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Design and Development of Automated Tomato Paste Machine

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Abstract
A tomato paste machine is an industrial device used to process tomatoes into concentrated tomato paste, the machine typically involves multiple stages, including washing, peeling, crushing, separating the seeds and concentrating the pulp by removing excess water. He final product is a smooth, thick paste that can be packaged for use in various food products, such as sources, soups, and condiments. The machine will be designed for high efficiency and small-scale production often featuring automated controls for consistent quality and output.
Tomato is a highly perishable fruits that deteriorates faster, hence, the need for immediate processing. Tomato paste is a common processed product mostly done manually that involves drudgery. To reduce drudgery and realize a quality tomato paste, an automatic tomato paste-making machine was developed and evaluated for its performance. The major performance evaluated was the sensory evaluation of the processed tomato paste.
The machine was developed from stainless steels and PVC pipes that are non-contaminating local materials. The automatic electronic components were developed by soldering of Integrated Circuits, timers, relays, diodes, thermostats, blenders, heaters and plug in conformity with the designed circuit diagram. The machine was evaluated by running it with no load and when fed with 3 kg tomato fruits at varying steaming.

Keywords: Washing, Peeling, Crushing, Separating the Seeds and Concentrating the Pulp, Removing Excess Water, Diodes, Thermostats, Blenders

1. Introduction

1.1 Overview

The growing need for water and energy, coupled with the limited availability of freshwater and fossil fuels, the alarming climate fluctuations, and environmental concerns, urgently demand for efficient resource utilization and the adoption of sustainable and optimized industrial practices. Industries of the food and beverage sector are among the most energy-intensive industries that use huge amounts of fresh water for various processes (Islam and Karim, 2019) According to the United Nations, globally about 72% of water resources are used for agriculture and irrigation, 16% is consumed by municipalities, and 12% goes to ward industrial uses (UN-Water, 2021), with 56% of it being consumed by the food and beverages industry (Bhatt and Mokonnen, 2022) [10]. Among them, the most water-intensive sectors include soft drinks and bottled water, dairy products, brewing, wine and spirits, as well as meat and fruits and vegetable processing. (Peterson, Gerbens and Mekonnen, 2022). In these sectors, water of potable quality is commonly employed as an ingredient, for cleaning, heating, cooling, transportation, and other essential processes.
There is an urgent need for effective resource use and the adoption of sustainable and optimalindustrial methods due to the rising demand for energy and water, the scarcity of freshwater and fossil fuels, the worrying climatic variations, and environmental concerns. The food and beverage industry is one of the most energyintensive sectors and uses a lot of fresh water for a variety of operations (Islam and James, 2019).
The United Nations estimates that around 82% of water resources worldwide are utilized for irrigation and agriculture, 16% areused by municipalities, and 12% are used for industrial purposes (UNWater, 2021). Of these, 56% are used by the food and beverage sector.
Unfortunately, while significant strides have been taken to enhance water use efficiency in agriculture using modern technologies like the Internet of Things (IT), drones, and satellites, as well as innovative methods such as smart farming according to (Abdul and Rajak, 2022) [1], there is still limited effort from the food and beverages industry to reduce freshwater

consumption during the processing of raw materials. Moreover, around 70% of the freshwater used being discharged as effluent containing high levels of biological oxygen demand (BOD) and chemical oxygen demand (COD) (Menses and Olmez, 2019). Hence, the management of water resources within the food industry remains less than optimal. This is despite wastewater treatment facilities progressively integrating state-of-the-art technologies to meet increasingly**.**

The design and development of a tomato paste machine aim to improve efficiency, reduce manual labour, and enhance the quality of processed tomato products. Tomato paste is a widely used ingredient in various cuisines, and its production requires careful processing to maintain flavour, texture, and nutritional value.

Industries of the food and beverage sector are among the most energy-intensive industries that use huge amounts of fresh water for various processes. According to the United Nations, globally about 72% of water resources are used for agriculture and irrigation, 16% is consumed by municipalities, and 12% goes to ward industrial uses (UN-Water, 2021), with 56% of it being consumed by the food and beverages industry.

Soft drinks and bottled water, dairy goods, brewing, wine and spirits, and the processing of meat, fruits, and vegetables are the industries that use the most water among them. Potable water is frequently used as a component in various industries for transportation, heating, cooling, cleaning, and other crucial operations.

1.2 History of Tomato Paste Machine

Tomato paste, that beloved red condiment that plays a starring role in many Iranian dishes, has a long and interesting history. This journey begins in the heart of South America and, through many twists and turns, ends up on the shelves of our kitchens. Let's turn the pages of this fascinating history together.

Can you believe that the tomato, which is now an integral part of our meals, was initially considered an ornamental fruit? Yes, the indigenous peoples of Central and South America used tomatoes as a decorative element for thousands of years before they were eaten. But this didn't last long. With the arrival of the Spanish in the Americas in the 16th century, the tomato made its way to Europe.

Europeans initially thought tomatoes were poisonous! Their bright appearance and resemblance to some poisonous berries led to this big misunderstanding. It took years for the people of Europe to realize their mistake and gradually incorporate tomatoes into their diets.

You might be interested to know that the first attempts to preserve tomatoes for long periods date back to the 17th century. At that time, a solution called "sweetbread" was invented. Sweetbread was a type of sugary sauce or powder that was combined with ascorbic acid (vitamin C) to help preserve tomatoes for longer. Sweetbread could be considered the first step towards the invention of tomato paste.

1.3 Problem Statement

Sorting, washing, crushing, heating, and packing are some of the laborintensive steps in the preparation of tomato paste. This procedure is mostly done by hand in many smalland mediumsized food processing businesses, which results in inefficiencies, inconsistent product quality, and expensive labor. Additionally, manual processes raise the possibility of contamination, spoiling, and low throughput, all of which have an impact on the shelf life of products and their ability to compete in the market.

Furthermore, current automated methods are sometimes costly and unsuitable for smallscale businesses, particularly those in developing nations. An automated tomato paste machine that is economical, small, and effective is required in order to meet hygienic and quality requirements throughout the whole process, from the input of raw tomatoes to the output of packed paste Scocian (M, 2016).

In order to increase production, guarantee consistency in paste quality, reduce operating expenses, and reduce the danger of contamination, this project intends to design and build an automated tomato paste machine that is both economical and easy to use. Choose a real-world problem.

It draws attention to the present issues with tomato paste manufacturing, including labor intensity, inefficiency, contamination concerns, and inconsistent product quality, particularly in manual or semi-automated systems.

1.4 Objective

(a) To analyse existing tomato paste machine for ergonomic deficiencies affecting user comfort, and safety.

(b) To identify key ergonomic principles applicable to environments through a review of relevant parties of tomato paste machine.

(c) To design a tomato paste machine that integrates ergonomic enhancements aimed at reducing waste tomatoes on the market and improving machine efficiency.

(d) To evaluate the effectiveness of the machine through user testing and comparative performance analysis.

1.4.1 Main Objective

To design and development an automated tomato paste machine.

1.4.2 Specific Objectives

Efficient processing of tomatoes to convert fresh tomatoes into paste with maximum yield and minimal waste.

Concentration of tomato juice to reduce water content under controlled conditions (often vacuum evaporation) while preserving colour, flavour, and nutrients.

Energy and resource efficiency to optimize water, steam. Power use during washing, heating, and evaporation processes.

Hygienic and safe operation to ensure sanitary processing with stainless steel equipment that meets food safety standards.

2. Literature Review

2.1 Introduction

The growing need for water and energy, coupled with the limited availability of freshwater and fossil fuels, the alarming climate fluctuations, and environmental concerns, urgently demand for efficient resource utilization and the adoption of sustainable and optimized industrial practices. Industries of the food and beverage sector are among the most energy-intensive industries that use huge amounts of fresh water for various processes (Junqua, R., Carullo, D., Ferrari, G., Pataro, A.C., Delgado-pando and Koidis, A., 2019) According to the United Nations, globally about 72% of water resources are used for agriculture and irrigation, 16% is consumed by municipalities, and 12% goes toward industrial uses (UN-Water, 2021), with 56% of it being consumed by the food and beverages industry.

2.2 Review of the Literature

Automated tomato paste machines have been developed to address the labour-intensive and time-sensitive nature of tomato paste production, enhancing quality, efficiency, and reducing drudgery in processing tomatoes, which are highly perishable fruits. Tomato lycopersicon esculent is a widely consumed fruit with high moisture content, making it prone to rapid spoilage after harvest. (Lee, S.Y., Sagong, H.G., Ryu, S., and Kang, D.H., 2012). This perishability creates a demand for immediate processing into products such as tomato paste, juice, powder, and sauces. Traditionally, tomato paste production, especially at the domestic and smallholder level, is a manual and laborious process that limits productivity and consistency.

The advancement towards automation in tomato paste production is motivated by the need to increase agricultural productivity, improve paste quality, and reduce the physical burden on producers. Automated tomato paste machines commonly integrate components such as steamers, blenders, electronic timers, sensors, and control circuits to efficiently process tomatoes under controlled conditions. These machines use principles like present steaming and blending times, automated heating, and blending operations orchestrated through electronic units built using integrated circuits, relays, and thermostats (Pan, Z., Atungulu, G.G., Wood, D., and McHugh, T., 2014).

Research has shown that optimal steaming and blending times improve the sensory qualities of tomato paste, including homogeneity, smoothness, and taste, indicating a direct impact of automation parameters on product quality.

The synergy between steaming and blending facilitates easier processing and enhances paste texture and flavour in figure 2.

Fig 1: Synergy Steaming

(Li, X., Pan, Z., Atungulu, G.G., Zheng, X., Wood, D., Delwiche, M., and McHugh, T.H., 2014). Besides machinery development, automation in tomato processing aligns with broader technological trends like smart agriculture and precision technologies, contributing to economic growth and quality improvements in agricultural products. Enabled and microcontroller-based systems are increasingly being explored to optimize process control further, reduce human error, and enable real-time monitoring of parameters such as temperature ph., and processing times.

Overall, the literature emphasizes that introducing automated tomato paste-making machines can significantly improve production efficiency, product uniformity, labour reduction, and encourage the adoption of mechanized processing, particularly in small-scale and domestic settings. (Li, X., Pan, Z., Atungulu, G.G., Zheng, X., Wood, D., Delwiche, M., McHugh, T.H., 2014). This progress reflects advances in agricultural mechanization, food processing technologies, and automation controls that together drive innovation in the tomato paste industry. This review will explore past developments, design principles, performance evaluations, sensor and control integration, and future directions toward more intelligent, sustainable, and scalable automated systems for tomato paste production.

Quality for product processing the quality aspects of tomato and tomato product, are divided into criteria for fresh market and product processing. Nutritional value, insecticides and fungicides, and organically status are important for consumer. For product processing, factor such as the colour of the fresh produce associated with quality and freshness. The perception for tomato is the redder the tomato the better it is (Liu, C., Zhang, Z., Liu, S., Liu, Q., Feng, B., and Tanzer, J., 2019). The red colour is due to lycopene, in which its lost can be accelerated by high temperature and exposure to oxygen. Viscosity is one of quality grade standards for ketchup and tomato sauce. Since the yields and quality influence by viscosity, it is also affecting the economics of the processors. The final viscosity is affected by temperature, size of finisher screen, milling, blade speed, and pulp preparation method.

Normally, processing of food decreases the nutritional value due to the reduction of compounds. Unit operations introduce air or heat treatment into juices will expedite oxidation of ascorbic acid, therefore, create the need for fast reduction in temperature. It has been reported that lycopene is highly available in processed tomato in contrast to in raw tomatoes. Lycopene is also stable to heat treatment and storage (Somavat, R., Mohamed, H.M.H., and Sastry, S.K., 2013) [4]. The degradation of lycopene may due to high temperature, exposure to oxygen, and low water activity. During handling, most lycopene may be converted from the all-trans form into the less bioactive, cisisomer, which can be contributed by the processes involved in the production of sauces, soups, and juice.

Fig 2: Phenolic of Tomato

The content of total phenolic of tomato puree is decreased at high temperature and short time of 98°c and 40 seconds via

pasteurization. In contrast, an earlier study reported that by blanching at 100°c for 30 minutes, there is an increase of tomato phenolic in range of 23 – 34 %. Therefore, there is a need to balance between temperature and duration of heat treatment for an optimum phenolic content. Pre-processing unit operation for tomatoes includes, grading, washing, sorting and trimming, coring and peeling.

Being a versatile vegetable, tomato able to be process to various products such as juice, paste, sauce, soup, ketchup, and canned tomatoes. The processing for tomato puree and paste include break, extraction and refining of juice, concentrating evaporation and sterilization and packaging. For canned whole tomatoes, the process includes peeling, sorting and filling, additives, exhausting and sealing, thermal processing, and cooling, labelling and packing. For tomato juice, the important process includes crushing, breaking and extraction, desecration, salting and filing, and homogenization and thermal processing.

The important process includes crushing, breaking and pulping, as well as formulation, follows by cooking, finishing and homogenization and lastly, desecration filling, sterilizing and cooling. Chillies sauce, the route almost similar using tomato as one of the ingredients. Tomatoes also can be process as dried tomato products, by dehydration process. Additionally, tomato also can be turn into powder. The tomato powder is produced by increasing the concentration of tomato solids from 30 to 40% in tomato paste to about 97%. Tomato powder is prepared from tomato paste, which is prepared by hot-break method. Even though, there are various dryer such as roller drum-dryer, foam- mat dryer, the spray-dryer appears to be the most suitable to produce high quality powder.

The process includes washed, sorted, blanched, peeled, sliced, diced, or left whole, inspected, and frozen on an individually quick-frozen belt freezer, via fluidization to −13 °c. However, frozen method was reported to be uneconomical. (Steven, R., and Hall, A., 2009). When tomato is processed, and there will be by-product. It is called tomato pomace, which constitute of skin and seeds (lignocellulosic-based substrate). It can be used to produce proteins and vitamin b12 for human consumption as supplement and source of non-conventional oil. Lycopene, able to be recovered from waste of tomato paste, tomato pulp, and tomato processing.

2.3 Related Works

The undesired physic-chemical changes can be easily controlled by various techniques e.g. vacuum evaporation. For instance, the colour and the flavour have been preserved by low pressure and temperature under vacuum evaporation (Peterson, S.D., Am´ on, R., Wong, T., Spang, E.S., and Simmons, C.W., 2022). Overall, there is an absence of standardization of methods and instruments to define quality. While colour can now be measured objectively, there are currently no standard colour requirements for tomato concentrates. Rheological measurements on both tomato juice and concentrates are reviewed; the power law finds wide applicability, although other rheological characteristics, particularly time dependency, have received far less attention and there has been little effort to relate rheological understanding to the commonly used empirical tests such as consistency measurements. The volatiles responsible for flavour and identified to the point where the natural of tomato paste can be imitated. Attempts to develop objective methods as a substitute for sensory assessment are reviewed vacuum cooking (Qu, W., Liu, Y., Feng, Y., and Ma, H., 2022). Tomato juice can be concentrated under vacuum evaporation in a shorter period without adding salt or thickening agents shown in figure 9.

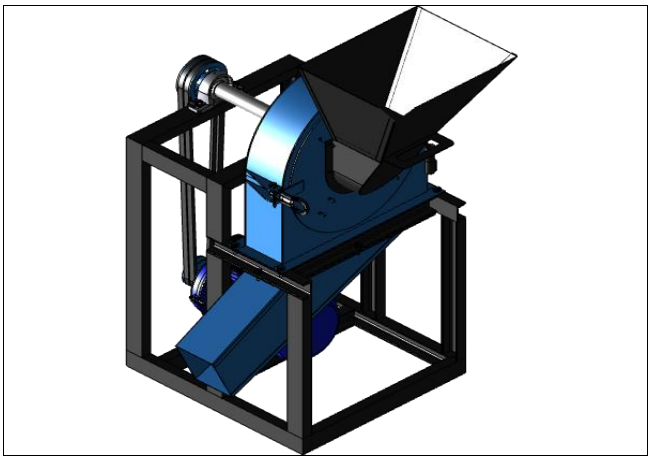


Fig 3: Thickening Machine Agents

3. Methodology

3.1 Introduction

This chapter will elaborate on the project requirements and also the different methodologies that will be used to collect and evaluate them. This chapter is formulated by combining all the project components and their functionalities. This chapter will also address all the user requirements so as to clarify the nature of the project. This chapter describes the methods and procedures that are required to follow for the successful completion of the design and manufacture of the automated tomato paste machine. In order to have a systematic and empirical approach to the development of the automated tomato paste machine, participants for purposes of data collection and analysis were identified and a research carried out, the data collected from participants was later analyzed and used in the design of the automated tomato paste machine.

3.2 Purpose

The purpose of this section is to elaborate on the user requirements for the automated tomato paste machine in much understanding and consistent manner as asked by the client. The growing need for water and energy, coupled with the limited availability of freshwater and fossil fuels, the alarming climate fluctuations, and environmental concerns, urgently demand for efficient resource utilization and the adoption of sustainable and optimized in doctrinal practices.

3.3 Target Users

The target users of the automated tomato paste machine, the main targets for the system are the small scale farmers and commercial farmers. The main goal of this machine is to allow small scale farmers and commercial farmers to use the machine. Also save them time when using the machine and reduce damage of tomato.

3.4 Methodology

In our days, many methodologies have been created of which can be applied and used depending on the project. For this project, the model will be used; because as this project incorporate three different concepts, therefore requirements

do not have change. By using the model, the way of gathering some requirements will be through interviews, surveys and questionnaires. The purpose of questionnaire is to gather what users are expecting from the design and development an automated tomato paste machine. The purpose of the interview is to have a good idea on how automated tomato paste machine work and also how to improve these processes by making use of the internet. From the feedbacks that will be collected, the prototype of automated tomato paste machine will be made so that users may evaluate the machine.

The crusher sometimes called a pulpier or blender is the first key processing unit after sorting and washing. Its role is to break down whole tomatoes into a smooth pulp**,** separating juice and flesh from the harder parts like skins and seeds, making the product ready for heating and concentration.

The methodology in research of tomato paste machines involves a combination of mechanical engineering, sensory evaluation, and process optimization. Here are the key methodologies used in the development and evaluation of tomato paste machines.

3.4.1 Mechanical Engineering

In addition to electrical parts including timers, relays, diodes, thermos tarts, blenders, and heaters, the machine's design and construction incorporate stainless steel and PVC tubing for noncontaminating ingredients. The quality of the tomato paste is greatly impacted by a number of criteria, including the heating and blending periods, which are used to assess the machine's performance.

3.4.2 Process Optimization

The tomato paste spraydrying process is optimized using methods such as response surface technique. Responses like powder yield, moisture, and overall color difference are monitored, while independent factors like feed flow rate and input air temperature are managed. An intake air temperature of 159 °C and a feed flow rate of 350 mL/h are found to provide the greatest results for powder production and reduced moisture content.

These procedures guarantee that the tomato paste machines are not only effective butalso provide superior goods that satisfy customers. For tomato fruit stakeholders' economic growth and agricultural production, the development and assessment of these equipment are essential.

3.4.3 Operating Procedure

Below the steamer, water is added and brought to a boil. Convection causes the steam from the boiling water to ascend to the tomato fruits, softening them so they may be blended. To guarantee that the tomato fruits get the steam uniformly, astirrer in the center of the steamer is turned periodically. The heating cuts off after a certain amount of time, and the blender starts up on its own. The steamed tomato enters the mixing equipment via PVC pipes. Conically coiled stainless steel in the blending unit's inner component provides propulsion during blending, ensuring that the tomato fruits are uniformly blended into a homogeneous paste.

3.4.4 Sensory Evaluation

The sensory evaluation is the test the tomato pastes produced by the machine was subjected to, in order to determine the palatability and acceptability of the paste. A subjective sensory evaluation was conducted on the tomato pastes. This was done by engaging human testers who are termed professional panellists. They were recruited through referrals from Food Technology and welding joints, bolts and nuts were properly fixed and intact during the machine operation. The present timing sensors on the machines were also found to be operational as designed.

The test that was used to assess the machine produced tomato pastes' acceptability and palatability is called the sensory evaluation. The tomato pastes underwent a subjective sensory examination. Professional panelists, or human testers, were used to do this. They were hired based on recommendations from Food Technology, and while the machine was operating, the welding joints, bolts, and nuts were securely fastened. It was also discovered that the machines' current timing sensors were functioning as intended.

Ultimately, the majority of the machine blended tomato paste was deemed well throughout the sensory examination. The tasting panelists stated that the batches with a shorter steaming timethree minuteswere the ones they didn't like. According to reports, the paste produced by this mixture was gritty and not uniform, which made it typically unfit for human eating.

On the other hand, the paste that performed the best was said to require a longer steaming time of six minutes. Pastes were said to be uniform and smooth to the taste at this steaming time, making them very good and generally appropriate for use in the preparation of any type of delicacy. However, batches with a steaming time of four minutes were classified as satisfactory. Pastes at this steaming time were said to be adequate and typically suitable for a wide variety of delicacy, including those with health issues.

3.5 Packaging

In recent years, the packaging industry has witnessed a significant evolution, driven by advancements in technology and shifting consumer preferences. One particular area within this sector that has gained attention is tomato paste equipment. Understanding the design considerations and user needs for this equipment can aid manufacturers and the food production industry in streamlining their processes. In this article, we will dive into the intricacies of tomato paste equipment from various perspectives including product definition, design principles, and future trends.

The packaging process of tomatoes involves several key stages to ensure the product's safety, quality, and convenience for consumers. Here are the main stages involved in the packaging process of tomatoes harvesting and transportation ripe tomatoes are harvested from the fields and transported to the processing facility promptly to maintain freshness and quality.

Plastic Containers

Plastic containers are increasingly used among producers seeking durability and convenience. These containers offer a higher degree of protection against physical damage and typically have better resistance to moisture and chemicals compared to cardboard. They can be made with features such as locking mechanisms and built-in handles, which facilitate ease of handling.

While plastic does not offer the same degree of ventilation as cardboard, modern designs often incorporate ventilation holes that balance protection with air circulation, minimizing spoilage rates. Additionally, plastic packaging can be designed to be stackable, optimizing storage space during transport. On the sustainability front, it is significant

to choose recyclable plastic options. Consumers are ever more conscious of plastic use, and offering recyclable plastic containers can align the product with market trends.

Objectives of effective packaging on reception and inspection

The extend beyond mere protection. One of the primary goals is to enhance shelf life. Packaging must limit exposure to air and moisture, which will lead to spoilage. Using materials that provide adequate barriers against environmental factors is crucial in achieving this. Additionally, the packaging must facilitate easy handling. For example, boxes designed for stacking can optimize space during transportation and storage. This not only reduces costs associated with logistics but also improves efficiency in supply chain management.

Sustainability is another objective that is gaining importance. With increasing awareness of environmental issues, consumers, and businesses alike are looking for eco-friendly packaging solutions. Utilizing biodegradable or recyclable materials can not only fulfil this objective but also enhance the brand's image in the eyes of environmentally conscious consumers.

In summary, the significance of appropriate packaging for tomato paste is multidimensional, encompassing product safety, consumer appeal, and operational efficiency. Understanding these elements is essential for agricultural professionals aiming to maximize the potential of their produce.

Emerging Technologies

Emerging technologies are reshaping how tomato paste is packaged. Innovations such as smart packaging utilize sensors to monitor freshness and quality, which is crucial for perishable goods like tomatoes. These sensors can detect temperature changes and ethylene levels, important factors affecting ripening and spoilage.

Other notable technologies include biodegradable materials made from natural sources. These materials break down more easily than traditional plastics, supporting sustainability. In addition, automated packing lines are improving efficiency, reducing labour costs, and minimizing human error. Among such automation, robotic arms streamline the packaging process, enabling quicker distribution. This response to the fast-paced market is essential for meeting rising demands for tomatoes in various forms.

Design Interpretation

An automated tomato paste machine is a purpose industrial system designed to transform fresh tomatoes into highquality tomato paste efficiently, safely, and hygienically, while minimizing manual labor. Its design reflects an integration of mechanical engineering, food science, automation technology, and process optimization principles. Below is a detailed interpretation of its design philosophy.

Output Efficiency

Maximizes the extraction of pulp and juice from tomatoes, ensuring high yield with minimal waste of raw materials.

Quality Preservation

Maintains the natural color, flavor, and nutrients of tomatoes using controlled heat and low-temperature concentration strategies.

Hygiene and Compliance

Utilizes foodgrade stainless steel and aseptic processing to meet sanitation standards such as:

Labour Minimization

Automation of automated tomato paste significantly reduces manual handling and drudgery.

Key Design Components

Tomato Receiving and Pre Washing System

Air bubble washers, rotary drumsor high Pressure jets remove debris, prevent damage, and enable uniform cleaning. Sorting conveyors manual or automated eliminate defective tomatoes and ensure only quality inputs proceed.

Crushing and Pulping Section

Crushers and pulpers break down fruit and release juice while separating seeds and skins. Preheating Hot or Cold Break inactivates enzymes that degrade pectin, controlling paste viscosity and flavor profiles.

Refining and Homogenization Units

Screens and conical blenders refine pulp by removing coarse solids. Stainless steel propellers in blenders ensure continuous and uniform processing into a smooth paste.

Evaporation and Concentration Systems

Forcedcir culation vacuum evaporator's fallingfilm or multiple effects remove water gently, limiting thermal degradation. Mechanical Vapor Recompression (MVR) or Thermal Vapor Recompression (TVR) enhances energy efficiency.

Sterilization and Pasteurization Units

Tube-in-tube, UHT, or plate-type sterilizers ensure microbialv safety.

Precise heating/cooling cycles preserve organoleptic qualities of flavor, color, and texture.

Aseptic Filling and Packaging

Automated filling into bags, tins, bottles, or pouches under s terile conditions.

Reduces contamination risk, extends shelf life, and supports diverse packaging requirements.

Automation and Control Systems

PLCs, sensors, timers, and relays coordinate steaming; blending, evaporating, sterilizing, and filling. Integrated dashboards enable realtime monitoring, predictive maintenance, and quality control.

Modularity and Scalability

Components can be reconfigured for different capacities 10-15kg and product variants. Designing tomato paste equipment begins with identifying the needs and constraints of the process. This involves thorough research and

understanding of the tomato paste production workflow, as well as regulatory requirements. A successful design team includes experts in food technology, mechanical engineering, and user experience to ensure a holistic approach.

A reputable manufacturer may begin the design process by evaluating different machine partsfor things like efficiency, cleanliness, and heat resistance. Before being scaled up for commercial production, these prototypes are tested in a controlled setting to satisfy industry standards and optimize operations.

The apparatus and equipments used to turn tomatoes into paste for use in cooking and business are referred to as tomato paste equipment. This equipment includes a variety of tools that turn fresh tomatoes into a thick, concentrated paste, including crushers, refining machines, and concentration systems. These devices' main goal is to guarantee the manufacturing of tomato paste that satisfies industry requirements while being effective, sanitary, and of superior quality.

For example, an efficient tomato paste line may start with a washing system to remove impurities, followed by a dicing machine that prepares the tomatoes for crushing. The crushed tomatoes are then cooked and concentrated using evaporators, with the final product being packaged in sterilized containers ready for distribution.

Ergonomics and Safety

Easy access for cleaning systems, reduced worker fatigue, and automatic shutdown features.

Precision Engineering

Exact control over temperature, pressure, and flow rates ensures consistent paste concentration brix levels and quality.

Guiding Principle

Aseptic vat filling machine, pipeline pump, buffer tank, tomato cleaning machine, tomato picking belt, tomato crusher, tomato preheating enzyme killer, tomato beater, tomato thickening, and tomato paste sterilizer are all part of the tomato paste manufacturing line. Connect all of the ketchup production lines.

Tomato Cleaning Machine

Made of premium SUS304 stainless steel, the tomato washing machine uses water as the medium and a powerful turbo fan to create bubbles and tumble the tomatoes for flexible cleaning.

In order to successfully inhibit tomato floating and tomato cleaning, spray pipes and nozzles are attached to the upper portion of the mesh belt during cleaning, and a high-pressure water pump is utilized for circulation spraying.

Tomato Crushing Machine

The tomato crusher is mainly suitable for crushing various berries and fruits and vegetables. At the same time, it can also crush pre-heated and softened fruits and vegetables. When working, the motor drives the flying knife shaft to rotate. When the tomato falls into the fuselage from the feeding hopper, under the interaction of the flying knife shaft and the bottom knife, the tomato can be broken, and the broken tomatoes fall into the filter screen.

What Refining Removes?

Seeds and seed fragments
Tomato skins peels
Fibrous core material
Vascular bundles tough fibres

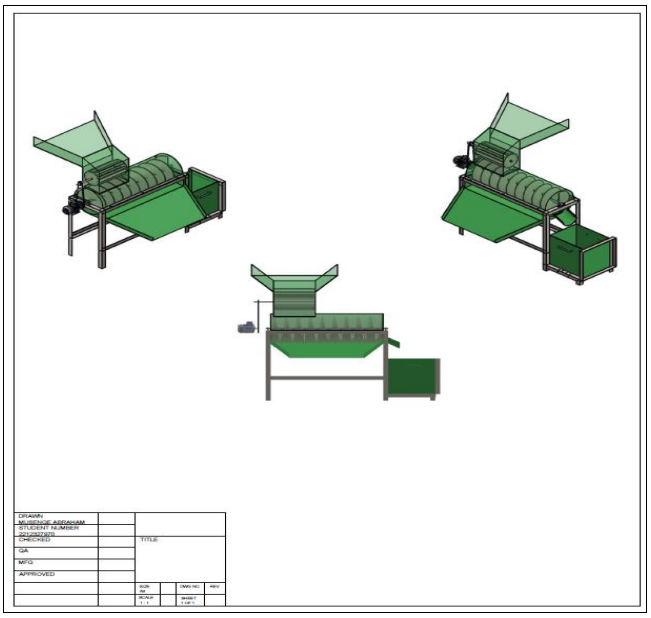
What Refining Achieves

Smooth, uniform texture
Improved mouthfeel
Better consistency
Enhanced colour (removes darker skin pigments)
Professional product quality.

Sensory and Performance Considerations

Automated timing of steaming and blending impacts the viscosity, homogeneity, and taste of the paste. Electronic timers and control circuits are designed to replicate optimal manual processing conditions, verified through sensory evaluation by trained panels.

Isometric Drawing of the Machine



Summary of the Chapter

The processes and procedures that must be followed in order to successfully complete the design and construction of the automated tomato paste machine are described in this chapter's overview. In order to develop the automated tomato paste machine using a methodical and empirical approach, research was conducted and participants were identified for data collection and analysis. The data collected from participants was then analysed and utilized in the design of the automated tomato paste machine.

There is a great need for effective resource use and the adoption of sustainable and optimum doctrinal practices because to the increasing demand for water and energy, the scarcity of freshwater and fossil fuels, the concerning climatic variations, and environmental issues.

In addition to electrical parts including timers, relays, diodes, thermos tarts, blenders, and heaters, the machine's design and construction incorporate stainless steel and PVC tubing for no contaminating ingredients. The quality of the tomato paste is greatly impacted by a number of criteria,

including the heating and blending periods, which are used to assess the machine's performance.

4. Results and Discussion

Introduction

The main purpose of this chapter is to test and also evaluate the automated tomato paste machine. The evaluation of the system will be done in order to find out if the users' requirements are met or not. To find out if the users expectations matches the system's structure, the usability and functionality of the automated tomato paste machine will have to be examined. In this chapter, various strategies, methodologies and results will be elaborated.

Machine Testing Results

The primary purpose of a testing machine is to evaluate the mechanical properties of materials by applying controlled forces and measuring their responses. This process is crucial for ensuring that materials meet the required standards of strength, durability and safety in various applications of tomato paste machine.

Testing machine is essential in industries such as manufacturing, construction, aerospace, and research, where the performance of materials can significantly impact the safety and reliability of products. They provide valuable date that helps engineers, and designers and manufacturers make informed decisions about material.

Material testing is used to determine the physical and mechanical properties of substances, such as raw materials and components, under various conditions. It is widely used in quality control in industries involved with materials, such as machinery or automotive, infrastructure, electronics, food, and medical products.

This content introduces the basics of universal testing machines, hereinafter simply referred to as testing machines. Testing machines can measure the strength, hardness, and fatigue.

Discussions

Automated tomato paste machines streamline the conversion of fresh tomatoes into high-quality, shelf-stable tomato paste by mechanizing and integrating key steps such as washing, sorting, crushing, heating, concentrating, sterilizing, and packaging. Automation reduces labour intensity, increases production capacity, preserves product quality, and enhances hygiene and safety standards.

Automated tomato paste machine processes encompass a fully integrated production line including washing, sorting, crushing, heating, concentrating, sterilizing, and aseptic packaging. The use of PLC controls, sensors, and programmable timers optimize each processing stage, resulting in high-quality, consistent, and safe tomato paste with improved efficiency, reduced labour, and energy savings. These systems are essential for modern agri-food industries aiming to scale production, maintain quality, and meet market demands.

Packaging and Product Customization

Convenient Packaging Solutions Automated filling with aseptic technology offers packaging formats like sachets, stand-up pouches, drums, and bag in box, catering to retail and industrial clients with portion control. Customized Tomato Paste Blends Sophisticated blending machinery produces tailor made products infused with herbs, spices, or organic inputs, matching evolving consumer preferences.

Summary of the Chapter

The summary of this chapter evaluation of the system will be done in order to find out if the users' requirements are met or not. To find out if the users expectations matches the system's structure, the usability and functionality of the automated tomato paste machine will have to be examined.

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Modular and Upgradable Plant Designs Machinery with modular architecture allows easier expansion or technology upgrades, maximizing operational flexibility and reducing maintenance time.

Customized Tomato Paste Blends Sophisticated blending machinery produces tailor made products infused with herbs, spices, or organic inputs, matching evolving consumer preferences.

5. Conclusion and Recommendations

Introductions

This chapter will be analysing all the chapters of this report and then summarize it by outlining the difficulties that was faced when developing the system. Finally, the future application will be describing features that could be added to improve the project.

The growing need for water and energy, coupled with the limited availability of freshwater and fossil fuels, the alarming climate fluctuations, and environmental concerns, urgently demand for efficient resource utilization and the adoption of sustainable and optimized industrial practices. Industries of the food and beverage sector are among the most energy-intensive industries that use huge amounts of fresh water for various processes (Islam and Karim, 2020). According to the United Nations, globally about 72% of water resources are used for agriculture and irrigation, 16% is consumed by municipalities, and 12% goes to ward industrial uses (UN-Water, 2021), with 56% of it being consumed by the food and beverages industry (Bhatt *et al*., 2022) [10]. Among them, the most water-intensive sectors include soft drinks and bottled water, dairy products, brewing, wine and spirits, as well as meat and fruits and vegetable processing.

Conclusion of the Product

Looking at the world in our days, Internet Technology has played a very important role in various aspects such as Marketing, Business, Banking and many more. Internet Technology has helped people in building web application. A good example is the automated tomato paste machine. The first step of this project was to design a prototype that is connected to the internet to facilitate users to make use of the system. Step two of this project was to make a website to allow the designing prototype to communicate with the website of this mechanism system. Many technologies were used to help design the mechanism system. The project has been implemented in different stages such as Literature

Review, User Requirements, Design and implementation, System Evaluation, System Maintenance. The expectation of this research is to show some ways in which automated tomato paste machine may help improve the life style of many farms owners and also save their time while needing a machine around a certain area such as rural areas, or any way around. Although all the objectives and requirements were met, some of the objectives still need to be implemented in the future so that the project could be more efficient and work effectively.

Conclusions on the Results

The food and beverage industrial sector plays a significant role in energy consumption and global water footprints, leading to substantial environmental impact. Among these industries, tomato processing stands out as one of the most resource-intensive, consuming large amounts of water and energy both thermal and electrical while generating substantial solid and liquid wastes. This review paper introduces a systematic approach based on Water Energy Nexus analysis, which serves to pinpoint the production process stages with the highest water and energy demands, thereby highlighting areas of inefficiency.

This framework empowers decision makers to implement customized strategies aimed at enhancing both efficiency and sustainability in tomato processing. By applying this approach, numerous key opportunities for efficiency enhancements have been identified. The majority of water usage is concentrated in the initial pre-processing steps, primarily during tomato washing and conveying into the facility. Additionally, a significant portion of the total water is consumed as steam in thermal processes and cooling operations. It is imperative to focus on implementing water conservation measures, especially in a closed-loop system during the initial stages, as well as exploring the potential for reusing steam condensate.

Important for Advanced Technologies

This is especially important for advanced technologies, as their integration into tomato processing lines requires a thorough assessment of their water and energy-saving potential at an industrial scale. Moreover, there are several technological challenges that must be addressed to enable their implementation on a larger scale. These challenges encompass up scaling as well as the need to improve equipment design, optimize process parameters, and manage the significant initial investment costs. Additionally, the seasonal nature of tomato production could be a further obstacle to their spread. The approach discussed in this review, specifically tailored to the tomato processing industry, can serve as a model for addressing similar challenges in other water and energy-intensive sectors within the food industry. Nevertheless, regardless of the specific food sector, implementing alternative practices and technologies necessitates a rigorous comparison with initial baseline levels of water and energy consumption at the key processing stages to quantify improvements effectively. In this regard, the accurate collection of data regarding water and energy flow is of utmost importance. Achieving this may involve the installation of sensors and monitoring systems, as well as the utilization of process simulation tools to precisely solve water mass balances and estimate flow rates. These measures can significantly assist facilities in enhancing their resource consumption efficiency.

Recommendations

Lack of a workshop is one of the biggest barriers to students projects in engineering and technical programs.

The other challenges were power most of the time there is no power, that's why the project was delayed.

Also the institution must start the project in the first semester so the student have enough time to research and go through all the stages.

The school should build a workshop for safe and genuine project because very few students who make majority they buy, which is not good for Academic Excellency.

Financial it was a challenge during the production of the automated tomato paste machine; I suggest the school if they can help buying components like motor, stainless steel and square tubes.

Future Works

Here are some exciting **future developments** and trends in tomato paste machine technologies that are shaping the industry:

Smart manufacturing AI-driven systems can be introduced for predictive maintenance, real-time monitoring, and optimizing processing conditions.

Robotics robotic arms are automating sorting, peeling, and packaging, improving speed and reducing labour costs of the machine.

Sustainability Innovations

Water recycling advanced water treatment systems is reducing water usage and environmental impact. **Renewable Energy** Solar, wind, and biomass energy sources are being adapted to power processing plants sustainably. **Zero-waste practices** tomato skins, seeds, and pulp is being repurposed into dietary fibres, animal feed, and biofuels.

Automation and AI Integration

Smart manufacturing AI-driven systems are being used for predictive maintenance, real-time monitoring, and optimizing processing conditions.

Robotics robotic arms are automating sorting, peeling, and packaging, improving speed and reducing labour costs.

Advanced Extraction and Concentration

Cold extraction preserves nutrients and flavour better than traditional heat-based methods.

Membrane filtration offers high-quality paste with minimal energy use.

Reverse osmosis and vacuum evaporation energy-efficient concentration techniques that maintain product integrity.

Packing Machine Innovations

Hygienic design machines now feature stainless steel construction and automatic sanitization to ensure food safety. **Eco-friendly packaging** support for biodegradable films, recyclable plastics, and paperboard containers. **Flexible machines** modular systems allow quick changes for different container sizes.

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Data and Connectivity

Integration sensors collect real-time data on performance, quality, and inventory. **Smart interfaces** touchscreens and remote access simplify operation and training. **Predictive analytics** helps forecast maintenance needs and optimize production schedules.

Design and Engineering Focus

User-cantered design future machines are being built with easier cleaning, intuitive controls, and ergonomic layouts. **Prototyping and testing** manufacturers are investing in heat-resistant, efficient, and scalable machine components. **Cross-disciplinary teams** engineers, food scientists, and designers collaborate to build smarter systems.

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