Design and Development of Banana Pseudostem Cutting cum Cleaning Machine

Akalya B S
Department of Food Processing and Preservation Technology,
Avinashilingam Institute for Home Science and Higher Education for Women,
Coimbatore.
20003uef06@avinuty.ac.in

Melvina A
Department of Food Processing and Preservation Technology,
Avinashilingam Institute for Home Science and Higher Education for Women,
Coimbatore.
20059uef25@avinuty.ac.in

Dr. k. Pooja
Assistant Professor,
Department of Food Processing and Preservation Technology,
Avinashilingam Institute for Home Science and Higher Education for Women,
Coimbatore.
Pooja_fppt@avinuty.ac.in

Abstract
Banana (Musa sp.) is the most grown horticultural fruit worldwide and in India. The share of banana production and average yield of bananas in India is about 29% of the world and around 60 tons per hectare. Banana pseudostems (Musa X paradisiac) have diverse applications worldwide. They're high in dietary fiber and utilized for making textiles, paper, and handicrafts due to their fibrous nature. The process of manually removing fibers from the banana pseudo-stem can be time-consuming and labor-intensive. Developing and optimizing a low-cost banana pseudostem processor for domestic use stands at the frontier of innovation, combining technology and sustainability to address a significant challenge in waste management. This comprehensive exploration will delve into the intricacies of this groundbreaking development, the challenges it seeks to overcome, the technological components involved, optimization strategies, its impact on households and the environment, and the broader implications for a sustainable future.

Keywords: *Banana, Banana Pseudostem, Dietary fiber, Pseudostem processor, Sustainable future.*

1. Introduction:

Banana pseudostem (Musa X paradiza) has many applications in the world. In agriculture, they are used as organic mulch or animal feed. In addition, some cultures use pseudostems for cooking or medicinal purposes for their nutritional value [1]. Banana pseudostem consists of three main parts namely the central core (10-15%), banana fiber (1.5-2%), and residual material after extraction of banana fiber (80-85%) containing juice (35- 40%) and scutcher (40-45%). Nutritional composition such as composed of protein (2.5), fat (1.7), free sugar (3.4), soluble dietary fiber (1.4), insoluble dietary fiber (27.4), starch (27.3), ash (0.3), and moisture (15.1). Mineral comprises Sodium (444.1) Potassium (944.1) Calcium (1335.3) Magnesium (255.0) Phosphorus (137.8) Iron (3.3) Zinc (8.1) Manganese (1.3) [2].

Figure 1.1 - Banana pseudo stem

(Source 1 https://plantwiseplusknowledgebank.org/doi/10.1079/pwkb.20147801392)

Automation was all the rage in technology in the late 1990s. Automation is used in many industries today, including manufacturing and food processing. Home applications are also designed with common people in mind in such a situation. The earlier manual processes are gradually becoming semi-automatic and automated. Banana pseudostem, also known as banana stem, is a fibrous waste product produced during banana cultivation [3].

It is usually discarded or burned but has potential value as a source of fiber and other materials. The goal of this project is to design and manufacture a home helper that can automatically cut and clean banana pseudostems, making them more readily available for processing and use. The home assistant is made using a combination of traditional and advanced manufacturing techniques. The cutting unit is made with disk shredders [4].

Banana pseudostem could be used in food more than in other industries. environment and increase its economic value. This study focused on the effective use of banana pseudostem by chopping and cleaning methods to obtain a high-quality fibrous pseudostem product for commercial use regarding nutritional composition and physicochemical properties of fiber components [5].

Developing and optimizing an affordable banana pseudo-vapor processor for home use is a groundbreaking innovation where technology and sustainability work together to solve a major waste management problem. This comprehensive review examines the complexity of this pioneering development, going back to its early stages, the challenges it aims to overcome, the technological components involved, optimization strategies, its impact on homes and the environment, and the wider implications of a sustainable future [6].

2. Materials:

2.1. Handler:

A food handler, also known as a food pusher, is a kitchen tool used to safely push food items, particularly vegetables or fruits into appliances like food processors or blenders. It helps keep your hands safe while ensuring that the food is properly processed or sliced. It is made of hard plastic; it's designed to fit into the feed tube or chute of the appliance to facilitate safe and efficient food preparation. This helps the banana pseudostem to efficiently slide down to the cutting blade from the top [7][8].

Figure 2.1- Handler

2.2. Cutting blade:

The dicing grid for the Robot Coupe food processor is a useful accessory that helps you create uniform diced vegetables, or other ingredients quickly and efficiently. It's a great addition to various recipes that require consistent cutting sizes. This blade is a 9*9 mesh type and each cube has a 10mm size surrounding on four sides [9].

Figure 2.2- Cutting Blade

2.3. Slicer:

The "Migsa HLC300-H6 Disco Rebanador 6 mm Complementor Processor Vegetables AH-HLC300" appears to be a slicing disc (disco resonator) designed for use as an accessory with the Migsa AH-HLC300 vegetable processor [10]. This particular slicing disc seems to be intended for slicing vegetables into 6-10mm cuts. It's likely a component or attachment specifically made for the Migsa AH-HLC300 vegetable processor to help in processing banana pseudostem efficiently [11].

Figure 2.3 - Slicer Blade

2.4. AC Motor:

An AC motor in the machine rotates the cutting blade and slicer. The main components in the AC Motor are Stator, Stator Core**,** Stator Windings, Rotor, Motor Shaft, Bearings, and Enclosure. It is a 1440 RPM motor but runs around 1000 to 1200 RPM [12].

Figure 2.4: AC Motor

2.5. Stirrer:

A stirrer is a tool or device used here to agitate substances within a container or vessel. It typically features a rod-shaped or paddle-like structure that is made of stainless steel with elongated sides to remove the fibers from the pseudostem as cleaning [13].

Figure 2.5 – Stirrer

2.6. DC Motor:

The motor model is DC3.6V and the motor rotation is <22000RPM under no-load and <15000 RPM under load which helps to run the stirrer to remove the fibers [14].

3. Methodology:

FEEDING

↓

CUTTING

↓

SLICING

↓

CLEANING
(EXTRACTION OF FIBER)

3.1. Feeding:

Feeding in a machine involves loading raw banana pseudo stem into the machine's input area to initiate slicing. This step ensures a continuous supply of the product for the slicing mechanism. The pseudo stem is placed into a hopper or loading zone, where they're guided toward the cutting blades through mechanisms like conveyors, gravity, or augers. Monitoring and adjusting the feeding rate are essential for optimizing the slicer's performance. Factors such as product size, shape, and slicing speed may influence the feeding process, requiring occasional adjustments for optimal results.

Figure 3.1 - Feeding

3.2 Cutting:

The cutting operation in a machine refers to the process of transforming Sliced pseudo stems into smaller, diced pieces. Unlike slicing, which produces uniform slices, cutting involves chopping the produce into smaller, irregularly shaped chunks or cubes. Similar to slicing operations, a machine for cutting comprises a feeding mechanism, which introduces the potatoes into the machine for processing. The cutting mechanism itself can vary, often incorporating rotating blades or dicing grids. These blades or grids cut the pseudo stems as they pass through, creating the desired smaller pieces.

3.3 Slicing:

The slicing operation in a machine involves a systematic process of transforming whole pseudo stems into uniform slices of a consistent thickness. These machines are designed to streamline the slicing process, ensuring efficiency and precision in food preparation. At the core of the machine are the slicing mechanisms. These can vary in design, ranging from rotating blades to adjustable cutting grids or disks. The potatoes are guided through these blades or grids, which cut them into slices of the desired thickness. The machine often allows for adjustments to control the thickness of the slices, catering to different culinary needs.

3.4. Cleaning (Extraction of fibers):

The extraction of fibers from a chopped banana pseudo stem by a stirrer involves the process of separating the fibrous material from the pseudo stem's chopped pieces using mechanical agitation. After chopping the banana pseudo stem into smaller sections, a stirrer or agitator breaks down the cellular structure and separates the fibrous strands from the pulp or residue. Typically, the stirrer agitates the chopped pseudo-stem sections in water or another solvent within a container or vat. This agitation helps to loosen the fibers by disrupting the cell walls and freeing them from the surrounding matrix. The action of the stirrer allows the fibers to separate and float or suspend in the liquid while the denser pulp or residue settles at the bottom. Once sufficiently extracted and separated, the fibers can be further processed or collected for various purposes. These extracted fibers from banana pseudo stems are commonly used in making textiles, handicrafts, paper products, or even for certain industrial applications due to their strength and durability. The efficiency of the extraction process can vary based on factors such as the duration and intensity of stirring, the solvent used, and the quality of the pseudo-stem material. Adjusting these parameters can affect the yield and quality of the extracted fibers.

Figure 3.4 – Cleaning (Fibre extraction)

Figure 3.5 – Cleaned Pseudostem

4. Formula used:

Capacity of cutting

$$\text{Capacity} = \frac{\text{Weight of the Initial product}}{\text{Time consumed}}$$

Efficiency of cutting

$$\text{Efficiency} = \frac{\text{Weight of the cutted Sample}}{\text{Weight of the Initial Sample}} * 100$$

Capacity of extractor

$$\text{Capacity} = \frac{\text{Weight of the Initial product}}{\text{Time consumed}}$$

Efficiency of extractor

$$\text{Efficiency} = \frac{\text{Weight of extracted fibre}}{\text{Weight of the Initial product}} * 100$$

5. Results and discussion:

The working efficiency of the cutter was optimized based on the various trial studies conducted on the designed machine.

5.1. Efficiency of the sliced cuts:

Table (5.1) below gives the brief details of observations from the trial studies conducted with Banana pseudo stem and their efficiencies were calculated using the formula

$$\text{Efficiency (\%)} = \frac{\text{Weight of the cutted Sample}}{\text{Weight of the Initial Sample}} * 100 \qquad (5.1)$$

No. of. Sample	Weight of initial sample (g)	Weight of uniform pieces(g)		Weight of damaged pieces (g)		Time consumption (s)		Sliced capacity (g/s)		Sliced efficiency (%)	
		Manual	Machine	Manual	Machine	Manual	Machine	Manual	Machine	Manual	Machine
Sample1	500	446	448	54	52	1200	35	0.416	14.3	89.2	89.6
Sample2	500	439	475	61	25	1195	20	0.418	25	87.8	95
Sample3	500	450	472	50	28	1189	20	0.420	25	90	94.4

Table 5.1: Observation for Slicing Capacity and Efficiency

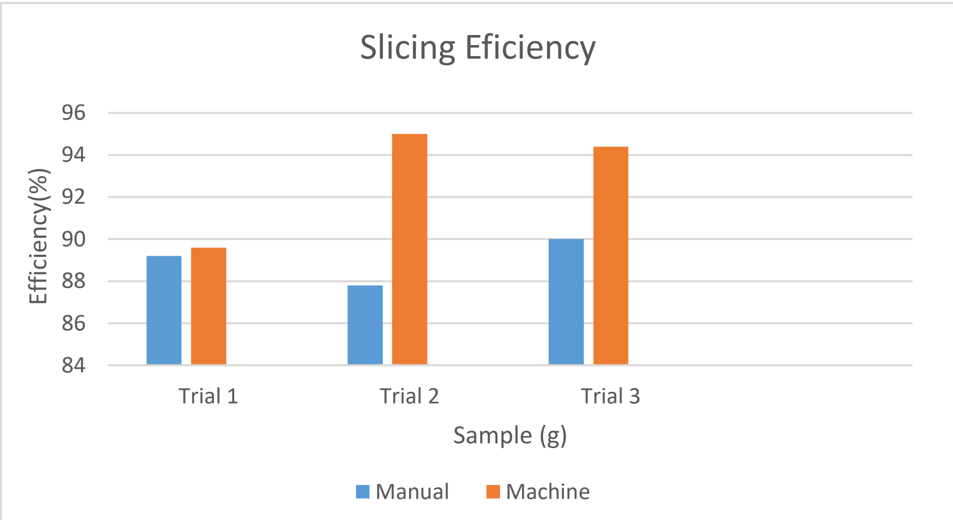

Figure 5.1: Graph for Cutting Efficiency

5.2 Capacity of the Slicer:

The cuter capacity deals with the quantity of Banana pseudo stems per second. From the various trial studies conducted with the pseudo stem. The values are tabulated in Table 5.2 cutting capacity was calculated using the formula,

$$\text{Capacity (g/s)} = \frac{\text{Weight of the Initial product}}{\text{Time consumed}} \qquad (5.2)$$

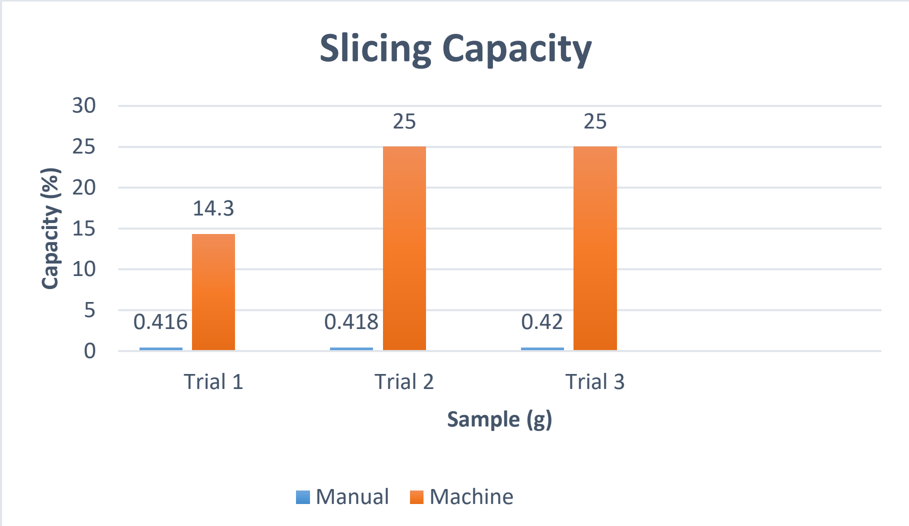

Figure 5.2: Graph for Slicing Capacity

5.3 Efficiency of the fiber extractor:

Table 5.3 below gives the brief details of observations from the trial studies conducted for the pseudostem and their fiber extractor efficiencies were calculated using the formula

$$\text{Efficiency (\%)} = \frac{\text{Weight of extracted Product}}{\text{Weight of the Initial product}} * 100 \qquad (5.3)$$

No. of. Sample	Weight of initial sample (g)	Weight of cleaned sample (g)		Weight of extracted fibers (g)		Time consumption (s)		Fibre extraction capacity(g/s)		Fibre extraction efficiency (%)	
		Manual	Machine	Manual	Machine	Manual	Machine	Manual	Machine	Manual	Machine
Sample1	500	420	399.34	77	95.89	285	195	1.75	2.56	15.4	19.17
Sample2	500	418	404.11	80	98.31	280	180	1.78	2.60	16	19.66
Sample3	500	423	401.69	82	100.66	277	192	1.80	2.77	16.4	20.13

Table 5.3: Observations for Fibre Extraction Capacity and Efficiency

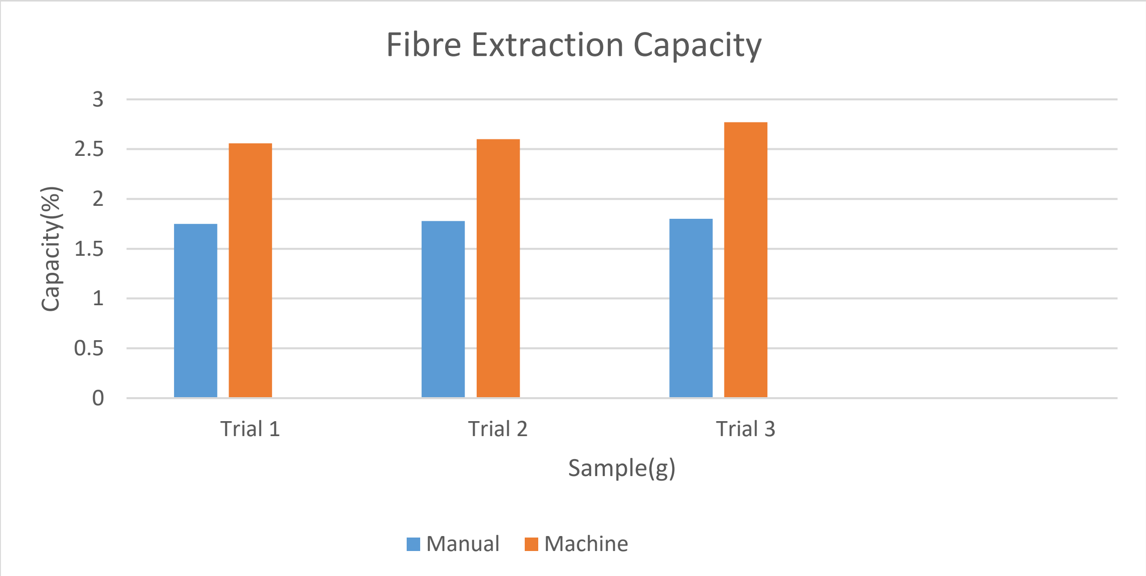

Figure 5.3: Graph for Fibre Extraction Efficiency

5.4 CAPACITY OF THE FIBFRE EXTRACTOR

The Fibre extractor capacity deals with the quantity of pseudostems that are sliced per second. From the various trial studies conducted for the pseudostem. The values are tabulated in Table 5.2 in slicing efficiency was calculated using the formula.

$$\text{Capacity (g/s)} = \frac{\text{Weight of the Initial product}}{\text{Time consumed}} \quad (5.4)$$

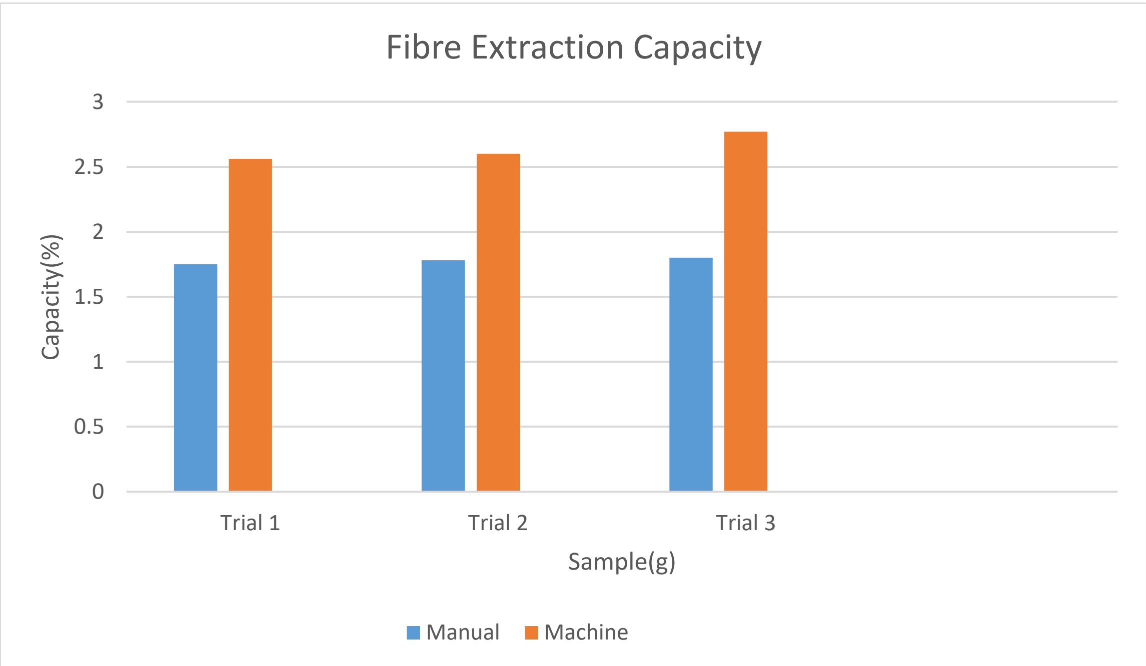

Figure 5.4: Graph for Fibre Extraction Capacity

The large industrial-based machine for cutting, slicing, and cleaning banana pseudostems typically involves separate processes for each task, which may require multiple machines and manual intervention [15]. Our one-stop solution machine streamlines the process by integrating cutting, slicing, and cleaning functions into a single efficient system, reducing labor costs and increasing productivity. It's designed to handle the entire process from start to finish, providing convenience and consistency in output.

6. Conclusion:

The domestic banana pseudostem cutting cum cleaning machine offers a tailored solution for domestic and small-scale use, prioritizing simplicity, affordability and ease of operation. It provides efficient cutting and cleaning capabilities, designed with the needs of individual users in mind. By focusing on user-friendly design, cost-effectiveness, and suitability for smaller applications, our domestic machine offers a compelling alternative tailored to the needs of individual growers. Solutions like this contribute to sustainable farming practices and improve the livelihoods of farmers around the world.

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