

Smart Automated Onion Skin Peeling Machine Using Parallel Roller Mechanism

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Abstract— The Smart Automated Onion Skin Peeling Machine is designed to reduce manual labor and improve peeling efficiency using a parallel roller mechanism driven by 12V DC geared motors. Onion presence is detected using an IR Proximity Sensor, while operating conditions are monitored using a DHT11 Temperature and Humidity Sensor to ensure stable performance. An HX711 Load Cell measures onion weight for batch control and uniform processing. Peeling completion and motor load variations are monitored using a Limit Switch and ACS712 Current Sensor, which help prevent over-peeling and mechanical damage. The system is controlled by an Arduino Uno / ESP32 microcontroller, programmed through the Arduino IDE. Operational data such as weight, motor current, and environmental parameters are transmitted to the cloud using Thing Speak for real-time monitoring and analysis. Python is used for data processing, automation logic, and performance evaluation. This system enhances peeling uniformity, improves safety, optimizes energy consumption, and provides a cost-effective smart solution for small- and medium-scale onion processing industries.

I. INTRODUCTION

The removal of outer dry skin from onions is an essential preprocessing step in food processing industries, commercial kitchens, and large-scale catering units. Manual peeling of onions is labor-intensive, time-consuming, and exposes workers to continuous irritation due to volatile sulfur compounds released during cutting and handling. In small and medium-scale processing units, dependence on manual labor reduces productivity, increases operational cost, and leads to inconsistent peeling quality and higher wastage.

Existing peeling methods such as manual knife peeling, abrasive drum peeling, or chemical treatment methods either cause excessive material loss, damage the edible portion, or require high maintenance. Chemical-based peeling is not suitable for safe food handling, and conventional abrasive

systems often lack precise control over peeling intensity. Therefore, there is a need for a safer, efficient, and automated solution that ensures uniform peeling with minimal wastage.

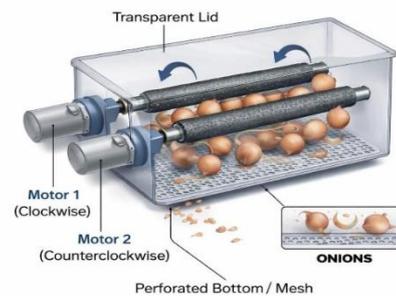


Fig.1: Illustration of Smart Automated Onion Skin Peeling Machine showing hopper feeding system, parallel counter-rotating rollers removing outer dry skin through friction, motor drive unit, and peeled onion discharge outlet.

This work focuses on the development of a Smart Automated Onion Skin Peeling Machine using a parallel roller mechanism. The system consists of a motor-driven roller assembly, a feeding hopper, a discharge outlet, and a control unit for regulating operational parameters. The rollers rotate in opposite directions to create controlled friction, enabling efficient removal of the outer skin without damaging the edible layers.

II. LITERATURE REVIEW

Singh et al. explained that onion peeling in small-scale industries is largely performed manually, leading to high labour cost, low efficiency, and inconsistent quality. Their study highlights that manual peeling causes excessive wastage of edible layers and worker discomfort due to prolonged exposure to onion fumes. The work emphasizes the need for mechanical peeling systems to improve productivity and hygiene standards.

Patel et al. presented a study on abrasive drum-based vegetable peeling machines. Their work describes the working principle of friction-based peeling using rotating drums lined with abrasive surfaces. However, the study reports that excessive abrasion may damage the edible portion and increase material loss, indicating the need for controlled peeling mechanisms.

Rao et al. discussed mechanical peeling systems using roller-based configurations for root vegetables. The research explains that counter-rotating rollers provide better surface contact and controlled friction compared to drum systems. Their findings show that parallel roller mechanisms can reduce wastage and improve peeling uniformity when rotational speed and spacing are properly controlled.

Kumar et al. reviewed automation in post-harvest vegetable processing. Their work highlights the importance of integrating motors, sensors, and microcontroller-based control units to regulate speed, pressure, and feed rate. The study emphasizes that automation improves efficiency, reduces manpower dependency, and ensures consistent output quality.

Sharma et al. examined food processing machinery design considerations including hygiene, material selection, and safety. Their research stresses that stainless steel structures, proper waste collection systems, and easy maintenance design are essential for food-grade machinery to comply with safety standards.

Ali et al. presented a smart vegetable grading and sorting system using sensor-based detection. Their work explains how intelligent control systems can improve operational accuracy and reduce processing errors. The study supports the integration of smart control features in agricultural processing equipment. Mehta et al. demonstrated the development of a small-scale automated peeling machine for commercial kitchens.

roller spacing can achieve effective peeling with minimal damage and lower power consumption.

III. DESCRIPTION OF EXISTING SYSTEM

In current small-scale and medium-scale food processing units, onion skin removal is primarily carried out using manual or semi-mechanical methods. These existing systems are simple and low-

cost but suffer from low efficiency, higher wastage, and inconsistent output quality.

Manual peeling is the most common practice in commercial kitchens, hotels, and small processing units. Workers remove the dry outer skin using knives or by hand. This method is labor-intensive, time-consuming, and exposes workers to irritation caused by onion fumes. Productivity is directly dependent on manpower, and large-scale processing becomes impractical. In addition, inconsistent peeling results in uneven surface finish and higher edible layer loss.

In industrial environments, abrasive drum peeling machines are used. These machines consist of a rotating drum lined with abrasive surfaces. Onions are tumbled inside the drum, and friction removes the outer dry skin. Although this method increases processing speed, it often leads to excessive abrasion, damaging the edible portion and increasing wastage.

Some processing units use water-assisted peeling or compressed air-based systems to loosen onion skins. These systems require additional resources such as high-water consumption or air compressors, increasing operational cost and maintenance requirements. Water-based methods also create waste disposal challenges.

Certain semi-automatic machines use single-roller or blade-assisted mechanisms. These systems may improve speed compared to manual peeling but lack precise control over roller spacing, pressure, and rotation synchronization. As a result, peeling efficiency varies depending on onion size and surface condition



Fig.2: Common market-available onion peeling methods including manual knife peeling, abrasive drum peeling machines, and small-scale semi-automatic peeling systems used in commercial kitchens and food processing units.

These machines operate using basic motor-driven rotation or cutting action to loosen and remove the outer dry skin. However, their effectiveness varies depending on onion size, surface dryness, and feed rate. Uneven contact between the peeling surface and the onion often results in incomplete peeling or excessive removal of edible layers. Moreover, these systems do not provide synchronized dual-roller action or controlled friction distribution, leading to inconsistent output quality and higher material wastage.

Overall, existing onion peeling methods depend heavily on manual labor, uncontrolled abrasion, or resource-intensive processes. Most available systems lack intelligent control, uniform friction distribution, and optimized energy usage. These limitations highlight the need for a smart automated peeling system using a controlled parallel roller mechanism to ensure uniform peeling, reduced wastage, and improved productivity.

IV. CHALLENGES IN EXISTINGSYSTEM

Existing onion peeling systems used in commercial kitchens and small-scale food processing units face several operational and efficiency challenges. Manual peeling requires continuous labor involvement and depends heavily on worker skill and consistency. Variation in peeling depth often results in excessive removal of edible layers or incomplete skin removal. Repeated manual handling also increases processing time and reduces overall productivity.

Conventional abrasive drum peeling machines operate using uncontrolled friction between the rotating drum surface and onions. Although they increase processing speed, they frequently cause higher material wastage due to over-abrasion. Peeling quality depends on drum speed, retention time, and onion size variation. Continuous mechanical impact may also damage softer onions.

Semi-automatic peeling systems based on single-roller or blade mechanisms provide limited adjustment for roller spacing and contact pressure. Uneven contact leads to inconsistent peeling performance. Smaller onions may pass without proper peeling, while larger onions may experience surface damage. These systems usually lack

synchronized motion control and adaptive adjustment.



Fig.3: Different varieties and size variations of onions showing differences in outer dry skin thickness, moisture content, and surface texture affecting peeling performance in conventional systems.

Overall, many existing onion peeling systems lack controlled friction application, energy-efficient operation, and uniform peeling mechanisms. Limitations in peeling consistency, material wastage, labor dependency, and adaptability to different onion sizes highlight the need for a smart automated onion skin peeling machine using a parallel roller mechanism with controlled speed, adjustable spacing, and optimized mechanical action to ensure uniform peeling with minimal loss.

V. BLOCK DIAGRAM

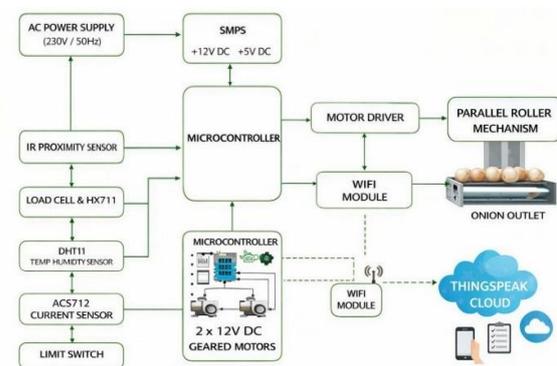


Fig.4: Block Diagram of the Proposed System

VI. FLOW CHART

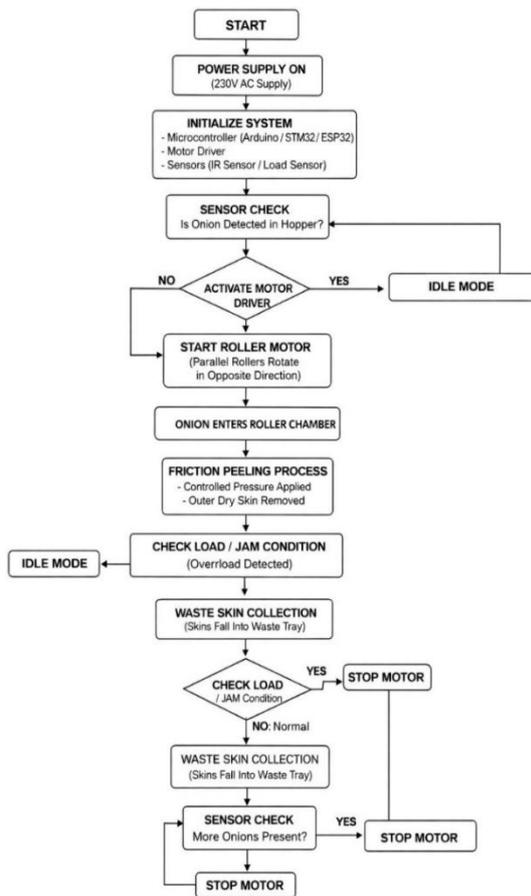


Fig.5: Flow Chart of the Proposed System

VII. HARDWARE IMPLEMENTATION

- a. DC/AC Motor: Used as the primary drive unit to rotate the parallel rollers at controlled speed for effective outer skin removal.
- b. Motor Driver: Regulates the rotational speed of the motor to maintain uniform peeling performance and prevent excessive abrasion.
- c. Parallel Roller Assembly: Consists of two or more synchronized rollers positioned in parallel alignment. The rollers create controlled friction to remove the dry outer skin without damaging the edible layers.
- d. Roller Support Frame and Bearings: Provide structural stability and smooth rotation of the rollers under continuous load conditions.
- e. Power Supply Unit (12V/24V): Converts AC mains voltage into stable DC supply for motor and control circuitry operation.
- f. Switching and Control Circuit: Includes ON/OFF control switches and protective devices

to ensure safe and isolated operation of the motor drive system.

- g. Skin Collection Unit: Removes detached onion skins from the peeling chamber to maintain cleanliness and prevent clogging.

VII. WORKING OF PROPOSED SYSTEM

The working of the proposed Smart Automated Onion Skin Peeling Machine Using Parallel Roller Mechanism is based on sensor-driven activation, controlled motor operation, and intelligent load monitoring to ensure efficient and uniform onion peeling. When the system is powered ON, the regulated DC supply energizes the microcontroller unit (LoRa SX1278 / STM32 based controller) along with all connected sensors and control modules. The controller initializes the system and continuously monitors the IR proximity sensor placed near the roller feeding section. This sensor detects the presence of an onion placed inside the peeling chamber.

During peeling, the ACS712 current sensor continuously monitors motor current consumption. When the onion skin is being removed, motor load increases due to surface resistance. As peeling completes, resistance reduces and motor current drops. The microcontroller analyzes this variation to determine the completion of the peeling process. Once the current stabilizes below the preset threshold, the controller automatically stops the motor.

After completion of peeling, the onion moves to the collection tray, while the removed dry skins fall into a separate waste tray. The system then returns to standby mode, waiting for the next onion detection cycle. By simplifying the system architecture, the machine remains cost-effective while maintaining full operational efficiency. The working principle focuses on mechanical friction-based peeling combined with intelligent load monitoring and automated motor control, ensuring uniform peeling quality, reduced manual effort, minimal wastage, and improved reliability suitable for small and medium-scale onion processing units.

IX. OPERATION OF PROPOSED SYSTEM

The operation of the proposed Smart Automated Onion Skin Peeling Machine Using Parallel Roller

Mechanism follows a controlled sequence from onion detection to automatic peeling and discharge. Initially, when the system is connected to the AC mains supply, the power supply unit converts the input voltage into regulated DC outputs required for the control and motor sections. The regulated 5V/3.3V DC line powers the microcontroller and sensor interface circuits, while the 12V DC supply is reserved for the DC geared motors driving the parallel rollers.

After initialization, the microcontroller continuously monitors the IR proximity sensor placed near the feeding section to detect the presence of an onion inside the peeling chamber. The sensed input is evaluated with the predefined control logic stored in the program. When onion presence is confirmed, the controller sends a trigger signal to the motor driver circuit

The motor driver then activates the 12V DC geared motors connected to the parallel roller assembly. The two rollers rotate in opposite directions, generating controlled friction and mild compression between their rubber-coated surfaces and the onion bulb. Due to the frictional interaction, the dry outer skin—being loosely attached—gets detached without damaging the inner edible layers. The adjustable roller gap ensures proper contact pressure for onions of varying sizes.

During the peeling process, the ACS712 current sensor continuously monitors motor current. As friction increases while removing the outer skin, motor load rises. Once the peeling is completed, resistance decreases and motor current drops. The controller analyses this variation to determine completion of the process. If excessive current is detected due to jamming or overload, the controller immediately stops the motor to prevent mechanical

X. RESULTS AND DISCUSSIONS

The developed smart automated onion skin peeling machine demonstrated effective and stable operation for controlled removal of outer dry onion skin in a continuous processing environment. The integrated roller and drive arrangement provided an automated, non-destructive peeling method using a parallel roller friction mechanism. The motor-driven roller assembly produced consistent rotational performance, enabling controlled mechanical

abrasion suitable for outer skin separation without damaging the edible layers.



Fig. 6: Developed Smart Automated Onion Skin Peeling Machine Using Parallel Roller Mechanism

The control and drive section ensured that the peeling rollers operated only under defined working conditions. The switching mechanism provided reliable isolation between the low-power control circuit and the high-current motor drive section. The power conversion stage consisting of a step-down transformer, rectifier, and filtering unit delivered stable DC supply for uninterrupted control circuit operation, while maintaining consistent motor performance.

The parallel roller mechanism exhibited steady rotational synchronization and achieved uniform peeling action within the processing chamber. The dry outer skin of the onion was removed in a controlled manner without excessive cutting, crushing, or material wastage. The optimized roller spacing and surface texture enhanced frictional interaction, enabling efficient separation of loose skin layers.

The overall system operation confirmed synchronized performance of feeding, peeling, and discharge stages with reduced manual effort. Compared to manual peeling and blade-based mechanical methods, the proposed system offers improved processing speed, consistent output quality, and safer operating conditions. Practical considerations such as roller surface material optimization, adjustable roller spacing, and improved dust extraction can further enhance field performance.



Fig.7: Working Model of the Proposed System

The overall system operation confirmed coordinated performance of sensing, control, induction heating and vapor delivery stages with reduced need for manual intervention. Compared to coil-based smoke methods and repeated chemical spraying, the system supports controlled vapor generation and safer operating conditions. Minor practical considerations such as enclosure sealing, airflow direction and chamber insulation can further improve field performance. The obtained operational results validate the suitability of the system for sustainable livestock insect protection applications.

XI. CONCLUSIONS

A smart automated onion skin peeling machine based on a parallel roller mechanism has been designed and implemented for small- and medium-scale onion processing applications. The system replaces manual peeling and blade-based cutting methods with a controlled mechanical friction approach using synchronized parallel rollers. This mechanism enables efficient removal of the outer dry onion skin while minimizing damage to the edible portion.

The motor-driven roller assembly ensures uniform rotational motion and consistent peeling performance. The power supply and control arrangement provide stable operation of the drive system and support continuous processing. Proper isolation between the control section and motor drive stage enhances operational safety and reliability.

The optimized roller spacing and surface characteristics facilitate effective outer layer separation through controlled abrasion rather than cutting. The integrated airflow arrangement assists in

the removal of detached onion skins from the peeling chamber, maintaining cleanliness and preventing accumulation within the system.

The coordinated functioning of feeding, peeling, and discharge stages supports automated operation with reduced manual intervention and improved processing speed. Compared to traditional hand peeling methods, the developed machine offers better productivity, uniform output quality, and safer working conditions.

The system demonstrates functional suitability for agricultural post-harvest processing applications. Further large-scale testing, roller material optimization, and long-duration performance evaluation can enhance durability, efficiency, and adaptability under varying onion sizes and moisture conditions.

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