roquefort Molds. They are also helpful in producing food and feed, and they function as catalysts (enzymes) in the manufacturing of bread and the citric acid that is used in soft drinks. Botrytis cinerea is used in the grape-to-wine process to break down the grape.

1.4 Viruses

Viruses are thought to be necessary intracellular organisms that require a live host to proliferate in food. It is believed that they need a live, vulnerable host in order to proliferate. Food, drink, contact with an infected individual, and other environmental elements are common ways in which they are disseminated. There are numerous known food-borne viruses, including hepatitis A virus (HAV), astroviruses, adenovirus serotypes 40 and 41, Human Noroviruses (HNoV), Parvoviruses, Hepatitis E Virus (HEV), sapovirus, Rrota Virus (RV), coxsackievirus A and B, Aichi Virus (AiV), enteroviruses, parvoviruses, and picornaviruses. Numerous pathogenic viruses are the most prevalent causes of nonbacterial gastroenteritis. Among the many different types of bacteria that include etiological agents are pathogenic microbes, such as parasites.

1.5 The Worldwide Scenario of Pathogenic Microbes Isolated from Fresh Fruits and Vegetables

Research on an E. Coli O157: H7 epidemic that was linked to spinach eating was carried out in October 2006 in 26 states in the United States and Canada. Three fatalities were noted and reported to the Centers for Disease Control and Prevention (CDC) out of 199 individuals infected with the disease. Additionally, of the instances that were recorded, almost 16% experienced acute renal failure, and 51% of those patients' required hospitalization. roughly 4,000 individuals were hospitalized in roughly 16 nations as a result of another E. Coli outbreak that shocked the whole world and resulted in 50 deaths. It has prompted experts to

consider the outbreak and potential countermeasures for similar outbreaks in the future. Outbreaks involving L. monocytogenes in addition to E. coli.

1.6 Literature review

1.6.1 Review on Design and Development of Vegetable Cleaning Machine [8]

The review on the design and development of vegetable cleaning machines highlights significant advancements and challenges in this field. The analysis underscores the importance of efficient and hygienic vegetable cleaning processes for food safety and quality. Various design approaches, including mechanical, pneumatic, and automated systems, have been explored to enhance cleaning efficacy and throughput. Challenges such as energy consumption, cost-effectiveness, and adaptability to different vegetable types remain pertinent areas for further research and development. Moving forward, integrating innovative technologies and considering sustainability aspects are critical for the continued improvement of vegetable cleaning machines, ensuring they meet evolving industry standards and consumer demands.

1.6.2 Microbial Contamination, an Increasing Threat to the Consumption of Fresh Fruits and Vegetables in Today's World [9]

The study concludes by highlighting the growing worry that modern society has about the safety of fresh fruits and vegetables due to microbial contamination. The results demonstrate the complexity of this hazard, which is caused by a number of variables including handling by consumers, storage, transportation, and farming methods. Foodborne diseases linked to contaminated produce are becoming more common, which means that numerous stakeholders—farmers, food processors, regulators, and consumers—need to work together to solve this issue urgently. Strict quality control processes must be put in place, hygienic practices must be adopted across the food supply chain, public awareness must be increased, and advanced technology for detection and mitigation must be invested in in order to guarantee the safety and integrity of fresh produce. Furthermore, creating comprehensive plans to reduce microbial contamination and protect the public's health while consuming fresh fruits and vegetables requires supporting multidisciplinary research collaborations and international cooperation.

1.6.3 Corrosion Analysis of Stainless Steel [10]

The study of stainless steel's corrosion analysis highlights the material's importance in a variety of industrial applications. This study clarifies the complicated corrosion behaviour that stainless steel exhibits under many environmental circumstances through extensive testing and analysis. The results provide important information on the mechanics behind corrosion processes, emphasizing how surface treatments, alloy composition, and ambient conditions affect a material's ability to withstand corrosion. Furthermore, the study pinpoints possible obstacles and constraints in extant corrosion mitigation tactics, hence instigating additional inquiry into innovative methodologies for augmenting the longevity and efficacy of stainless steel in corrosive milieus. All things considered, this research advances our knowledge of corrosion processes and offers useful advice to engineers, materials scientists, and business professionals that work with stainless-steel structures and components in their construction and upkeep. To tackle new corrosion problems and speed up the creation of stronger, more sustainable materials for a range of engineering uses, more research in this field is needed going forward.

1.6.4 Manufacturing and Applications of Stainless Steels [11]

The research paper extensively explores the manufacturing processes and diverse applications of stainless steels. Through a comprehensive examination of various manufacturing techniques such as casting, forming, machining, and welding, it highlights the critical factors influencing the properties and performance of stainless-steel products. The article also emphasizes the importance of stainless steels in a number of industries, such as the food processing, automotive, aerospace, and construction sectors, because of its remarkable mechanical strength, corrosion resistance, and aesthetic appeal. Stainless steels are essential materials in contemporary manufacturing and building processes due to their durability and adaptability. In response to changing technical and industrial needs, the article also highlights the significance of continuing research and development activities targeted at improving the performance and broadening the uses of stainless steels. All things considered, the information presented in this article highlights how crucial stainless steels are to promoting innovation and advancement in a variety of sectors.

1.6.5 Ozone Application in Fresh Fruits and Vegetables [12].

The application of ozone in fresh fruits and vegetables presents a promising method for enhancing food

safety, extending shelf life, and maintaining overall quality. Through extensive research and experimentation, it has been demonstrated that ozone treatment effectively reduces microbial contamination, including pathogens such as bacteria and fungi, while minimizing chemical residues. Moreover, ozone application helps in preserving the nutritional content, flavour, and texture of produce by inhibiting enzymatic browning and degradation processes. Despite its efficacy, challenges remain regarding standardization of ozone application protocols, optimization of dosage levels, and ensuring compliance with regulatory standards. Continued investigation into the mechanisms underlying ozone's effects on various types of produce, as well as its environmental impact, is warranted. Overall, integrating ozone technology into post-harvest handling and processing practices offers a sustainable approach to ensuring food safety and quality throughout the fresh produce supply chain. Its adoption holds significant potential for mitigating foodborne illnesses and reducing food waste, thereby benefiting both consumers and producers alike.

1.6.6 Effects of ozone treatment on pesticide residues in food: a review [13]

From the research paper that follows one of the paper's key takeaways is the amount of ozone that can be diluted and consumed. Ozone generators are machines that produce ozone (O_3), a potent oxidant with antiseptic and odor-eliminating qualities. Regarding pesticide residues, this technology has become popular in the field of washing fruits and vegetables, which begs the question of how successful it is.

Although ozone therapy can effectively degrade some pesticides on produce's surface, its effectiveness varies based on the particular pesticide and treatment technique. But its real power is in getting rid of mold, viruses, and bacteria; this can improve food safety by lowering the chance of foodborne infections. Because of this, ozone presents a viable substitute for strong chemical washes and provides a more thorough method of disinfection.

Specific care is needed in proposing the ozone dilution solution of the system.

1.6.7 Study on Characteristics of Pneumatic Nozzle and Blowing System [14]

Important information on the common nozzles used in air and water-based activities can be found in the accompanying paper. For the best flow pattern, consider nozzle thickness as well as other factors such nozzle caliber. In addition, the information included in the research report can be used to choose the various system accessories that are required for the machine. Additionally, a particular kind of pneumatic components that work with both air and water supply are included. The article provides systematic information about the fittings, connectors, and particular types of tubing that need to be chosen for the machine. The report discusses four different types of nozzles: single, improved, high efficiency, and pointer. As the report states, pressure drop over the entire constructed system is required for both water and air testing. One of the key conclusions drawn from the content cited is the necessity of pneumatic parameter monitoring for system development.

1.6.8 Numerical Study of Turbulent Air and Water Flows in a Nozzle Based on the Coanda Effect [15].

Important details and a conclusion about the ideas of turbulent and laminar flow seen at the nozzle outputs are provided in the paper that follows. The values of the Reynolds number in the designated range for the environmental conditions under which the nozzle setup is being evaluated are also described in the article that follows. In addition to the functional data, graphical data is also acquired that illustrates the relationship in both situations between the mass flow rates and the air and water deflection jet angles. The paper also thoroughly discusses the case of septum insertions using air and water, which aided in the design of the nozzle mixing. The flow rate data is computed and interpreted from the paper using mechanical and magnetic flow meters, which aids in the investigation of optimal flow patterns that will generate the necessary turbulence in the chamber. The following study paper data has also aided in the design and development of the nozzle orifices and slot sizes, which are advantageous in causing agitation and churning within the tank. Simulation pictures successfully demonstrate the Coanda principle in a brief introduction. The following research paper, to conclude. has been beneficial in the obtainment of the idea in the design and development of the nozzle.

1.6.9 Colloidal Silver Hydrogen Peroxide: New Generation Molecule for Management of Phytopathogens [16]

The research paper "Colloidal Silver Hydrogen Peroxide: New Generation Molecule for Management of Phytopathogens" highlights the promising potential of colloidal silver hydrogen peroxide (CSHP) as an

innovative solution for controlling phytopathogens. Through a comprehensive review of literature and experimental findings, it is evident that CSHP demonstrates significant antimicrobial activity against a wide range of phytopathogens. The unique properties of CSHP, including its stability, low toxicity, and eco-friendly nature, position it as a favorable alternative to conventional chemical pesticides. Moreover, its mode of action involves multiple pathways, reducing the likelihood of pathogen resistance development. While further research is necessary to optimize application methods and assess long-term environmental impacts, the findings underscore CSHP's viability as a novel approach for sustainable plant disease management. Embracing CSHP could lead to reduced dependence on traditional pesticides, fostering environmentally friendly agricultural practices while ensuring crop protection and yield enhancement in the face of evolving phytopathogens.

1.7 Existing Research Gap

Solutions available in the market are way too expensive. Small scale industries, startups, local vendors cannot use the existing solution due to price and scale of these machines.

Machines available in the market does not provide cleaning and disinfection at a same time. Disinfection is not efficient. Lesser implementation of pneumatic based system. Wastage or overuse of various components creates unnecessary increase in cost.

They are hard to operate needs skilled labour and High maintenance cost.

1.8 Advantages Over Existing Technology

Cheaper solution and affordable for small scale industries, whole sellers, start-ups. Compact design that does not require much space to install. Cleaning and disinfection with the help of Ozone Generator and chemical are possible. Disinfection increases the shelf life, reduce bacteria from the fruits and vegetables with cleaning and disinfection, we are providing dryer to dry the washed fruits and vegetables. Minimal components are used in the machine and each component is utilized efficiently. Hence less maintenance and no skills require (easy to operate)

Using pneumatic based system, different types of nozzles for the turbulence in water and volume boosters for drying.

A reciprocating compressor with 190-210ltr(approx.) tank capacity with output pressure between 5-7 bar is enough. Providing foot operated (detent type) or timer-based operation (according to the user budget).

2. DESIGN & DEVELOPMENT

2.1. Parts: -

This machine is divided in two parts:

1.Washer and disinfection machine

2.Drying machine

Washer and disinfection machine-In washer part we have designed a tray which will be hinged on to a chamber which is submerged in water. 2 nozzles have been fixed upon the chamber in which ozone is flown to create the turbulence necessary in washing process. According to the research done it was found that 5 bar of pressure with the mixture of O2 and O3 is the most appropriate for washing purpose. Silver Hydrogen Peroxide is added in the water as a cleansing agent. Entire system is operated on the basis of Foot operated pedal. Between every interval in which water has to be changed multiple batches of Fruits/Vegetables can be washed. After washing is done all the water can be drained out at the bottom through the butterfly valve.

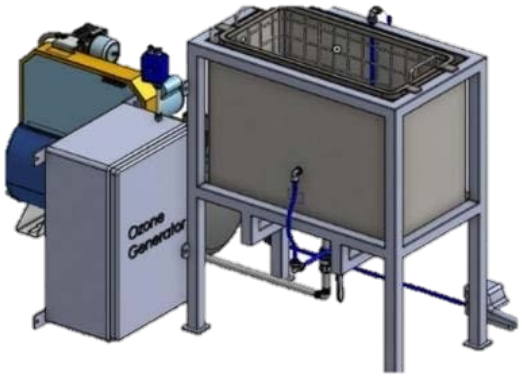

Figure 1. Design view of washing chamber

Dryer machine - After the washing process is completed in washing chamber the same Tray must be picked up manually and kept upon the Dryer. Foot operated pedal is used similarly as used in the washing chamber through which the flow of compressed air through the nozzles and also the volume boosters which will be used in the controlling the flow of the volume of air. It will enhance the drying of Fruits and vegetables efficient in all directions possible. The water droplets that have been left over after the washing through the washing chamber will be accumulated in the tray below.

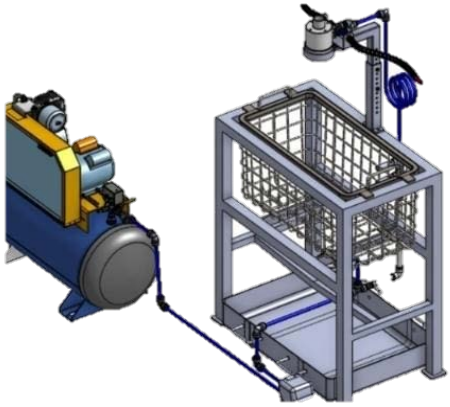

Figure 2. Design view of Drying Chamber

The distance between dryer and washer is such that operator can easily pick up Tray from washing chamber and place it on dryer without moving any distance

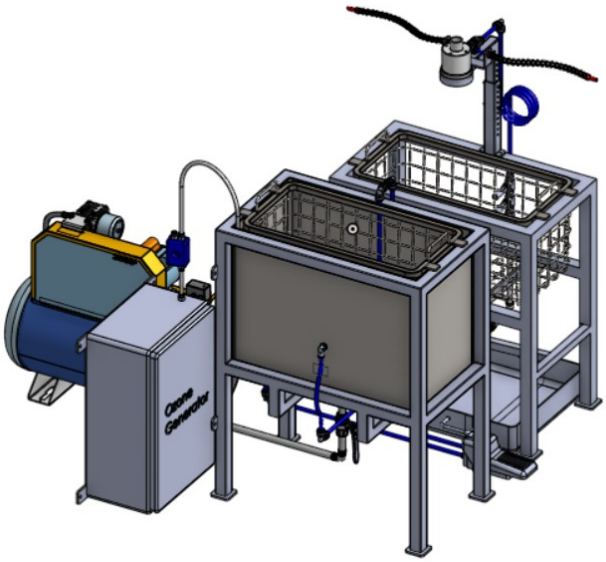

Figure 3. Design view Washing and Drying Chamber Combined.

2.2 Methods:

In our machine we can control the washing process in batches in such a form that same tray can be used for washing as well as drying process. Tray is placed in a washing chamber which is already submerged in water. Ozone is passed through nozzle into the chamber which creates turbulence in the washing chamber. Silver hydrogen peroxide is used as a cleansing agent. Due to turbulence created in the washing chamber it helps in cleaning fruits and vegetables in better manner as the particles can be easily removed with the help of the pressure created by the turbulence. It is not necessary to change water after every batch of washing. When it is necessary to change water, the already used one can be dissipated out through the butterfly valve provided at the bottom. After washing is completed, the same tray has to be manually lifted up and placed in the drying chamber. Multiple nozzles are present in the drying chamber through which compressed air is passed. Volume boosters have also been used in Dryer to control the volume of air that is passed in the Dryer. The excess of Water that has been left out of the Washing Chamber is accumulated in the Tray provided below the drying chamber which can be easily picked up manually and water can be throne out.

The entire system works on the compressor generating compressed air, each component used is attached using pneumatic pipes, fitting, joints, and clamps. Both the Washing/disinfection/drying machine are operated using foot operated valve detent type (cost effective), timers can be put into consideration according to the budget of consumer.

A worker just must place his foot on the valve and remove it. The entire compressed air starts flowing towards all the washing/disinfection nozzles and pipes of washer as well as all the boosters and nozzles in the dryer simultaneously.

3. DESCRIPTION OF COMPONENTS USED IN WASHER/DRYER

3.1 Ozone Generator:

An ozone generator, also known as an ozone machine, is a mechanism that creates ozone by converting oxygen from a variety of sources, including dry air, ambient air, and concentrated oxygen. By giving oxygen molecules (O2) more energy, which causes the oxygen atoms to split apart, ozone generators generate ozone (O3), which is then carried to the washing bucket by the ozone pump via the ozone tube. Through nozzles, the ozone gas is released into the water. It dissolves in the water when it comes into touch with the water machine in the washing bucket, creating ozone water.

Concentration and lifetime:

1. The applied dose of concentration of ozone in water is 3 ppm. But the transfer efficiency of ozone is less than 100%. So, the final concentration in the water will be 1.5-2 ppm.

2.ozone has a lifetime of 10-20 minutes in the water after which time it breaks down to oxygen.

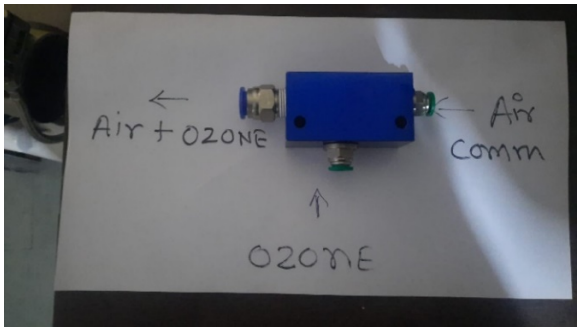

Figure 4. Ozone Inlet and Outlet

Why using ozone:

1. Research indicates that ozone reduces food-borne diseases and enhances the flavor and appearance of fresh salad for the RTE market.
2. It lengthens shelf life and transportation distance while reducing microorganisms that cause food to deteriorate.
3.Toxic substances, like pesticides, in food can be broken down and made biodegradable by the chemical oxidizing action of ozone.

Cleaning Substance: Which disinfectant is used as a cleaning agent is up to the individual. However, the research indicates that silver hydrogen peroxide is the most effective cleaning agent.

3.2 Hydrogen Peroxide:

An ally of plants, hydrogen peroxide is a naturally occurring disinfectant. In addition to eliminating many forms of bacterial and fungal development from fruits and vegetables, it also has the potential to enhance plant health in the process.

The oxidizing qualities of hydrogen peroxide make it a powerful disinfectant. Commercially available 3% hydrogen peroxide can be used to sterilize surfaces.

All harmful stabilizers seen in hydrogen peroxide at greater concentrations are absent from this concentration of hydrogen peroxide. Furthermore, a concentration of 3% hydrogen peroxide is potent enough to eliminate bacteria and dissolve without harming human skin.

Addition of the silver to Hydrogen Peroxide to make Silver-Hydrogen-Peroxide:-

Hydrogen – Peroxide is unstable.

It decomposes to hydrogen and oxygen.

Silver when added helps to prevent the decomposition of hydrogen and oxygen making it a slow process of decomposition.

3.3 Nozzle:

Nozzles play a crucial role in pneumatic systems, serving as essential components for controlling the flow of compressed air. These nozzles are designed to convert the potential energy of pressurized air into kinetic energy, facilitating various applications.

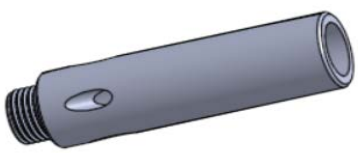

Figure 5. Nozzle

By regulating the nozzle's shape and size, engineers can achieve precise control over airflow velocity and direction. Pneumatic nozzles are commonly used in industries for tasks such as cleaning, cooling, and conveying materials. The efficiency of pneumatic systems heavily relies on the proper selection and maintenance of these nozzles.

Nozzles play a vital role in the efficiency of fruit washing machines, ensuring thorough cleaning and sanitation. These specialized components are strategically placed within the machine to deliver pressurized water or cleaning solution onto the fruits. The design of these nozzles is paramount, as it determines the coverage and intensity of the cleansing process. Typically, a variety of nozzles is employed to accommodate different fruit shapes and sizes, ensuring a comprehensive wash. The nozzles are configured to target critical areas, such as crevices and stems, where contaminants may reside. Adjustable nozzles provide flexibility, allowing operators to tailor the washing process based on the specific fruit being processed. The precision of these nozzles contributes to water conservation, as they direct the cleaning solution precisely where it's needed, minimizing waste. Regular maintenance of the nozzles is essential to prevent clogging and maintain optimal performance. The efficiency and effectiveness of a fruit washing machine hinge significantly upon the design and functionality of its integral nozzles.

Nozzle uses in Washer/Disinfection machine-

Two Nozzles used in the cleaning/disinfection machine; one nozzle is clamped at a slanting position inside the chamber allowing the air to hit the bottom of the chamber creating turbulence. The second nozzle is clamped on the Mesh facing upward directly on the basket; combined efforts of both the nozzle allows greater turbulence inside the chamber.

Nozzle used in Dryer-

In dryers, two nozzles attached to coolants pipes on the telescopic mechanism. Remaining nozzles are optional attached on the side for more efficient drying from the sides.

Table 1. Nozzle Specification

Name	Prose HT &V Nozzle
Type	Stand-alone nozzle with and without ball valve
Blow Type	Extremely high thrust, extremely high penetration, and high volume
MOC	Stainless steel
Air Amplification	3 times the compressed air consumed
Noise level	98-99 db. approx.
Air Consumption	1050 LPM (37 CFM)
Thrust @300 mm	1500 grams @300 mm
Payback period	30-40 working hours
Inlet connection size	¼” BSP male thread
Can be used in different nozzles	no

The mechanism of washing fruits in water turbulence in a fruit washing machine can be explained by principles of fluid dynamics, particularly utilizing Newton's laws of motion.

1. Newton's First Law (Law of Inertia) - The fruit washing machine initiates water turbulence by creating a flow of water. According to Newton's first law, an object at rest (the contaminants on the fruit) tends to stay at rest unless acted upon by an external force. In this case, the external force is the moving water.

2. Newton's Second Law (Law of Acceleration): - As water flows through the machine, its acceleration and velocity increase. According to Newton's second law, the force applied to an object is equal to the mass of the object multiplied by its acceleration (F = ma). In this context, the force of the water is directed at the contaminants on the fruit.

3. Bernoulli's Principle: - As water accelerates through the machine, its pressure decreases. This principle helps create turbulence by varying the pressure around the fruit surfaces. The lower pressure regions encourage the dislodging of contaminants.
4. Turbulent Flow: - Turbulent flow in the water, driven by the machine's design, results from the chaotic and irregular motion of fluid particles. This turbulence enhances the cleaning process by creating a dynamic environment. The irregular motion of water disrupts the boundary layer around the contaminants on the fruit, making it easier for them to be detached and carried away.
5. Drag Force: - The turbulent water generates a drag force on the contaminants adhered to the fruit. This force is a result of the friction between the water and the contaminants, aiding in their removal.

4. SS BASKET

The SS Basket in the fruit washing machine plays a pivotal role in ensuring efficient and thorough cleaning of fruits. Constructed from stainless steel, the basket is corrosion-resistant and durable, meeting the high standards of hygiene required in food processing. Its design allows for optimal water flow, facilitating the removal of dirt, pesticides, and contaminants from the fruits. The perforated surface of the basket ensures proper drainage, preventing water stagnation and promoting a sanitary washing process. With carefully spaced gaps, the SS Basket accommodates various fruit sizes, offering versatility in handling different produce. Its sturdy construction enables the basket to withstand the rigors of daily use, providing longevity to the fruit washing machine. The SS Basket's ease of removal and cleaning simplifies maintenance, contributing to the overall efficiency of the fruit washing process. Designed for seamless integration into fruit washing machines, this basket exemplifies a commitment to both functionality and sanitation in the food industry.
In this machine we are using two SS304 baskets. One will be used in dryer and another in washer. The baskets will be used to keep those fruits and vegetables.
Dimension:
Height:250 mm
Length: 500 mm
Breadth: 250 mm
Material: Here we are using stainless steel for the basket. Because stainless will not react with ozone and other disinfectors.
The figure (f) converts entire basket assembly into a solid object to complete the analysis of the density, mass, volume, and surface area to get an estimation about the waste carrying capacity of the basket.

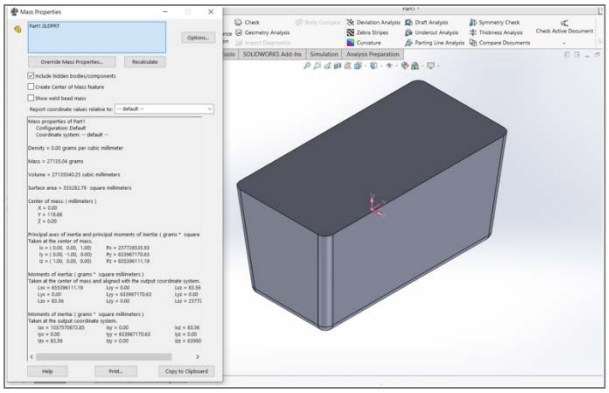

Figure 6. Volumetric Analysis

Results are as follows-

Output –
Mass: 27135.04 gm
Volume: 27135040.25 cubic millimeters
Payload= 27135.04(gram)x10^{-3}= 27.13504 kg.
Centre of Mass: (millimeters)
X = 0.00

Y = 118.68
Z = 0.00

5. PNEUMATIC TUBES

Pneumatic pipes play a crucial role in various industries, serving as conduits for the transportation of compressed air or gases. These pipes are typically constructed from durable materials such as steel, aluminum, or plastic, ensuring they can withstand the pressure generated by the pneumatic systems. The seamless design of pneumatic pipes minimizes the risk of leaks, promoting efficient and reliable air transmission. Their lightweight nature facilitates easy installation and flexibility in routing, contributing to streamlined operations in manufacturing and automation processes. Pneumatic pipes are essential components in pneumatic systems that power tools, machinery, and other equipment, providing a clean and adaptable energy source. Regular maintenance is imperative to sustain optimal functionality, as any compromise in the integrity of these pipes can lead to decreased efficiency and safety hazards. The standardized sizing of pneumatic pipes enables compatibility with a wide range of pneumatic devices, fostering interchangeability within industrial setups. Employed in applications ranging from automotive manufacturing to robotics, these pipes exemplify a fundamental aspect of modern industrial infrastructure. As technology advances, the evolution of materials and design in pneumatic pipes continues to enhance their performance, making them indispensable in the realm of industrial automation and machinery.
We will use 8mm pneumatic pipes to connect nozzles with compressor in both drier and washer and to carry ozone + Air from ozone generator to water in only washer.

6. FOOT OPERATED VALVE:

A detent-type foot-operated valve is a mechanical device designed for hands-free control in various industrial applications. This valve features a decent mechanism, ensuring it maintains its position once activated, providing stability and control. By utilizing foot pressure, users can conveniently operate machinery or control fluid flow without the need for manual hand manipulation. The detent mechanism prevents unintended changes in the valve position, enhancing safety and precision in operation. This type of valve is commonly employed in machinery where hands-free operation is essential, such as in manufacturing processes or medical equipment. Its design promotes efficiency and ergonomic functionality, contributing to a seamless and controlled workflow.
The detent-type foot-operated valve exemplifies a reliable and versatile solution for enhancing operational convenience and safety in diverse industrial settings. Here we will use detent type foot operated valve to turn on the functions of both drier and washer. By using this foot operated valve, we can operate the whole functions of the systems by our foot.

7. SS TRAY

The SS tray, made from stainless steel, stands as a pivotal component in the efficient management of wastewater. Crafted with durability in mind, it serves as a reliable container for storing and containing wastewater in diverse industrial and domestic settings. Its corrosion-resistant nature ensures a prolonged lifespan, allowing it to withstand the harsh conditions often associated with wastewater. The SS tray's design facilitates easy maintenance, contributing to a hassle-free waste management system. Its non-reactive properties make it an ideal choice for handling a variety of wastewater types, preventing contamination, and ensuring environmental safety. The tray's sleek and seamless construction minimizes the risk of leakage, promoting a secure containment environment. With a smooth surface, it simplifies the cleaning process, maintaining hygiene standards in wastewater handling. Its versatility extends to accommodating different volumes of wastewater, adapting to the specific needs of varied applications. The SS tray thus emerges as an integral and dependable solution in the quest for effective wastewater storage, combining robustness, longevity, and adaptability in its design and functionality.
SS Tray used to collect wastewater in the drying system. It is removable. When it will be filled, we can remove it manually and clean the water inside it.

8. VOLUME BOOSTER

A volume booster in a pneumatic system is a critical component designed to amplify the output flow of compressed air. This device plays a pivotal role in enhancing the performance of pneumatic actuators by

ensuring swift and efficient operation.

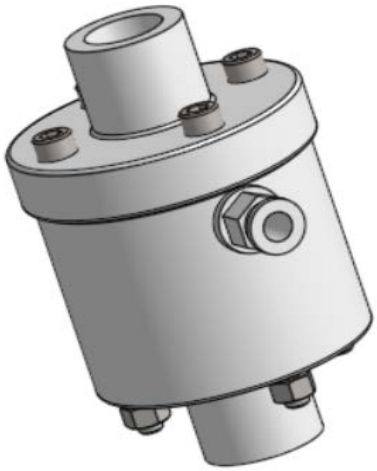

Figure 7. Volume Booster

Typically installed between the control valve and the actuator, the volume booster receives a low-pressure control signal and intensifies it to a higher pressure suitable for driving the actuator. This amplification process is essential for applications requiring a rapid and forceful response, such as in industrial automation or process control systems. The volume booster operates by utilizing a diaphragm or piston arrangement, which responds to the input signal and regulates the flow of compressed air accordingly. This not only speeds up the actuation process but also provides precise control over the actuator's movements. The use of volume boosters contributes to system responsiveness, allowing for better control and increased efficiency in pneumatic applications. Additionally, these devices contribute to energy savings by optimizing air consumption and minimizing response times, making them indispensable in various industrial settings.

Two volume boosters used in the drying system. These volume boosters used to dry those fruits and vegetables. Volume boosters generally sends air in high pressure which will help to dry the water of the fruits.

In our dryer system first volume booster will be attached above the basket with a stand and second volume booster will be attached at the bottom of the basket. The first volume booster will be connected to the compressor with a foldable pneumatic pipe. The foldable pneumatic pipe helps to adjust the height of that volume booster. The second volume booster will be connected to the compressor by a normal pneumatic pipe.

9. COOLANT PIPE

Coolant pipes are vital components in automotive systems, facilitating the circulation of coolant to regulate engine temperature. Constructed from durable materials like aluminum or steel, these pipes ensure efficient heat exchange, preventing engine overheating. Their intricate design and precise engineering contribute to the seamless functioning of the cooling system, enhancing overall vehicle performance and longevity. Regular inspection and maintenance of coolant pipes are essential for optimal engine health and temperature control.

Using two coolant pipes in the Drying system to connect the nozzles. Also using coolant pipes to adjust the positions of the nozzles because coolant pipes are flexible.

10. AIR COMPRESSOR

A mechanical device that transforms power into compressed air is called an air compressor. It works by compressing air and storing it in a tank with the help of a pump that is powered by an electric motor, diesel engine, or gasoline engine. After that, the compressed air may be put to use in a variety of ways, such filling tires with air, running pneumatic machines, and providing clean air for industrial operations. Positive displacement and dynamic (centrifugal) air compressors are the two primary categories of air compressors. Dynamic compressors increase air velocity and convert it to pressure, whereas positive displacement

compressors function by trapping and lowering the volume of air. To ensure the lifetime and best performance of air compressors, proper maintenance is essential for their safe and effective operation.
Air compressor used to control the pressure of the air passing through the nozzles to wash those fruits and vegetables.
Size: - 190-210 liter.

11. DISINFECTION TECHNIQUES

11.1. Ozone Generator

As the Tray filled with Fruits/Vegetables is placed in the washing chamber it gets submerged in Water. As the waves are passed through water it creates turbulence which result in easier dislocation of the particles from the surface of the fruit.

11.2 Disinfectant

Hydrogen peroxide as a disinfectant in this equipment. An ally of plants, hydrogen peroxide is a naturally occurring disinfectant. In addition to eliminating many forms of bacterial and fungal development from fruits and vegetables, it also has the potential to enhance plant health in the process.
An excellent method to protect yourself and your family from dangerous germs that are always trying to enter your body is to wash fresh vegetables with hydrogen peroxide.

1. Colorless Liquid
2. Chemical Formula - H_2O_2
3. Chemical Formula Similar to That of Water - H_2O.

It could also be useful for several other things, such surface cleaning, first aid, and serving as a backup oxygen supply for solid waste slurry bioreactors.
How does Hydrogen peroxide work as a cleansing agent?
Because of the additional oxygen molecule, hydrogen peroxide has greater oxidizing power. It may therefore take in electrons from other materials. This makes it an effective disinfectant since it may oxidize a microorganism's cell membrane, causing a loss of structure and ultimately the pathogen's death.
The oxidizing qualities of hydrogen peroxide make it a powerful disinfectant. Commercially available 3% hydrogen peroxide can be used to sterilize surfaces.
All harmful stabilizers seen in hydrogen peroxide at greater concentrations are absent from this concentration of hydrogen peroxide. Furthermore, a concentration of 3% hydrogen peroxide is potent enough to eliminate bacteria and dissolve without harming human skin.

Why Hydrogen Peroxide is better than Other Cleansing Agent?

1. Not harmful by nature.

2. It breaks down into oxygen and water, making it ecologically benign and regarded by the FDA and EPA as "generally recognized as safe," or GRAS. Ph has no effect on it, but the organic load in the wash water does.

3. Conversely, hydrogen peroxide and other disinfection chemicals like bleach and ammonia have comparable disinfecting abilities. They do, however, include harmful substances like chlorine and salts that are incompatible with the internal workings of living things.
Additionally, it was found that using a greater concentration of hydrogen peroxide during the cleaning process caused the nutrients to drop since the vegetable's surface did not contain any bacteria and the agent had to react with them. nutrients.

From all the research done it is advisable to use hydrogen peroxide with 5% concentration.

12. RESULT AND DISCUSSION

12.1. Components:

Table 2. List of all components

Sr. No.	Component Name	Component Quantity
1	Stainless Steel Washing Chamber	1
2	Mild Steel Rod with adjusting screw	1
3	Washer support structure (stand)	1
4	Dryer Mild Steel Stand	1
5	Fruit Crates	5
6	Clips	4
7	Industrial Compressor (10 HP, 500 Lit tank capacity) Heavy Duty	1
8	Industrial Compressor (1 HP, 125 Lit Tank Capacity)	1
9	Ozone Generator	1
10	Ozone + Air Mixing Nozzle	1
11	Air Manifolds (Junction boxes)	5
12	Manifold connectors (brass)	5
13	Manifold Plugs Brass	6
14	Manifold Plugs Plastic	2
15	Coolant Pipes	4 to 6
16	Air Saving Nozzle (Delrin)	15-22
17	Air Saving nozzle (Stainless Steel)	6-8
18	Volume Booster (AOC)	2-3
19	PU Tubing Pneumatic 8 mm OD	46 m
20	PU Tubing Pneumatic 6 mm OD	12 m
21	PU Tubing Pneumatic 12 mm OD	9 m
22	Pneumatic L Fitting (Normal)	3-5
23	Pneumatic L Fitting (Brass)	1
24	Pneumatic T Fitting (Brass)	2
25	Pneumatic L Connector (Normal)	6
26	Pneumatic T Connector (Normal)	2
27	Pneumatic Ball Valve	3-4
28	5/2 Detent Type Foot Operated Valve	1
29	5/2 Spring Return Floor Operated Valve	1
30	ON/OFF valve	2
31	Dead Weight	1
32	Drain Valve (Ball Valve)	1
33	Teflon Tape	6 m
34	Tray	1
35	Pneumatic Y type connector	2

These are all the components used in the actual fabricated machine.

12.2. Material Composition

12.2.1. Mild Steel

Carbon serves as the primary alloying ingredient in mild steel, which is an iron alloy. It is among the most extensively utilized types of steel and has a variety of general-purpose uses. The popularity of mild steel can be attributed to its good machinability and weldability, as well as its reasonable strength at a reasonable price. Different grades of mild steel have varying carbon concentrations; higher carbon contents result in stronger steel that is less ductile. Sometimes, to enhance qualities like tensile strength, corrosion resistance, and wear resistance, more alloying elements are added.

Figure 8. Dryer Stand (MS)

Mild Steel, often abbreviated as MS, is a type of low carbon steel that finds widespread use in various industries due to its exceptional versatility, durability, and cost-effectiveness.

Figure 9. Washer Stand (MS)

The term "mild" is indicative of its low carbon content, typically ranging from 0.05% to 0.25%. This distinguishing feature contributes to its malleability and ease of fabrication, making it a preferred choice for an array of applications.

One of the key reasons for the widespread use of mild steel is its favorable balance of strength and ductility. While low carbon content makes it malleable and easy to work with, the steel retains sufficient strength for many structural and industrial purposes. This combination of characteristics renders it suitable for an extensive range of applications, spanning construction, automotive manufacturing, shipbuilding, and more.

In the construction industry, mild steel plays a pivotal role in the creation of structural frameworks. Its ability to withstand substantial loads, coupled with its formability, allows engineers to design and construct buildings with efficiency and structural integrity. Furthermore, mild steel's weldability is a significant advantage in the assembly of structural components, enabling seamless connections that contribute to the overall stability of the construction. In automotive manufacturing, mild steel finds application in the production of vehicle bodies, chassis, and various components. Its formability allows for the creation of complex shapes, contributing to the sleek and aerodynamic designs of modern vehicles. Moreover, its strength provides essential structural support, ensuring the safety and durability of automobiles on the road.

Shipbuilding is another sector where mild steel is indispensable. Its combination of strength and weldability is crucial for constructing vessels capable of withstanding the harsh conditions of the open sea. Mild steel's resistance to corrosion, though not as high as some other alloys, is often addressed through protective coatings or treatments, enhancing its durability in marine environments.

Beyond its mechanical properties, the cost-effectiveness of mild steel is a driving factor in its widespread adoption. The abundance of raw materials, coupled with efficient manufacturing processes, makes mild steel an economical choice for various applications. This affordability extends its accessibility to a broad spectrum of industries, from large-scale construction projects to small-scale manufacturing. In conclusion, mild steel, denoted by the abbreviation MS, stands as a versatile and indispensable material in the realm of materials science and engineering. Its unique combination of strength, ductility, and cost-effectiveness renders it invaluable in diverse sectors, playing a crucial role in shaping the infrastructure and products that define our modern world.

12.2.2 Stainless Steel

Stainless steel generally exhibits excellent corrosion resistance in water due to its chromium content, which forms a protective oxide layer on the surface. This passive film prevents further oxidation, enhancing the material's durability. However, the specific behavior can vary based on stainless steel grades and water conditions. In normal freshwater environments, stainless steel typically remains corrosion resistant.

Figure 10. Washer Chamber (SS)

Factors influencing stainless steels behavior in water include temperature, pH levels, and the presence of impurities. Elevated temperatures and extreme pH values can impact the protective oxide layer, potentially compromising corrosion resistance. Stainless steel defends against corrosion through a natural process involving the formation of a protective chromium oxide layer on its surface. This passive film is the key to the material's remarkable resistance to rust and corrosion. Stainless steel is primarily composed of iron, chromium, nickel, and other alloying elements. Chromium plays a crucial role in corrosion resistance, typically constituting at least 10.5% of the alloy. When the stainless steel is exposed to oxygen in the atmosphere or water, chromium reacts with it to form a thin, invisible layer of chromium oxide on the surface.

The chromium oxide layer acts as a barrier between the metal and the surrounding environment. This barrier is self-renewing and self-healing, meaning that if it is scratched or damaged, chromium from adjacent areas reacts with oxygen to repair the protective film. This intrinsic ability to regenerate the oxide layer contributes to the long-term corrosion resistance of stainless steel.

Additionally, the alloying elements in stainless steel, such as nickel and molybdenum, further enhance its resistance to corrosion. Nickel, for example, improves the stability of the protective layer and contributes to the steel's overall durability. Molybdenum enhances corrosion resistance in aggressive environments, such as those with high chloride concentrations, making stainless steel suitable for applications like marine environments. Stainless steel grades are classified based on their microstructure, and the two most common types are austenitic and ferritic. Austenitic stainless steels, which include popular grades like 304 and 316, have a face-cantered cubic (FCC) crystal structure. This structure enhances their corrosion resistance and makes them well-suited for a wide range of applications, including food processing, chemical processing, and architectural purposes. While stainless steel is highly corrosion-resistant, certain conditions can affect its performance.

Extreme environments, such as those with high chloride concentrations, may lead to localized corrosion issues like pitting or crevice corrosion. Proper alloy selection, considering the specific application and environment, is crucial to ensuring optimal corrosion resistance. Regular maintenance practices, such as cleaning and avoiding exposure to harsh chemicals, can help maintain the protective oxide layer. In summary, the inherent corrosion resistance of stainless steel arises from the formation of a stable, self-renewing chromium oxide layer, coupled with the beneficial effects of alloying elements, making it a durable and versatile material in various industries.

12.3 Machine Assembled with All the Components

Figure 11. Assembled Machine

Figure 12. Turbulence

Figure 13. Dryer working

12.4 Graphical Representation

12.4.1: Washing/Disinfection vs Time:

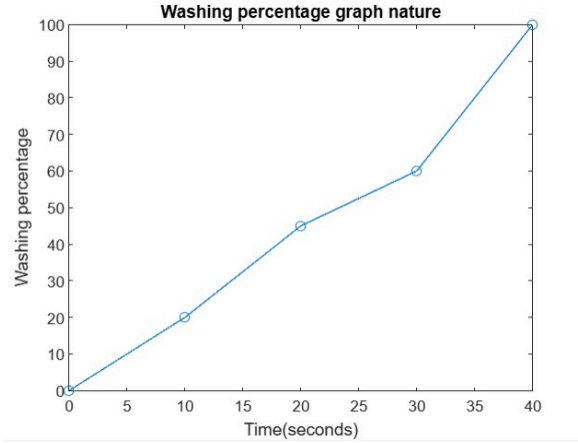

Figure 14. Washing % vs Time

12.4.2 Drying vs Time:

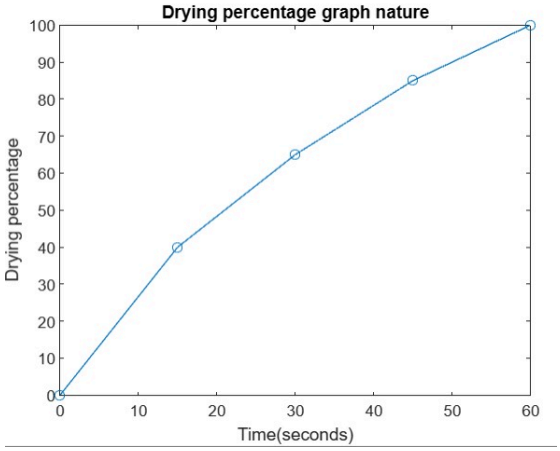

Figure 15. Dryer % vs Time

13. FUTURE SCOPE

This semi fruits/ vegetables automatic washing has a lot of scope in the agricultural sector as well as Agro products production. Because of the huge application scope for Women's self-help groups, also called as महिला बचत गट in Marathi. These self-help groups have been receiving quality support from the state government with many financial help and easy compliance policies.

Second important scope is for the use in MSME industries. Many small-scale agriculture industries will find this product beneficial, especially those who are preparing fruit-based products like jams, jellies, pickles. They are not able to afford complete automation solutions, so this has tremendous scope here

Another important scope is they are beneficial in regions where there is shortage of skilled labour. Unskilled local labour is not in a position wo work in cohesion with the higher level fully automatic machines as compared to semi-automatic ones.

This also find scope where the operator has limitation in the operation expenses of the machine and the machine expense has to be recovered as soon as possible

14. CONCLUSION

The development and implementation of a semi-automatic disinfection, cleaning, and drying machine for fruits and vegetables represent a significant stride towards enhancing food safety and quality. The integration of advanced technologies in this machine underscores its potential to mitigate microbial contamination, reduce pesticide residues, and improve overall hygiene. Through a combination of innovative features such as automated disinfection processes, efficient cleaning mechanisms, and rapid drying capabilities, the machine not only streamlines post-harvest handling but also contributes to the preservation of nutritional content and shelf life of fruits and vegetables. The research findings highlight the machine's efficacy in addressing crucial challenges in the food supply chain, promoting consumer health, and ensuring compliance with stringent quality standards. Furthermore, the semi-automatic nature of the system strikes a balance between operational efficiency and user involvement, making it a practical and accessible solution for diverse agricultural settings. As we move forward, continued research and development in this domain will be crucial to refining and expanding the technology, fostering sustainable practices, and advancing food safety on a global scale. So, targeting our initial planning we have successfully developed the prototype of our batch type semiautomatic fruits / vegetables washing, drying and disinfection.

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