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Stainless Steel Construction for Palm Sap Filtration Using the Buchner Method

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ABSTRACT

Palm sap, the primary raw material for palm sugar and other derivative products, often faces quality issues due to the presence of solid particles, dirt, and microorganisms that accelerate fermentation and spoilage. This study aimed to design and construct a stainless steel filtration device based on the Buchner method to enhance the cleanliness and quality of palm sap. The filtration system employs a vacuum mechanism to expedite the separation of solid impurities, improving efficiency over conventional gravity methods. Laboratory-scale testing evaluated filtration capacity, clarity, and process time efficiency. Results demonstrated that the device significantly increased sap clarity while reducing filtration time. Additionally, the stainless steel construction proved easy to clean and durable for repeated use. This innovation benefits traditional Minahasa farmers in North Sulawesi, enabling them to produce higher-quality palm sugar. The filtration process effectively reduced dust and water content while increasing sugar concentration to 21.3 Brix without requiring extensive cooking. The use of the Buchner method and SS304 stainless steel construction ensures consistent filtration quality, offering a practical solution to improve palm sap processing and enhance farmers' incomes.

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INTRODUCTION

In the realization of the development of the National Tourism Strategic Area (KSPN), in 2019, Likupang has been designated by the Government of Indonesia as one of the five Super Priority Tourism Destinations (DPSP), and Likupang tourist area is located in the administrative region of North Minahasa Regency, North Sulawesi Province.

With the designation of Likupang as Indonesia's leading tourist destination, there is an opportunity to increase economic development in North Sulawesi, especially in the North Minahasa Regency. Moreover, after the Corona Virus-19 Pandemic that hit the world in the 2020-2022 period has been successfully handled by the Government of Indonesia, the national and regional sectors have begun to show hope of recovery.

Tourist attractions with all their uniqueness and beauty which include the diversity of natural resources, cultural styles and the results of man-made creativity are a number of factors that have the potential to be the basis for supporting the economy in various regions of Indonesia, including in North Sulawesi Province, especially the optimization of a number of related sectors that can support the Likupang tourism climate.

The existence of palm trees that have become one of the most prominent sources of opinions from traditional farming communities in the Minahasa Regency region, as generally in North Sulawesi, needs more attention to be managed more commercially as a form of local wisdom that deserves to be developed through appropriate technological breakthroughs so that it can become a tourism commodity in North Minahasa in particular.

The thinking underlying this research is the existence of a number of empirical facts that until now the traditional processing of palm plant potential in various regions of North Sulawesi Province has not shown maximum results. In addition, the modernization of science and technology has also not been able to show a significant aggregate to the populist economy.

Nira arenga is a sweet liquid obtained from tapping on flower bunches of palm trees, Arenga pinnata. Nira palm has considerable potential as a raw material for the production of various types of products, one of which is palm sugar, ant sugar, and bio-ethanol. One of the main problems of sap processing is the amount of dirt, solid particles, and microorganisms in sap that support the fermentation process and reduce the quality of sap. Therefore, the filtration process is very important to maintain the cleanliness and quality of sap before it is used for the production process. Based on this background, the problem formulation in this study is:

1. Is it possible to carry out the invention of a filtration production tool for water content separation in sap palm without heating mechanization?
2. Can the invention of production equipment to reduce water content in palm sap significantly contribute to the economy of palm farmers?

Traditional filtration methods use a variety of simple equipment that is unhygienic and time-consuming, making it inefficient in terms of production scale. M. Ma 'ruf et al. recommend a filtration device that meets the sanitation

and efficiency standards of a single pod. To see this need, filters must be made of materials that are effective, hygienic and meet heavy sanitation standards. Therefore, stainless steel material was chosen because it is rust-resistant, easy to apply, and uses food-grade hygiene in accordance with the processing of food substances.

Buchner's method that uses the principle of vacuum pressure as an effort to filter liquids has been known as one of the ways that can accelerate the rate of the filter. By using negative pressure, the method will be able to produce clearer sap. Therefore, this study aims to design and develop a filtration tool for palm sap using stainless steel material using the buchner method. It is hoped that the results of this study provide an innovative solution to the treatment of palm sap water that is hygienic, efficient, quality, and supportive for the small-medium industry that relies on palm sap-based products.

The formulation of the two problems in this study correlates to the independence of Micro, Small and Medium Enterprises (MSMEs) related to the optimization of applied applications of the research partnership production process to increase the potential of palm crops as plantation industries. The identification of the design of the filtration production tool invention involves the process of discussing prototypes of various concepts to ensure the compatibility of product quality with consumer demand for expertise based on cultural local wisdom related to the process of identifying relevant technical features in obtaining a comprehensive design so that it is possible to achieve speed, ease and safety of use in the process of producing palm sugar water obtained from traditional local farmers.

LITERATURE REVIEW

1. Micro, Small and Medium Enterprises

Likupang, located in North Minahasa Regency, North Sulawesi Province, has been designated as one of the areas to be developed because it has geostrategic advantages, especially the tourism sector, based on Government Regulation No. 84 of 2019 On Special Economic Areas (KEK).

Nevertheless, 2020 became the starting point for Indonesian tourism in the wake of the Corona Virus-19 hurricane, which the United Nations World Tourism Organization (UNWTO) notes describe as a nightmare in the history of world tourism as international tourists plummeted 86%.

On the other hand, the cultural potential and local wisdom in the development of tourism become part of the product of human creativity that has economic value. According to Law No. 10 of 2009 on Tourism, tourist attraction is everything that has uniqueness, beauty, and value, in the form of a diversity of natural wealth, culture, and man-made products to which tourists visit.

In crisis conditions, less than 2% of Micro, Small, and Medium-sized Enterprises (MSMEs) have been incorporated. In fact, SMEs are proving to be better able to survive the economic crisis in Greece, where entrepreneurs have the strategic goal of exploring and exploiting sources of value creation.

The importance of innovation capability in terms of production is also needed by MSME entrepreneurs to improve performance. Not only in terms of

products, innovations can also be made related to production processes, in the form of new production processes and development of existing processes.

2. Palm Plants

Quoted in Elfriede, the directions of research on the potential of palm plants at present include chemical and organoleptic characteristics of palm sugar, modernization of palm sugar production, risks that may affect production yield, as well as correlations to public welfare.

Palm plant (Arenga pinata Merr) is a plant that has the potential to be developed as an agro-industrial commodity in Indonesia, mainly found in 14 provinces, such as Papua, North Maluku, North Sumatra, West Sumatra, West Java, Central Java, Banten, North Sulawesi, South Sulawesi, Southeast Sulawesi, Bengkulu, Nangro Aceh Darusalam, and South Kalimantan.

Palm crop acreage increased by an average of 2.0% with a production growth rate of 1.9% per year, with Nira's main product having a productivity between 8-22 liters/tree/day. According to some studies, the palm plant (Arenga pinnata.) contains secondary metabolite compounds such as alkaloids, flavonoids, tannins, saponins, triterpenoids, galactomanes, and phenols that can act as antioxidants.

With an area of palm crops at 5898.98 Ha, the province of North Sulawesi has a total production of 2249.30 tons, and is one of the areas that produces a lot of traditional palm sugar so that the quality of palm sugar produced by farmers is still low due to the long cooking process. According to Elfriede1 et.al., it was found that the presence of bacteria in palm sugar can be caused by contact with humans during traditional processing production processes.

Local farmers' palm sugar has not been able to compete well due to limited knowledge and low producer awareness of the importance of product quality. The differences are based on personal hygiene, sanitary facilities, harvesting conditions, heating temperature, heating time, and storage conditions.

To be processed into palm sugar, palm water must meet pH and brix requirements, i.e. pH 6 - 7.5 and brix level above 17. Palm sugar can be an alternative to cane sugar due to its popularity and high production in Southeast and South Asia (Indonesia, India, Malaysia, Philippines, and Thailand etc.), as well as leading to economic value benefits.

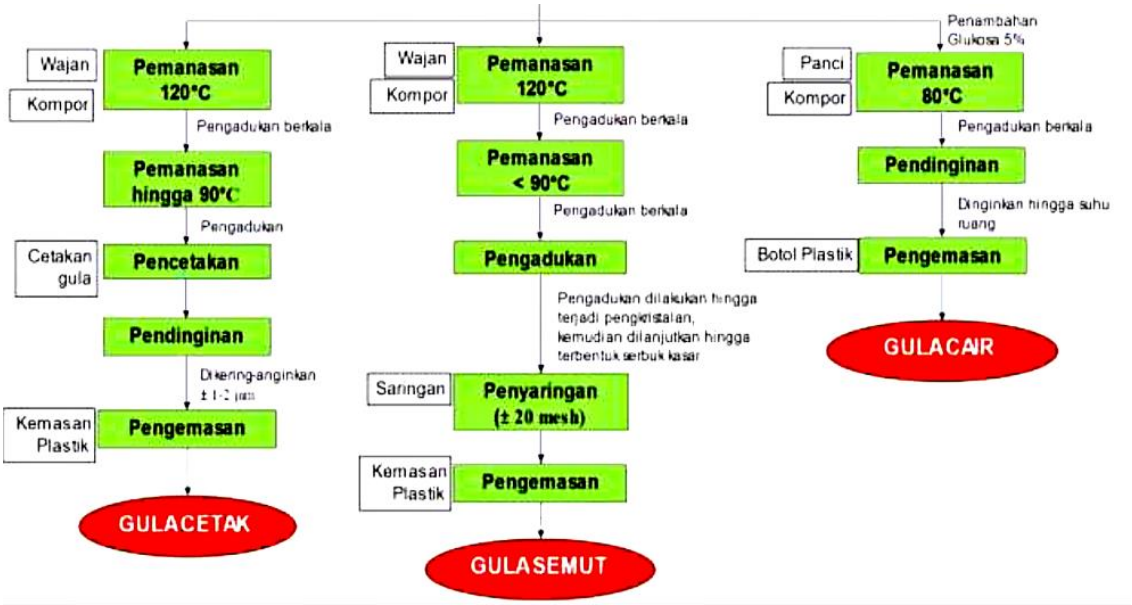

Figure 1. Aren Sugar Making Process

The composition of palm sugar, also known as palm sugar, also has the advantage of being rich in oligo elements (Cu, Fe, Mn, Br, and Zn), and microelements (P, Mg, Si, Cl, Na, S, Ca, and K), as stated by Fuadi et al. (2023), and antioxidant content.

3. Buchner Method

Filtration is a physical separation method used to separate liquids (solutions) from solids. The liquid that has been processed through filtration/sieving is called the filtrate. Sieving is the physical separation of liquids and solids in a mixture. The filtration process is significantly influenced by the sampling time and mixing time; the greater the time, the more precipitate is filtered by the filter. However, sometimes the residue is the desired product. Besides using gravity to force the liquid through the septum (filter medium), a driving/pulling force can also be used to force the liquid through the septum in the form of gravity filtration, vacuum filtration, pressure filtration, and centrifugal filtration.

4. Stainless Steel

Metals can be damaged by corrosion due to electrochemical reactions between the metal and its environment, causing rusting and reducing the quality of the metal. The use of metal materials widely applied in the industry is steel, with alloying elements of Nickel (Ni), Chromium (Cr), and Manganese (Mn) that can make the steel resistant to corrosion and can be applied at both low and high temperatures.

METHODOLOGY

This research is an Applied Research related to the invention of a production equipment that is one part of the production process of Palm Wine products produced from the main raw material of Palm Sap Water as referred to

by CV. Aren Minahasa as a research partner (beneficiary). In the last 10 years, there has been no scientific study on the Palm Wine product, palm sap, although a number of literatures mention the potential of the product.

This research uses a descriptive analytical design on dynamic changes in the time span unit of the performance design of a fermentation tank that has a dual function to facilitate the process of separating the water content of palm sap and sugar from farmers' tapping. In the previous process, only filtering was carried out through conventional filter cloth media.

Before this research was conducted, the research partner had designed an initial design for a filtration tool to separate the water content and sugar from palm sap, but the system and method used had not been clarified, so that in the construction research that will be studied and tested are the principles of applied scientific technology in order to meet the standardization of measuring the level of effectiveness and efficiency that is feasible.

Fresh palm sap in this study was obtained from tapping in the morning and evening carried out by traditional farmers in the Tanggari area, North Minahasa, North Sulawesi Province, and given coconut fiber as a natural preservative to slow the growth of yeast microorganisms, then sterilized by cooking to a temperature of 100^{o} Celsius.

The equipment used is a Palm Sap Filtration tool. Made with stainless steel material type Stainless Steel 304 thickness 2mm, vacuum media with a medium suction power of 13,000 kpa, Cotton Cellulose filter paper with a filtration thickness of 10 µm and a pore size of 0.7 - 1.2 µm, Brix Meter measuring tool, Stainless Steel cooking pan 30 cm, 5 Liter container size Food Grade quality, 500 mL measuring cup and a plastic dipper / scoop.

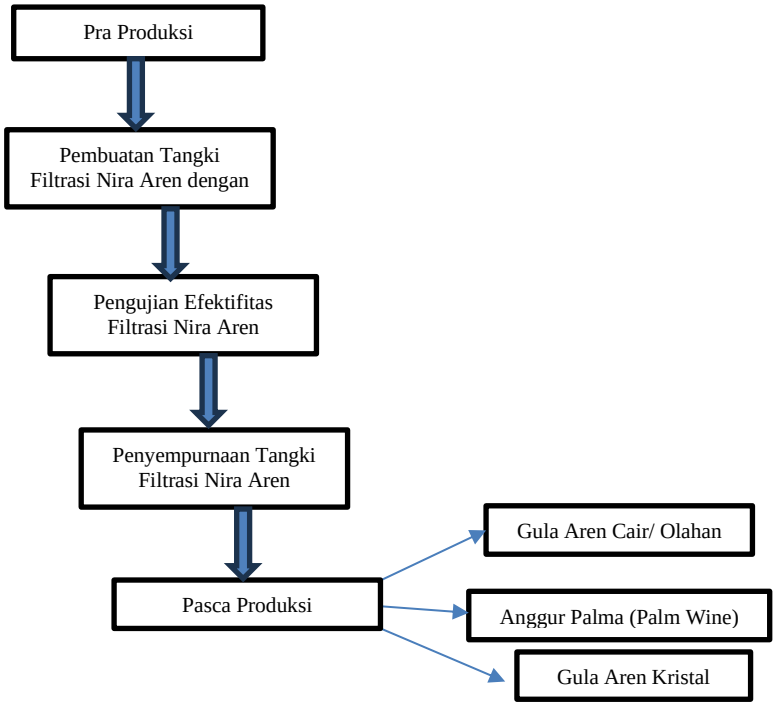

Figure 2. Research Method Flowchart

RESULT

This research achieved significant results, including:

1. An efficient filter design was developed using a stainless steel, corrosion-resistant, hygienic device that meets food safety standards. The device's vacuum system is based on the Buchner method, which accelerates the filtration process.
2. The potential efficiency of the Buchner filtration method tends to increase filtration time compared to other active methods, thereby increasing production. The filtering process yields cleaner, clearer water that meets food processing standards in terms of clarity. Furthermore, it offers efficiency in terms of quality, durability, and maintenance. Because the material is proven resistant to corrosion and unaffected by the natural acids in palm sap, the device can be used without damage. The device's design allows for easy maintenance and cleaning, making it convenient for use in homes or small-scale industries.
3. Component quality testing showed that the filter equipment effectively removes solid particles, impurities, and contaminants from palm sap, thus improving the raw material quality for further processing. Filtration results indicate that the palm sap remains stable during initial storage because microorganisms are effectively reduced through the filtration process.
4. The large-scale implementation is suitable for small and medium-sized enterprises or industrial-scale applications due to its ease of use and cost-effectiveness. These devices can be locally produced at an affordable price, providing a practical solution for farmers and palm sap derivative products.

The device testing results show that the stainless steel filter with the Buchner method is an effective, functional, and hygienic device for processing palm sap. This filtration can improve product quality and bring economic benefits to palm sap processing industries.

After 2 hours of tapping, palm sap (Arenga Palm Sap) has a distinctive sweet taste because it is still in the initial phase of natural fermentation, and the formed alcohol content does not significantly affect the taste and quality. In this phase, the palm sap is sterilized by heating to 100° Celsius.

The sugar content of the palm sap before heating was 16 Brix and increased to 17.3 Brix when heated to boiling point. After cooling for two hours in an open container, the palm sap sugar content increased to around 17.7 Brix due to water evaporation after boiling.

Table 1. Mid Score of Palm Sap Quality from Filtration

Filtrasi	Vacuum	Nilai ºBriks
Tanpa Media Filtrasi	Tidak	17,7 ºBriks
Cotton Cellulosa	Ya	21,3 ºBriks

The filtration process is carried out after the palm sap has cooled and is inserted into a filtration device that has been coated with Cotton Cellulose filter paper. A total of 500 mL of sterilized palm sap water is used with three

repetitions. Each filtration process uses a vacuum with a suction power of 13,000 kpa so that the filtration process can take place in a controlled manner, making it easier to observe. The results of the three repetitions of palm sap filtration can increase the sugar content of the palm sap quite significantly, reaching an average of 21.3 Brix. Another by-product is that the dust content is clearly visible spreading sporadically on the filter paper layer when the palm sap sugar water is flowed through the filtration discharge valve. The increase in sugar content of palm sap from 17.7 Brix to 21.3 Brix or 20.34% is a significant result. The size of the filtration hole is 0.3 cm on a cross-section with a diameter of 21 cm with a height of 7 cm can facilitate the performance of a vacuum of 13,000 kps, thus providing adequate space for the process of separating water and sugar content in the water sap. The performance of the gravitational field still functions to facilitate adequate pulling force on the results of the separation of the vacuum power used. Another important thing to be stated in this study is that the characteristics of palm sap in various places, both in North Sulawesi, Indonesia, and in the Asia Pacific, are very likely to have a number of differences in quality, including the value of sugar content in sucrose and glucose. Therefore, the results of this study cannot be generalized but as a study of the potential for separating water and sugar content in palm sap.

DISCUSSION

For further development, it is recommended:

1. Testing this tool on a large industrial scale to see the performance and efficiency in larger production quantities.
2. Adding additional innovations, such as automation systems or vacuum pressure gauges, to increase user convenience and efficiency.

CONCLUSIONS AND RECOMMENDATIONS

According to the results of the study "Palm Juice Filtered Stainless Steel Structure Using Buchner's Method", the following conclusions are drawn:

1. Successful development of stainless steel filtration equipment design. A stainless steel vacuum filter based on Buchner method was successfully designed and developed. The stainless steel material used is proven to be corrosion-resistant, easy to clean, and meets food-grade standards, making it ideal for processing foods such as palm juice.
2. High filtration efficiency. Compared with the traditional gravity method, the vacuum system of the Buchner method significantly speeds up the filtration process. The device can effectively filter solid particles, impurities and other contaminants to produce clearer and better quality palm juice.
3. Material durability and easy maintenance. The stainless steel material has the advantage of resisting the natural acidity of palm juice, so the tool can be used for a long time without damage. In addition, the tool is easy to disassemble and clean, making it easy to reuse.
4. Improve the quality of palm trees. The filtration results showed that the tool was able to improve the quality of palm juice by reducing pollution

and impurity levels, thereby making the sap more stable and ready for further processing.

5. Industry-scale implementation potential. The filtration device has great potential for implementation in household scale and small and medium-sized industries. Its simple, efficient and affordable design enables the tool to be widely used, especially in palm juice producing areas.
6. Contribution to the local food industry. Using this tool can increase the added value of palm juice products such as palm sugar, palm sugar and bioethanol, thereby providing economic benefits to the community and supporting the sustainability of the local food industry.

ADVANCED RESEARCH

For advanced research, future studies could explore optimizing the stainless steel filtration tool for larger-scale industrial applications. This includes investigating ways to enhance the device's capacity and efficiency to meet the demands of medium and large industries. Additionally, further research could focus on integrating automation into the vacuum system to streamline the filtration process and reduce labor intensity. Exploring alternative materials or coatings that enhance durability while maintaining food-grade standards could also be beneficial. Moreover, a comprehensive assessment of the device's economic impact on local communities and its scalability in different palm juice-producing regions would provide valuable insights. Finally, examining the tool's effectiveness in processing other food products or liquids could broaden its applications and increase its utility in diverse food industries.

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