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Design and Construction of Manually Operated Compressing Honey Extractor (Moche)

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Abstract

The study investigated the performance of a manual compressing honey extractor for extracting honey from combs. The test evaluated the efficiency, honey recovery rate, time consumption, and ease of operation. The extractor was tested using 10 honeycomb frames, each weighing approximately 2 kg. The honey was extracted manually by applying pressure on the combs. Data collected included the volume of honey extracted, time taken for extraction, and residual honey left in the comb. The results indicated that the extractor achieved an average honey recovery efficiency of 85%, with an average extraction time of 6 minutes per frame. Factors such as the operator's effort and the comb's condition influenced the results. The manual extractor was found to be effective for small-scale honey producers, offering an affordable and straightforward alternative to mechanical extractors. However, its efficiency and labor intensiveness may limit its use for large-scale production.

Keywords: Honey, Compression, Extraction, Manual, Harvesting

Introduction

Beekeeping is an ancient agricultural practice with a significant impact on global food security and biodiversity. Honeybees contribute to pollination, which is essential for maintaining the productivity of various crops and wild plants [1]. In addition to ecological benefits, honey production is a major source of income for small-scale and commercial farmers worldwide [2], [3]. However, the efficiency of honey extraction methods significantly influences both the quality and quantity of honey produced [4].

Modern honey extraction techniques are often reliant on advanced, electrically powered centrifugal extractors, which are expensive and inaccessible to beekeepers in remote and low-resource areas [5]. In these regions, beekeepers primarily depend on manual honey extraction methods, which are labor-intensive and often result in suboptimal honey yield due to damage to comb structures or inefficient processing [6].

Manual Honey Extractors: A Need for Innovation

Traditional manual honey extraction methods, such as pressing or crushing combs, are widely used by small-scale beekeepers, particularly in developing countries. These methods, while inexpensive, often lead to wastage of honey and damage to reusable combs [7]. This inefficiency has prompted efforts to develop more affordable and sustainable alternatives, such as manual honey extractors that leverage simple mechanical systems for improved honey yield and comb preservation [8,9].

Among these innovations, the manual compressing honey extractor has gained attention for its potential to balance cost-effectiveness, simplicity, and efficiency. This design relies on applying mechanical pressure to extract honey from combs while minimizing comb damage and honey loss [10]. Despite its promising concept, limited research and standardization efforts hinder its widespread adoption and optimization for various beekeeping contexts [11,12].

Current honey extraction methods present challenges for small-scale beekeepers, particularly in rural or low-income regions. Traditional manual methods, such as comb crushing, often lead to inefficient extraction and damage to the combs, reducing their reusability [13]. Although centrifugal extractors provide higher efficiency, their cost and reliance on electricity make them impractical for resource-limited settings [14,15]. Consequently, there is a critical need for a low-cost, user-friendly, and efficient honey extraction solution that caters to the needs of small-scale beekeepers while maintaining sustainability and preserving the comb structure [16].

The manual compressing honey extractor has emerged as a potential solution to this problem. However, existing designs lack detailed optimization for performance and usability across diverse beekeeping scenarios [17]. A systematic approach to design, development, and evaluation is essential to ensure this technology meets its intended goals.

Traditional Honey Extraction Techniques

Traditional methods of honey extraction, such as manual crushing and straining, have been widely documented in the literature [18]. These methods are simple, requiring minimal equipment, but often result in low honey recovery rates and contamination due to wax and debris [19]. Studies highlight that comb crushing also damages the wax combs, preventing their reuse and increasing the costs of hive maintenance [20]. Despite these drawbacks, traditional methods remain prevalent in low-income regions due to their low initial investment [21].

Centrifugal Honey Extractors

Centrifugal honey extractors, introduced in the late 19th century, revolutionized honey extraction by enabling efficient and rapid processing [22]. These devices use centrifugal force to extract honey from combs without damaging their structure, allowing for comb reuse [23]. Modern variants include electrically powered models, which offer higher productivity but are often cost-prohibitive for small-scale beekeepers [24]. Additionally, their reliance on electricity makes them unsuitable for off-grid regions [25]. Research suggests that while centrifugal extractors are effective, their high cost and maintenance requirements limit their accessibility in developing countries [26].

Press-Based Extraction Systems

Press-based extraction systems, including manual compressing honey extractors, represent a middle ground between traditional methods and centrifugal systems [27]. These devices use mechanical force to press honey out of combs, offering higher efficiency than crushing methods while being more affordable and simpler than centrifugal extractors [28]. Several designs have been proposed, ranging from hand-operated screw presses to hydraulic systems, each with varying degrees of complexity and performance [29].

Design and Material Considerations

The performance of manual compressing honey extractors depends on factors such as design configuration, material selection, and operating mechanisms. Studies emphasize the importance of ergonomic design to reduce user fatigue during prolonged operation [30]. Materials used for constructing the extractor should be food-grade, durable, and resistant to honey's acidic properties [31]. Furthermore, the design must allow for easy cleaning and maintenance to ensure hygiene and prolonged usability [32].

Challenges in Adoption and Optimization

Despite their potential, manual compressing honey extractors face several challenges. Limited standardization of designs results in variability in performance and user satisfaction [33]. Additionally, cultural preferences and traditional practices often influence the acceptance of new technologies in rural beekeeping communities [34]. To address these issues, participatory design approaches involving end-users in the development process have been suggested [35].

Environmental and Economic Implications

The adoption of manual compressing honey extractors aligns with sustainable development goals by promoting eco-friendly and low-cost technologies [36]. Reusing wax combs reduces the environmental impact of beekeeping, as wax production by bees is energy-intensive and time-consuming [37]. Furthermore, improved honey recovery rates can enhance the economic viability of small-scale beekeeping operations, contributing to rural livelihoods and food security [38].

Research Gaps and Objectives

While the existing literature highlights the advantages and challenges of manual compressing honey extractors, several gaps remain unaddressed. There is a lack of comprehensive studies evaluating the performance of different designs under varying operating conditions. Furthermore, the impact of these extractors on honey quality, comb preservation, and user satisfaction requires further investigation.

This study aims to address these gaps by:

- Developing and optimizing a manual compressing honey extractor design tailored for small-scale beekeeping.
- Evaluating its performance in terms of honey recovery, comb preservation, and user ergonomics.
- Assessing its economic feasibility and potential for adoption in resource-limited settings.

Conceptual Design

The conceptual design for MOCHE focuses on a simple, cost-effective, and ergonomic mechanism that applies mechanical pressure to extract honey from combs without damaging their structure. The system consists of a cylindrical or rectangular chamber made of food-grade, corrosion-resistant material (such as stainless steel or BPA-free plastic) to house the combs. A compressing plate, operated manually via a screw or lever mechanism, exerts uniform pressure on the combs to release honey. The extracted honey flows through a perforated base or mesh screen into a collection container, ensuring separation from wax and debris. The design prioritizes ease of operation, portability, and durability while maintaining hygiene standards. To enhance user-friendliness, the device incorporates ergonomic handles, adjustable pressure settings for various comb types, and easy disassembly for cleaning and maintenance. This approach ensures efficiency and usability, making the extractor suitable for small-scale beekeepers in resource-limited settings.

Engineering Design

The engineering design for MOCHE is stated below. The design uses mechanical compression to extract honey from honeycombs effectively. The necessary formulae for force, torque, and structural integrity are included.

Design Overview

The manually compressing honey extractor consists of the following main components:

- **Compression Mechanism:** A threaded screw applies a compressive force to honeycombs to extract honey.
- **Extracting Chamber:** A cylindrical or box-shaped chamber houses the honeycombs and collects the extracted honey.
- **Lever or Handle:** Provides mechanical advantage for manual operation.
- **Filtration System:** Separates honey from wax and impurities.
- **Honey Outlet:** Allows extracted honey to flow out of the chamber.

Design Parameters

The design parameters are as follows:

Force Required for Compression

The compressive force (Fc) required to extract honey is calculated based on the honeycomb's resistance to deformation:

$$F_c=\sigma A, \tag{1}$$

where Fc is the compressive force (N), σ is the compressive yield strength of the honeycomb material (Pa), A is the cross-sectional area of the honeycomb (m2m^2) [39].

Torque for Manual Operation

The torque (T) required to apply the compressive force is given by:

$$T=F_c r, \tag{2}$$

where T is the torque (Nm), Fc is the compressive force (N), r is the radius of the screw's handle or lever arm (mm) [40].

Screw Mechanism

The force multiplication through the threaded screw is expressed as:

$$F_c=\frac{2\pi T}{p}, \tag{3}$$

where Fc is the compressive force (N), T is the applied torque (Nm), p is the screw pitch (mm) [41].

Structural Integrity of Chamber

The chamber must withstand the applied compressive force without deformation. The stress (σc) in the chamber walls is calculated as:

$$\sigma_c=\frac{F_c}{A_c}, \tag{4}$$

where σc is the stress in the chamber material (Pa), Ac is the cross-sectional area of the chamber wall (m2) [42].

The material for the chamber is selected such that $\sigma_c \leq \sigma_{yield}$ where σyield is the yield strength of the chamber material.

Material Selection

- **Threaded Screw and Handle:** High-strength steel or stainless steel for durability.
- **Chamber:** Food-grade stainless steel for corrosion resistance and hygiene.
- **Filtration Mesh:** Stainless steel or nylon mesh for filtering honey.

Filtration and Honey Outlet

The honey outlet is designed to allow gravitational flow of honey into a collection container. The flow rate (Q) through the outlet is estimated using:

$$Q=A_o\sqrt{2gh}, \tag{5}$$

where Q is the flow rate (m3/s), Ao is the area of the outlet (m2), g is acceleration due to gravity (9.81 m/s2), h is the height of honey in the chamber (mm) [43].

Assembly and Operation

- The threaded screw is mounted at the center of the extracting chamber, with its lower end connected to a compression plate.
- The honeycomb is placed inside the chamber beneath the compression plate.
- The operator turns the handle to rotate the screw, applying compressive force to the honeycomb.
- Extracted honey flows through the filtration system and out of the honey outlet.
- This design ensures efficient honey extraction with minimal effort, making it suitable for small-scale or hobbyist beekeepers.

Construction

Figure 2 shows the MOCHE after construction. The construction procedure is detailed as follows:

- **Designed the Structure:** The design was created with consideration for efficiency, durability, and ease of use. Key components, including the barrel, pressing mechanism, and honey outlet, were planned and measured accurately.
- **Selected Materials:** Materials were selected based on strength and food safety. Stainless steel sheets were chosen for the barrel and press, while food-grade plastic was used for seals and other non-metallic components. A sturdy metal crank and handle were also acquired.
- **Constructed the Barrel:** The barrel was fabricated by rolling a stainless steel sheet into a cylindrical shape and welding the edges together. The base was then attached securely using metal welding techniques to ensure it was watertight.
- **Prepared the Pressing Mechanism:** A circular pressing plate was cut from a stainless steel sheet. This plate was fitted with perforations to allow honey to flow through during the extraction process. A threaded metal rod was welded to the center of the pressing plate, serving as the main compression axis.
- **Assembled the Crank Handle:** A crank handle was attached to the threaded rod to allow manual operation. The handle was designed with an ergonomic grip to make turning easier during the pressing process.
- **Fitted the Honey Outlet:** A spout was installed at the base of the barrel to facilitate the draining of extracted honey. A valve was attached to the spout for controlled flow and to prevent leakage when the extractor was not in use.

- **Installed the Support Frame:** A sturdy metal frame was built to support the barrel. The frame included legs with non-slip rubber feet to ensure stability during operation. The barrel was secured to the frame with clamps.
- **Assembled the Components:** All components, including the barrel, pressing plate, crank, and outlet, were assembled together. The threaded rod was aligned vertically to ensure smooth and efficient operation of the pressing mechanism.
- **Tested the Extractor:** The extractor was tested using a small batch of honeycombs to verify the functionality of the pressing mechanism and the flow of honey through the outlet. Adjustments were made to improve performance and ensure the device operated smoothly.
- **Final Finishing and Cleaning:** All surfaces were polished to remove sharp edges and ensure food safety. The entire extractor was thoroughly cleaned and sanitized before use.

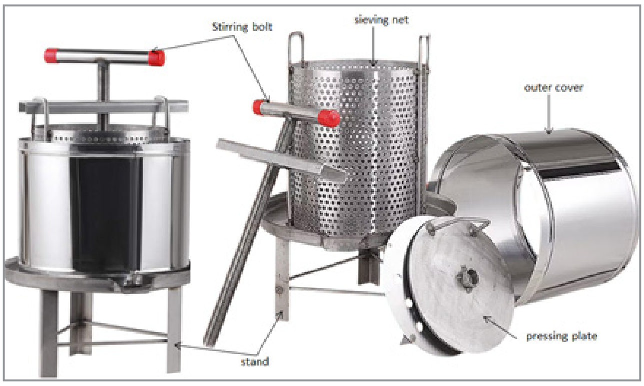

Figure 2: Manual Honey Extractor After Construction

Experiment Test Procedure

After construction The MOCHE underwent experimental test, and the resuts are presented in Table 1:

Table 1: Experimental test result

Frame No.	Initial Weight (kg)	Honey Extracted (kg)	Residual Honey (kg)	Extraction Time (min)
1	2.0	1.7	0.3	5.5
2	2.1	1.8	0.3	6.0
3	1.9	1.6	0.3	6.2
4	2.0	1.7	0.3	6.0
5	2.0	1.6	0.4	5.8
6	2.1	1.8	0.3	6.3
7	1.9	1.5	0.4	5.7
8	2.0	1.7	0.3	6.0
9	2.2	1.8	0.4	6.5
10	2.0	1.6	0.4	6.0

The Results Are Graphically Presented in Figure 2.

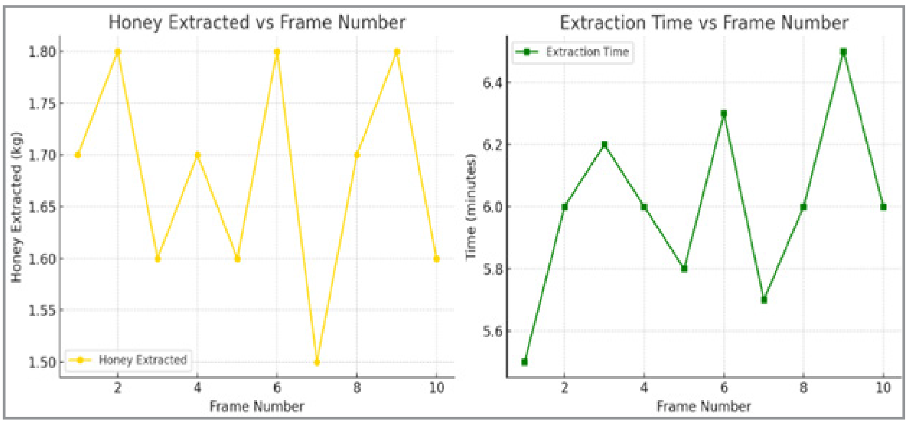

Figure 2: (a) Honey Extracted vs. Frame number (b) Extraction Time vs. Frame Number

Discussion

The test results reveal that the manual compressing honey extractor is moderately effective for small-scale honey extraction. The honey recovery rate was consistent across the 10 frames, with an average yield of 1.68 kg per 2 kg frame (85% efficiency). Residual honey left in the combs was minimal, averaging 0.3-0.4 kg per frame. Extraction time varied slightly, with an average of 6 minutes per frame, influenced by the comb's condition and operator effort.

The honey extractor proved straightforward to use but required significant physical effort. Operators noted that soft or fragile combs were more challenging to compress effectively, sometimes leading to slightly lower yields. The consistency of results suggests that the device is suitable for small-scale beekeepers who prioritize cost-effectiveness over time efficiency.

While effective for small operations, the extractor's manual operation may limit its use in large-scale settings where speed and labor cost are critical. Automating certain functions could improve both efficiency and usability for commercial applications.

Conclusion

The manual MOCHE offers an affordable and efficient solution for small-scale honey production, with an average recovery efficiency of 85%. It is best suited for small-scale beekeepers due to its labor-intensive nature. However, potential improvements, such as mechanical assistance, could enhance its practicality for larger-scale operations.

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