A Single-Feed 3-in-1 Cinnamon Processing Machine

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I. INTRODUCTION

Cinnamon holds global recognition as a necessary spice and a vital food ingredient. Apart from being highly regarded as a spice, it shines in areas such as medicine, as a powerful agent against cancers, heart diseases, and diabetes [1], [2]. Various cinnamon breeds exist worldwide. True Cinnamon, native to Sri Lanka and commonly known as Ceylon Cinnamon, is renowned for its superior taste, aroma, and quality. It contains significantly less coumarin, a potentially harmful substance when compared to alternatives such as Cassia cinnamon [3], [4]. Cinnamon trees yield various extractants, including cinnamon oil from leaves. The most sought-after extract is obtained from the inner bark, which is the primary focus of this project. The cinnamon industry exhibits remarkable resilience and growth, continuing strong export performance during the pandemic. While it faces fierce competition from Chinese Cassia in terms of quantity, Ceylon cinnamon remains unrivalled in quality.

Cinnamon extraction is a labour-intensive process cantered around harvesting the prized inner bark of cinnamon stems. Skilled workers are pivotal for ensuring product quality and process efficiency. High labor costs and the need for specialized skills in cinnamon processing pose significant challenges, leading to demotivation among planters and exacerbating the labor shortage issue.

In addressing above gaps, this research aims to design and develop an automated machine for cinnamon processing that includes the functions: scraping, rubbing, and peeling in a single feed, as a solution for the high demand of skilled laborers, with high efficiency and acceptable quality output.

II. LITERATURE REVIEW

The background study for this research started with a thorough analysis of the cinnamon peeling process followed by previous mechanization attempts related to this industry, and other related industries.

A. Traditional Cinnamon Harvesting Process

The process begins with harvesting cinnamon sticks, removing knots and leaves, and soaking the stems to facilitate later stages (see Fig.1). These later stages involve scraping to delicately remove the outer layer, rubbing with a brass rod to ease inner bark removal, and meticulous peeling with a stainless-steel knife tool. These initial steps form the basis for further processing tailored to specific cinnamon product outputs.

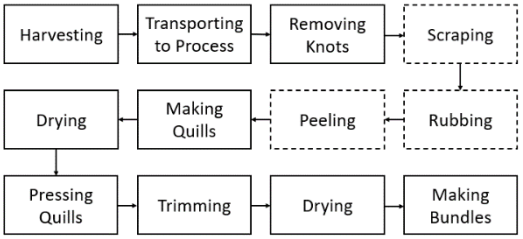

Fig.1. Steps of Traditional Cinnamon Processing

B. Previous Mechanization Attempts

This phase involved studying the previous attempts to mechanize the process. The identified design limitations are as follows:

- Mostly dedicated to accomplishing one singular task of harvesting process (scraping, rubbing, or peeling).
- Cinnamon stems do not have uniform shapes and different cross sections. These approaches mostly fail to address these factors.
- Not being developed up to an industrial performance level.
- Insufficient efficiency.
- Still requires skilled labor for a certain extent.

C. Mechanization Attempts of Similar Industries

In cassava peeling, sugar cane peeling, and timber debarking industries, similar forms of mechanization approaches could be seen. These studies gave insights into the concept development stage presented in this paper.

III. MATERIALS AND METHODS.

The following sections outline the research methodology.

- Literature Review and Field Visits:
  A comprehensive literature review was carried out to study the industry, previous attempts, and similar industries. A field visit was arranged to the National Cinnamon Research and Training Centre to explore and get hands-on experience in manual processing methods.

- Design Conceptualization:
  Various mechanisms and approaches were developed using for key processing stages.
- Morphological Analysis:
  . Morphological analysis is used to select mechanisms for conceptual design and in the subsequent process of choosing the final concept.
- Prototype Testing:
  Three individual sub-assemblies will undergo refinement to achieve their specific functionalities within the machine. The overall performance of the machine will be evaluated by measuring the purity of the chips it produces.

A full-scale functional prototype was built using stainless steel, box bars, nylon, and guitar strings. NEMA 23 stepper motors ensured precise operation.

IV. Results and Discussion

The developed mechanisms are shown in Fig.**2**, Fig.**3** and Fig.6. These were designed as modules to be assembled into a tall structure as shown in Fig.7 which is the CAD model of the complete assembly. The fully assembled mechanism is designed to process three steps, scraping, rubbing, and peeling in a single pass which is the novel concept presented in this research as the 'Single feed 3-in-1 mechanism'.

Scraping results were generally positive, with minimal inner bark damage, improved processing time with a sufficient quality output. Handling of non-uniform stems, however, has caused occasional inner bark damage. Further, issues with knots and stem diameters below 30 mm and above 45 mm were observed. The peeling mechanism displayed moderate control but caused some inner bark damage and had challenges related to resistance torque due to burrs, jerky motion, and issues with wire tangling. Effective peeling was limited to diameters between 30 mm and 45 mm. Fig.4 and Fig.5 shows the sample output of the mechanisms developed.

In traditional cinnamon processing, quill-shaped products of varying grades are the norm. However, the machine produces chips, which may contain unwanted elements such as outer bark and stem pieces. Since it is difficult to compare the machine-produced output with the quills produced in the manual method, the output quality is evaluated by measuring the weight of inner bark chips within 1 kg output.

Fig.2. Scraping Mechanism

Fig.3. Peeling Mechanism

Fig.4. Scraping Results

Fig.5. Peeling Results

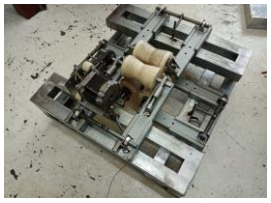

Fig.6. Rubbing/Transferring Mechanism

Fig.**7**. 3D Model of the Complete Assembly

Manufacturing and assembly complexities posed challenges, affecting component fitting and causing changes in shapes and dimensions. Burr on components impacted plate movements, and high spring tensions contributed to inner bark damage.

V. Conclusion

In conclusion, this project aimed to develop a single machine for scraping, rubbing, and peeling operations in cinnamon processing. The manual methods of three sub-processes were studied thoroughly through literature and field visits. It helped to identify issues and drawbacks in those processes. Thereafter, individual mechanisms were developed for scraping, rubbing/transferring, and peeling. These mechanisms were modeled using CAD package. Morphological analyses were carried out to select the most suitable mechanisms. Similarly, the most suitable design was selected. The prototype is developed in three segments, and it will be used to validate the concept. The objectives 1 and 2 have been achieved and further research is directed towards achieving Objective 3, which with the prototype testing stage.

The developed mechanism can only handle one cinnamon stick at a time. As further research, this design can be extended to handle multiple sticks (a bulk of cinnamon) at the same time, to increase productivity, and to accommodate a wider range of cinnamon stem diameters.

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References

[1] "Cinnamon | Plant, Spice, History, & Uses | Britannica." Accessed: Jan. 15, 2023. [Online]. Available: https://www.britannica.com/plant/cinnamon

[2] "On barks of Cinnamomomum zeylanicum Nees," Int. J. Res. Pharm. Pharm. Sci..

[3] K. Abraham, F. Wöhrlin, O. Lindtner, G. Heinemeyer, and A. Lampen, "Toxicology and risk assessment of coumarin: Focus on human data," Mol. Nutr. Food Res., vol. 54, no. 2, pp. 228–239, Feb. 2010, doi: 10.1002/mnfr.200900281.

[4] B. G. Lake, "Coumarin Metabolism, Toxicity and Carcinogenicity: Relevance for Human Risk Assessment," Food and Chemical Toxicology, vol. 37, no. 4, pp. 423–453, Apr. 1999, doi: 10.1016/S0278-6915(99)00010-1