Design & Development of a Lead Screw Driven Mechanism for Making Blanched Fenugreek (Methi) Cubes

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***Abstract*—Processing of Blanched Fenugreek (Methi) Leaves in Small-Scale Food Industries Is Mainly Performed Manually, Which Often Results in Inconsistent Cube Size, Higher Labor Effort, Hygiene Issues, And Lower Productivity. To Address These Challenges, This Project Focuses on the Design and Development of a Lead Screw–Driven Mechanism for Making Blanched Fenugreek (Methi) Cubes for the Controlled Pressing and Formation of Blanched Methi Cubes. The Proposed System Converts Rotary Motion into Linear Motion Using a Lead Screw Mechanism, Allowing Uniform Compression and Consistent Cube Formation While Minimizing Manual Intervention. The Design Prioritizes Simplicity, Reliability, And Cost-Effectiveness, Making It Suitable for Small-Scale Food Processing Applications. A Functional Prototype Was Developed Based on Appropriate Material Selection, Load Estimation, And Fundamental Mechanical Design Principles. The Results Demonstrate Improved Dimensional Accuracy of Cubes, Enhanced Process Consistency, Reduced Operator Fatigue, And Increased Productivity. Overall, The Developed Mechanism Offers a Practical and Economical Solution That Improves Hygiene, Efficiency, And Product Uniformity, While Supporting Scalable Operations in Small-Scale Food Processing Industries.**

I. INTRODUCTION

The Processing of Fenugreek (Methi) Leaves in Frozen Food Industries Involves Several Stages from Cutting to Final Packing. Although Certain Equipment Such as Choppers and Blower Units Are Used for Initial Processing, Many Operations Still Depend on Manual Handling. After Washing and Blanching At 85–90 °C Followed by Rapid Cooling, The Blanched Fenugreek Leaves Are Manually Filled into Rubber Moulds by Hand. This Manual Filling Process Often Produces Uneven Cube Sizes and Irregular Shapes Due To Non-Uniform Filling of the Moulds. In Addition, Direct Hand Contact with The Product Creates Hygiene Concerns and May Affect the Cleanliness of The Final Food Product. The Dependence on Manual Labor Also Leads to Variations in Production Rate and Causes Operator Fatigue During Continuous Operation. Furthermore, After Freezing At −18 °C, The Cubes Are Removed from The Moulds and Packed Manually, Which Increases Cycle Time and May Result in Inconsistent Product Quality. Among These Issues, Manual Cube Filling Is Identified as The Most Critical Bottleneck Because It Directly Affects Dimensional Accuracy, Hygiene, And Overall Productivity. To Overcome These Limitations, The Design and Development of a Lead Screw Driven Mechanism for Making Blanched Fenugreek (Methi) Cubes Is Proposed. The Mechanism Converts Rotary Motion into Controlled Linear Motion to Enable Continuous and Uniform Feeding of Blanched Fenugreek into The Mould. This Approach Helps Achieve Even Cube Size with Improved Dimensional Accuracy, Reduces Manual Involvement, Improves Hygiene Standards, Minimizes Operator Fatigue, And Enhances Labour Efficiency. The Proposed System Is Designed To Be Simple, Reliable, And Cost-Effective, Making It Suitable for Small- To Medium-Scale Food Processing Applications While Improving Productivity and Process Consistency.

II. LITERATURE REVIEW

The literature review covers studies on screw feeding, extrusion, die design, and cutting mechanisms used in material and food processing. Existing research mainly focuses on dry or granular materials, with

limited work on soft, blanched leafy vegetables, highlighting the need for an integrated mechanized cube-forming system.

A. Fadeyibi, Z. Z. Osunde, G. Agidi, E. C. Egwim et al. [1] presented a detailed study on the design of a single screw extruder for homogenizing bulk solids. Their work focused on analytical modelling of hopper dimensions, screw geometry, barrel volume, and material throughput to achieve stable feeding and uniform extrusion performance. The study also highlighted that optimized screw geometry improves material mixing and flow uniformity, supporting continuous operation of screw-based feeding systems.

David Mills et al.[2] examined screw feeder systems used in biomass feeding for thermochemical reactors. The study analysed the effects of screw pitch, rotational speed, hopper design, and material properties on feeding behaviour, with special attention to flow instability issues. The authors reported that improper feeder design causes jamming and inconsistent discharge, emphasizing the importance of proper hopper–screw integration for stable material feeding.

Pranav Niturkar, Sanket Kedar, Mangesh Saraf, Pratik Badhan et al. [3] developed an auger-type feed screw and casing system for food extrusion applications. Their research addressed continuous feeding, material compression, and flow stability through optimized screw and casing design. The results showed uniform output during pressing, while indicating that moisture content significantly affects material flow in soft food materials.

V. Jagadeesh, M. Rama Narasimha Reddy et al. [4] analysed square-section extrusion using non-linear converging die profiles through finite element modelling and experimental validation. The research focused on material flow behaviour and extrusion force requirements, demonstrating that non-linear die profiles reduce extrusion load and improve flow uniformity for consistent square-shaped products.

Shyam Darewar et al. [5] presented the design and development of an automated laddu making machine aimed at reducing manual labour while improving hygiene and production efficiency. The system integrates feeding, cutting, and shaping mechanisms driven by a screw conveyor to produce uniform laddus. Their study showed improved productivity, consistent laddu size, and reduced human effort, making the system suitable for small-scale food industries.

Siddhi Kamat et al. [6] developed an automatic mechanical cutter using a crank and slotted lever mechanism to minimize human involvement in cutting operations. The fabricated prototype demonstrated continuous cutting through mechanical linkages, offering faster processing with simple construction and economical operation for agricultural and small industrial applications. Karan Sathe, Mayuri Bokade, Priyanka Gaikwad, Vaibhavi Phad et al. [7] designed and fabricated an automatic pipe feeding and cutting machine using crank and slotted lever mechanisms. Their study demonstrated repetitive cutting motion using mechanical linkages without complex control systems, providing an economical automation solution with consistent cutting performance for size-controlled material processing.

Dr. Bhuvaneswari M et al. [8] designed and fabricated an automatic laddu shaper machine for cottage and small-scale industries using CAD modeling and prototype testing. The machine produced uniform laddus with reduced processing time, labor, and material wastage, highlighting the effectiveness of automation in food processing systems.

Vasyl Vasylkiv, Dmytro Radyk, Mykola Stashkiv, Larysa Danylchenko et al. [9] evaluated the influence of loading zone geometry on torque requirements in screw feeders using experimental methods and DEM simulations. The findings indicated that improper loading creates dead zones, increasing torque and energy consumption, whereas optimized feeder geometry enhances efficiency and operational stability. Peng Chen, Tianci Huang, Bei Wu, Huaiyuan Qian, Fangping Xie, Baohua Liu, Dawei Liu, Xu Li et al. [10] developed a discharge-rate model by studying hopper–screw conveyor interaction using response surface methodology and validation experiments. The study confirmed that hopper geometry strongly affects discharge stability and filling coefficient, highlighting the importance of integrated hopper–screw design for consistent material flow.

III. PROBLEM STATEMENT AND DESCRIPTION

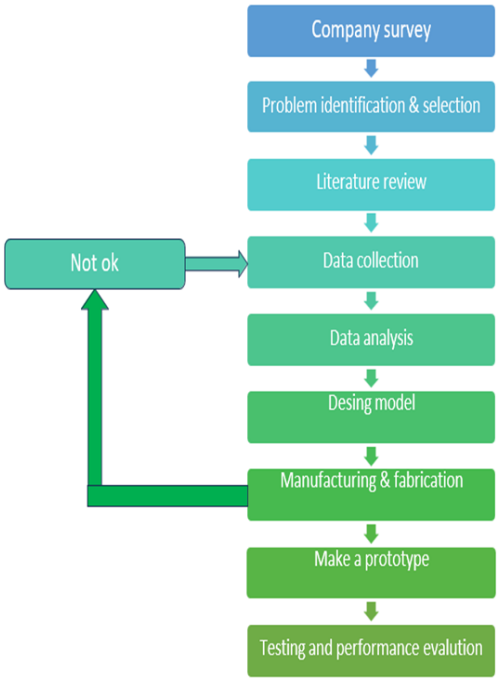
Problem Statement – “Design & Development of a Lead Screw Driven Mechanism for Making Blanched Fenugreek (Methi) Cubes. Manual Filling of Blanched Fenugreek (Methi) Leaves into Rubber Moulds

Produces Uneven Cube Sizes, Hygiene Concerns, And Higher Labour Effort. This Study Focuses on the Design and Development of a Lead Screw Driven Mechanism to Achieve Uniform Cube Formation, Improve Process Hygiene, And Increase Production Efficiency While Reducing Operator Fatigue.

Fig 1: Manual Filling Fenugreek (Methi) In Mould

Problem description - High Manual Dependency Exists in Several Stages of Fenugreek (Methi) Processing Such as Stem Removal, Cube Filling, And Packing, Which Leads to Uneven Cube Sizes, Hygiene Concerns, And Production Output That Varies According to Worker Performance. Manual Filling of Blanched Fenugreek into Rubber Moulds and Manual Removal of Cubes After Freezing Increase Cycle Time and Cause Operator Fatigue, Resulting in Reduced Process Efficiency and Lower Productivity. In Addition, Variations in Cube Dimensions, Shape, And Packing Accuracy Affect Product Standardization and Quality Consistency. The Continuous Dependence on Manual Labour Also Increases Operational Effort and Limits Production Capacity in Small-Scale Processing Units. Therefore, There Is a Need for A Mechanized Solution Such as a Lead Screw Driven Mechanism to Achieve Uniform Cube Formation, Reduce Human Involvement, Maintain Better Hygiene, And Improve Overall Process Efficiency and Productivity.

IV. METHODOLOGY



V. DESIGN AND CALCULATION

Lead screw calculation:
Diameter Of Screw (D) = 245 mm
Pitch Of Screw (P) = 100 mm
Length Of Screw (L) = 400 mm
For A Single Start Screw,
Lead = Pitch
Lead = 100 mm
Number Of Turns Required for Full Travel

$$\text{Number Of Turns} = \frac{\text{Length}}{\text{Lead}}$$

$$\text{Number Of Turns} = \frac{400}{100}$$

$$\text{Number Of Turns} = 4$$

So, 4 Rotations of the Screw Will Move the Pressing Plate By 400 mm.
Helix Angle

$$\tan\alpha = \frac{\text{Lead}}{\pi D}$$

$$\tan\alpha = \frac{100}{3.14 \times 245}$$

$$\tan\alpha = \frac{100}{769.3}$$

$$\tan\alpha = 0.13$$

$$\alpha = 7.4^{\circ}$$

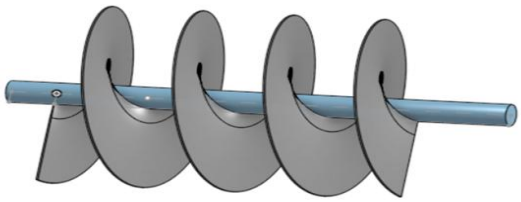


Fig 2 Lead Screw Design

Barrel Dimension:
Diameter of barrel :250 mm
Outer Dia.:250mm
Inner Dia.:247mm
Thickness of Plate :3mm

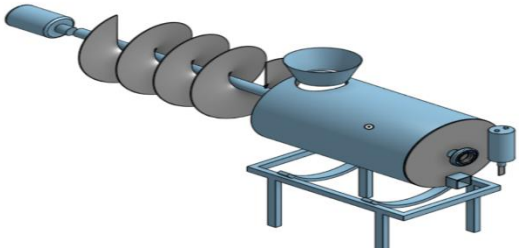


Fig 3 Cad Model of Machine

VI. RESULT & DISCUSSION

The performance of the methi (fenugreek) cube making machine was evaluated through simulation-based analysis due to the incomplete availability of drive components.

The simulation results demonstrated that the lead screw mechanism effectively conveyed and compressed the blanched methi material within the barrel, enabling continuous and stable extrusion through the square die. The actuator-assisted cutting mechanism showed proper synchronization with the extrusion process, resulting in uniform cube-shaped output. The analysis indicates that the proposed machine is capable of producing consistent cube dimensions with an improved production rate compared to conventional manual methods. The controlled extrusion process also contributes to better material handling, reduced wastage, and improved hygiene conditions while minimizing labour dependency and operational cost.

However, experimental validation of the system could not be carried out because the gearbox and actuator were unavailable during the project period; therefore, the presented results are based on theoretical calculations and simulation outcomes. Variations in actual performance may occur under practical operating conditions due to factors such as material moisture content, machine alignment, and process parameters.

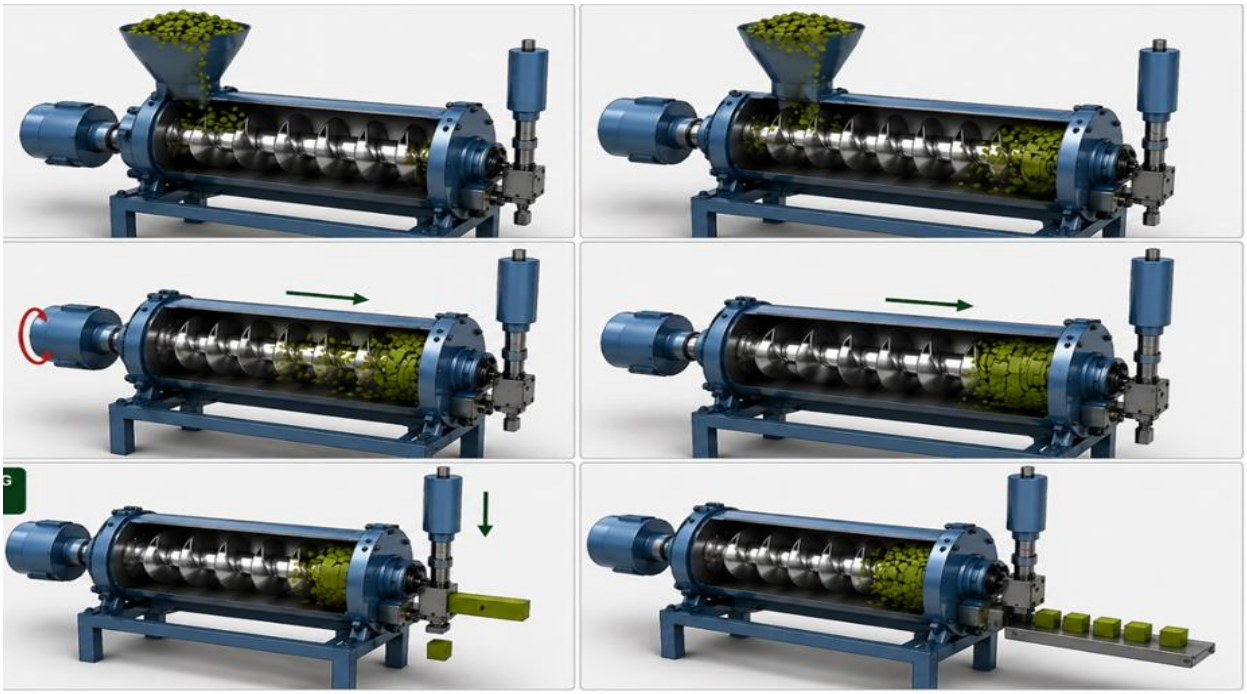


Fig 4 Process of Making Fenugreek Cube

VII. CONCLUSION

This research presents the design and development of a lead screw–driven mechanism for producing blanched fenugreek (methi) cubes with improved consistency and reduced manual intervention. The major components, including the barrel, lead screw, hopper, and support frame, were designed using standard engineering calculations and partially fabricated, while the operating principle based on screw extrusion and actuator-assisted cutting was established and verified through simulation. Due to the unavailability of a suitable gearbox and actuator within the project duration, complete assembly and experimental validation could not be carried out; therefore, performance parameters such as production rate, efficiency, and cube quality could not be experimentally evaluated. However, simulation results demonstrated the feasibility of continuous material flow, effective compression, and uniform cube formation. The proposed system is technically suitable for small-scale food processing applications, offering benefits such as improved hygiene, reduced labour dependency, and consistent product quality. This work also provides a strong foundation for future development involving full system integration, experimental testing, and optimization of operating parameters to enhance overall performance and reliability.

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