

Milk Pasteurization Machine for the Farmers Group Association of Sido Makmur, Sidorejo, Gunungpati, Semarang City

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Abstract

The Sido Makmur Farmers' Association Sidorejo, Gunungpati, Semarang City has promising potential to become a tourist village based on cow's milk. The problem is that the management of cow's milk products is not optimal because it is still done in a conventional way and does not pay attention to hygiene and sanitation. Until 2020, the Sido Makmur Sidorejo livestock farmer group continues to strive to increase cow's milk products. Therefore, the community service team assists in the safety of dairy cow's milk to be safe from biological, chemical and physical contamination by testing cow's milk in accordance with the Indonesian National Standard Source: SNI 01-3141-1998 (SNI Fresh Cow Milk). The service team also provides assistance in the development of dairy cow's milk products, especially during the fasting month, when demand decreases, overproduction occurs so that at that time cow's milk can still be processed to produce products that can be offered to visitors. In this service activity, the team designed and built a Pasteurization machine with a milk capacity of 15 liters. Based on the results of the experiments carried out, the system can process temperatures between 60°C and 80°C in accordance with the provisions for Pasteurization at medium temperatures.

Keywords: *community service; milk quality; pasteurization machines*

Introduction

Situation Analysis

As an agrarian country, around 70% of Indonesia's population works as farmers. Apart from being farmers, in general, they are also breeders. Activities such as farmers and ranchers are supported by topography and natural conditions that allow the two activities to complement each other. This is reflected in the residents in the village of Sido Makmur, Jatirejo, who have good natural wealth, and fertile soil so that a source of dairy cattle feed is available. Even residents in the village of Sido Makmur provide special feed for their dairy cows in the form of an edible portion of jackfruit (mandai) which is rich in nutrients that affect the nutritional content of the milk produced. In addition, at the time of harvesting cantaloupe, residents feed cantaloupe skin which is also still rich in nutrients. Based on the method of raising livestock, farmers have developed by providing diversification of animal feed other than raw materials that become livestock rations (grass and additional concentrates). Another advantage of the area is the availability of good water so that livestock drinking is not a problem. The location of the livestock barn is not in the middle of the settlement so it does not cause odor or pollution for residents. Known weaknesses are the procedure for managing the livestock cages, the process of milking, and funds to carry out milk processing which do not guarantee hygiene for consumers. Map of the village is shown in Figure 1.

The Soegijapranata Catholic University (Unika) community service team together with PKTT Sido Makmur Jatirejo has an idea of how to improve the quality of dairy milk so that it is safe for consumption by consumers and has standards in accordance with SNI (National Standardization Agency of Indonesia, 1995), (National Standardization Agency of Indonesia, 1998). The choice of location is one of the considerations for the service team considering that the PKTT is located in the Jatirejo tourist village location so that if tourists or guests visit the location they can directly consume dairy cow's milk safely (free from biological, chemical and physical contamination). In addition to meeting consumer needs, good quality dairy cow's milk is important for the population to increase the family's nutritional intake so that it can be beneficial for the growth of toddlers (preventing stunted growth of toddlers).

Partner Problems

Referring to the Semarang Regency Regional Regulation Number 2 of 2016 concerning Animal Husbandry (Semarang, 2016) and Animal Health and the Semarang City Regional

Regulation No. 3 of 2010 (Semarang, 2010), concerning Tourism, strengthened by Article 71 Paragraph 1, Law No. 18 of 2012, that food is the responsibility of everyone involved in the food chain so that it is obligatory to control the risk of harm to food, both from materials, equipment, production facilities, as well as from individuals so that food safety guaranteed. So the Soegijapranata Unika community service team formulated the existing problems as follows:

- a. Partner problems relating with the procurement of the number of livestock so that the demand from consumers has not been fulfilled, while the traders who accommodate milk production become the first distributors with the provisions of the price determined by the trader. This happens because during the Moslem fasting month demand decreases but traders are still willing to buy at a predetermined price. If this condition continues, the farmer will only become a worker, not an owner (Abdullah, 2008).
- b. The partner's problem regarding the increasing demand for milk from the Semarang and surrounding areas that have not been fulfilled is part of the community service team to create an innovation of pasteurization tools so that dairy cow's milk that has gone through the pasteurization stage has a longer shelf life and guarantees the quality of the milk from biological contamination (microorganisms).
- c. Partner problems to develop good results become part of the service team to help analyze milk quality in accordance with Indonesian national standards by paying attention to hygiene and environmental sanitation of cowsheds and cow hygiene.
- d. Bookkeeping and taxation problems that have not been organized can be resolved with the assistance provided by the Soegijapranata Unika community service team.

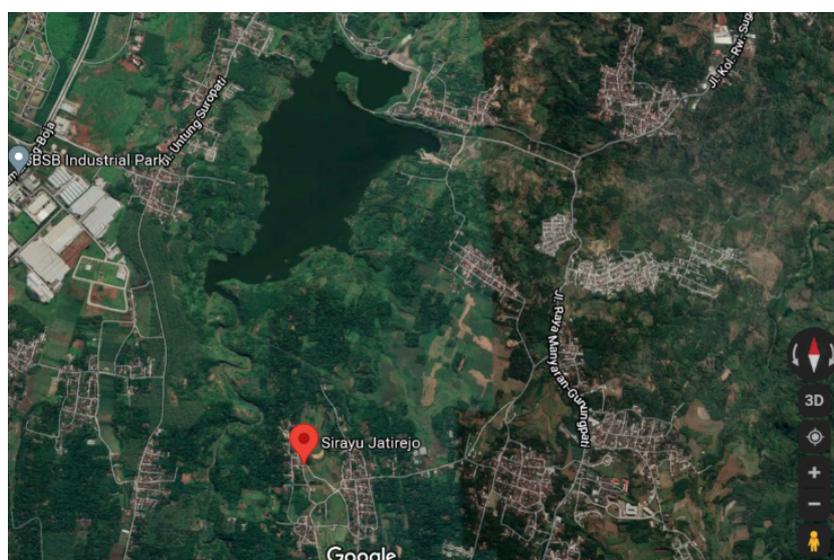


Fig. 1. Sirayu Hamlet, Jatirejo Village, Gunungpati District, Semarang City (maps.google.com)

Problem Solution

Through the activities of the service team, it is hoped that they will be able to unravel the problems of partners to be simpler and can have a positive impact on both the Sido Makmur PKTT and other farmer groups in the Jatirejo area. Solution specifications are as follows:

- a. Partner problems on points a,b and c with the management of unhygienic dairy cows and poor environmental sanitation, it is necessary to guarantee milk quality through testing in accordance with Indonesian national standards. The importance of milk guarantees for consumers who consume it is an integral part of the promotion of Sido Makmur village, Jatirejo as a center for dairy cows.
- b. Partner problems regarding unorganized bookkeeping and taxation management can be resolved accompanied by experts in the field of bookkeeping and taxation (Faculty of Economics and Business), training on the development of dairy-based products delivered by Food Technology experts (Faculty of Agricultural Technology) to assist in the use of pasteurized innovation tools given by the Soegijapranata Unika service team (experts from the Faculty of Engineering).

Methods

The method of implementing this activity describes the stages or steps in implementing the solutions offered to overcome problems with partners with the following details:

- a. The parties involved in community service activities are partners of Makmur Rejo Farmer and Sido Makmur.
- b. Methods and stages in the community service:
 1. starting from the identification of community needs,
 2. proceed with planning,
 3. next is the manufacturing process,
 4. perform testing of Pasteurisation tool operation,
 5. the next stage is the operational assistance of the Pasteurization tool and,
 6. application of these results to the two target community groups/partners.
- c. The working procedure to support the realization of the offered method is to design a Pasteurization tool, implement it and conduct experiments with the assistance of partners in program implementation.
- d. Evaluation of program implementation and program sustainability after completion of appropriate technology application activities to the community in the field is carried out

by periodic monitoring. The goal is to find out the effectiveness of the system and the shortcomings that exist in the Pasteurization tool.

The functions and benefits of community service results can be obtained by both parties. The Soegijapranata Catholic University community service team has provided benefits to partners to improve the quality of milk production so that they can have good selling power. Residents are given the training to be able to increase their income by processing milk derivatives. The quality of milk will be guaranteed with the Pasteurization tool. This can have a good impact on residents. Thus, the function of community service provided by the Soegijapranata Catholic University team can be useful for the sustainability of cooperation with partners and partners can benefit. Figure 2 shows the dissemination of information for the farmers.

Partners get a good economic and social impact from the community service provided by the Soegijapranata Catholic University community service team. Partners gain knowledge of the processing of milk derivatives into several product variants that can be processed by each household. This target is important so that partners can become economically independent citizens. With the expertise provided, partners are expected to be able to sell the products produced as part of the development of milk productivity and the residents of Jatirejo to be a role model for other regions. This is very positive because it can have a social impact on society.



Fig. 2. Dissemination for livestock farmers group association in Sirayu, Jatirejo, Semarang

Community service by the Soegijapranata Catholic University Team is an inseparable part of the collaboration that has been fostered with partners in Jatirejo. In addition to improving the quality of milk productivity, with the Pasteurization tool, it can also contribute to other sectors in the form of tourism because Jatirejo is close to a tourist village that produces kolang-kaling and corn products. So, the residents of Jatirejo have the advantage of being able to collaborate between farmer groups and women to increase their respective production activity and products.

Cow's Milk Pasteurization

Pasteurization is used to preserve foods that are susceptible to high temperatures. The heating process with pasteurization does not kill all bacteria, only slows or reduces microbial growth in foodstuffs. Commercial-scale sterilization of food is still not commonly used because it can affect the taste and quality of the product. (Rankin et al, 2017). Pasteurization of milk, especially cow's milk, is by heating to a temperature below the boiling point of milk (Khadir, 2003). The purpose is to kill germs or pathogenic bacteria. However, the spores can still live. The benefit of Pasteurization is to extend the shelf life of the product and not spoil the milk quickly (Tadjine et al, 2019). There are two methods used in the milk pasteurization process, namely Low-Temperature Long Time which is done by heating the milk to a temperature of 63°C-65°C with being maintained at that temperature for 30 minutes. Another method is High-Temperature Short Time, where the heating process is carried out at high temperatures in a short time (73°C-75°C) or more, for 15-16 seconds. Microorganisms that can quickly and easily grow in milk cause milk to be easily damaged, only within 5 hours after the milking process. Milk processing needs more attention before milk is consumed.

Milk Pasteurization Machine Design

Milk Pasteurization equipment or machines are designed in a form that is not much different from those that already exist and are used. The principle used in this design is ease of use, maintenance, and repair. The purpose of the design model is so that farmers can easily operate the Pasteurization tool and can carry out maintenance in an easy way. On the other hand, if something goes wrong it will be easy to fix it by oneself. The machine design consists of an outer drum, an inner drum, a water outlet valve, a milk discharge valve, a heating element, a motor along with a belt and pulley, a mixer, and an electronic control system (Niamsuwan et al, 2011). The following is a connection diagram between parts of the pasteurization tool.

The temperature sensor will read the temperature at any time and send the information to the controller. The controller will turn off the heater if the inner tube temperature exceeds the previously set. Conversely, the controller will turn on the heater if the temperature is less than the setting value. The speed sensor reads the number of revolutions per minute. If it exceeds the setting value, the rotation will be lowered. If the rotation is less than the setting value, the process of increasing the motor rotation will be carried out. Figure 3 shows the machine.

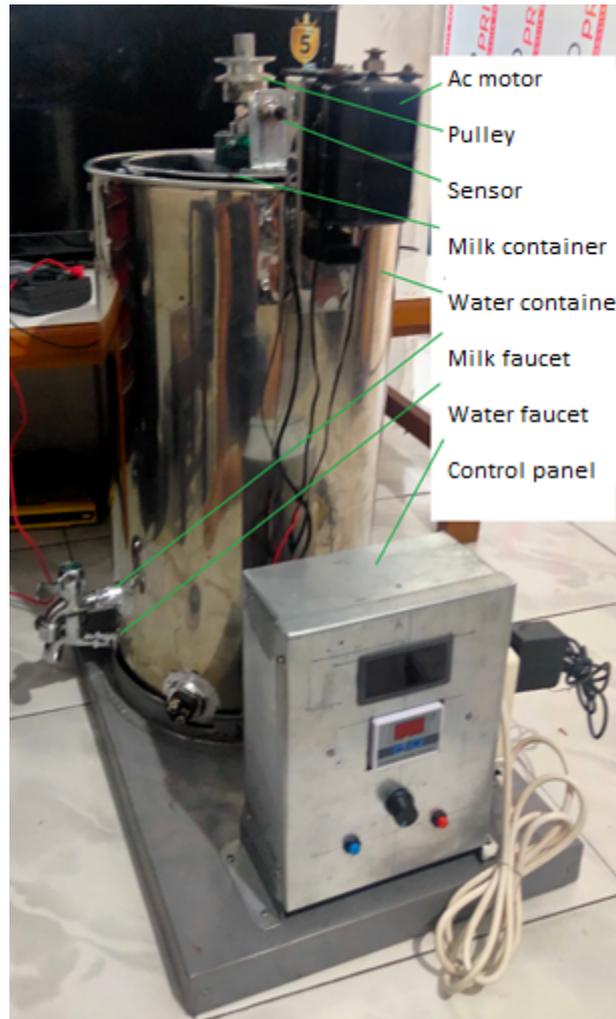


Fig. 3. Milk pasteurization machine for livestock farmers group association in Sirayu, Jatirejo, Semarang

Diagram in Figure 4 illustrates the overall working process of the machine starting from the stages of adding water and milk to the heating and stirring process to produce even heating. The following diagram illustrates the overall working process of the machine starting from the stages of adding water and milk to the heating and stirring process to produce even heating.

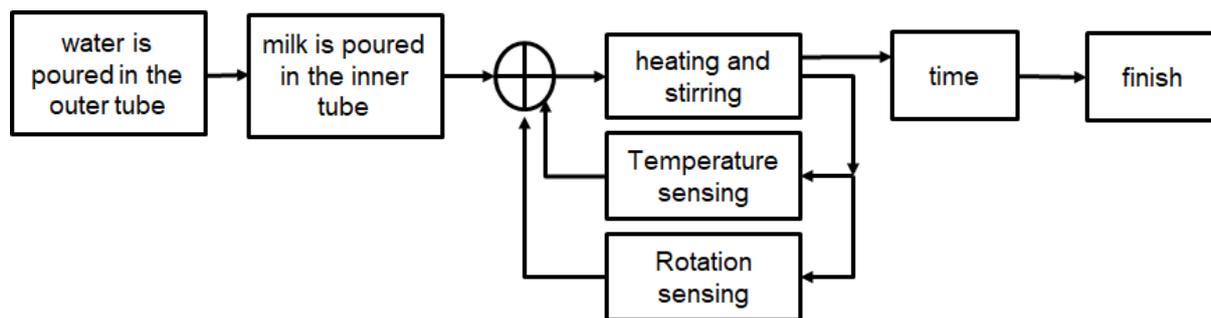


Fig. 4. Block diagram of milk pasteurization machine

Inner Tube

The inner tube in Figure 5 serves to accommodate the milk to be processed. The volume of the tube is adjusted to the capacity of the milk to be processed at a certain time. In this community service activity, the tube is designed for a milk volume of 15 liters. The volume is adjusted to the production capacity of the milk to be processed by Pasteurization. The inner tube is 45 cm high and 22 cm in diameter, so that the overall inner tube volume is 17 liters. The milk in the tube is only filled with a maximum of 15 liters to provide space for the movement of milk during stirring in the heating process, so as the milk does not spill into the outer tube containing the heated water. The inner tube has an outlet through the outer tube to expel the processed milk. The end of the channel is fitted with a faucet to facilitate the removal of milk from the inner tube. The faucet is installed at the bottom of the inner tube, so that it can release milk optimally and make cleaning the inner tube easier. The material used to construct the inner tube is stainless steel. The connection process is carried out with a soldering and rivet process. Some leak-prone parts are coated with a heat-resistant sealer.

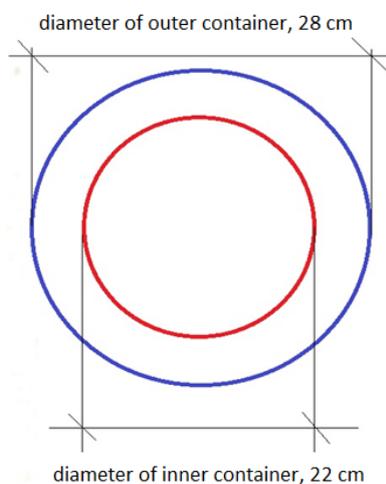


Fig. 5. Design of inner container diameter and outer container diameter

Outer Tube

The outer tube in Figure 6 serves to accommodate the water to be heated. The volume of the tube is adjusted to the capacity of the milk to be processed at a certain time. The outer tube is designed for a volume of 15 liters of water, the same as the amount of processed milk. So it takes a tube with a volume twice the milk tube. The outer tube measures 55 cm high and 28 cm in diameter, resulting in an overall inner tube volume of nearly 34 liters. The tube in the milk has a maximum volume of 17 liters, so there is still 17 liters of room left to hold water. The water stored in the outer tube has the same volume as the processed milk, which is 15 liters. In that condition, the water does not spill to the outside of the tube due to expansion by the heating process. The outer tube as a water reservoir has an outlet through the outer tube to remove water to assist the process. The end of the channel is fitted with a faucet to facilitate the removal of milk from the inner tube. The faucet is installed at the bottom of the outer tube, in order to maximize milk ejection and facilitate cleaning of the outer tube. So there is no need to tilt the tube to pour out most of the water from inside the tube, while cleaning. The material used to compose the outer tube is also made of stainless steel, as is the inner tube. The connection process is carried out with a soldering and rivet process. Some leak-prone parts are covered with a heat-resistant sealer, such as the inner tube.

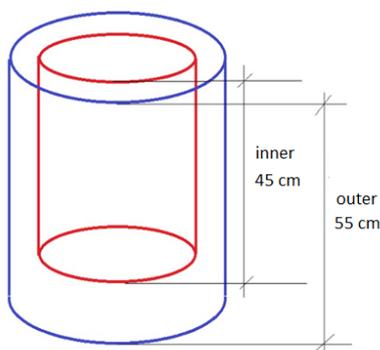


Fig. 6. Design of inner tube height and outer tube height

Stirring Motor and Stirring Plate

The inner tube contains milk to be processed by Pasteurization. The heating process is carried out by means of heated water. The heated water in the outer tube will propagate the milk in the inner tube. The heating of the milk will be evenly distributed throughout the milk by adding a stirrer. The stirrer is rotated by an electric motor mounted on the side of the tube. The location of the rotating motor is not placed on the top of the tube to maintain the hygiene of the milk. The rotation of the stirrer by the motor is channeled through the pulley and belt

which is connected to the stirring shaft. Belts and pulleys are protected with plates so that debris due to the mechanical friction of rotation does not fall into the milk.

The stirrer motor is composed of a 220V AC motor commonly used in sewing machines with a power of 125 Watts. The motor is connected to the axle by means of a belt and a pulley. The type of belt used is plastic with nylon reinforcement and is often applied in pairs with the attached sewing machine motor. The stirrer pulley made of aluminum with a diameter of 2.5 cm is attached to the top of the stirrer. The pulley attached to the side of the motor uses a pulley built into the sewing machine motor with a diameter of 1 cm. Based on the pulley comparison, there is a reduction in the rotation of the milk mixer by 2.5 times less than the rotation of the motor.

Milk that is processed by Pasteurization is heated to the same temperature as possible. So it is necessary to stir the process during heating the milk, so that the heat is evenly distributed in all parts of the milk liquid. On the inside of the milk tube, there are two pairs of stirring plates. The stirring plate is placed on one axis with a pulley connected to an electric motor. The stirrer axis is placed right in the middle of the inner tube, with the lowest height being 5 cm above the bottom of the milk tube.

The axis is mounted on a bearing that is tied to a stand that is placed across the milk tube. The axis is made of stainless steel rods with a diameter of 1.25 cm. At the base of the axis, a pair of stainless steel stirring plates are installed with a size of 5 x 5 cm. Just above the pair of stirrer, installed another pair of stirrer with the same size. The position of the pair of stirrer plates is perpendicular to the stirrer below. With this construction, it is hoped that during heating, the position of the liquid will always change by stirring, so that heat can be spread evenly throughout the milk liquid. This construction can be seen in Figure 7.

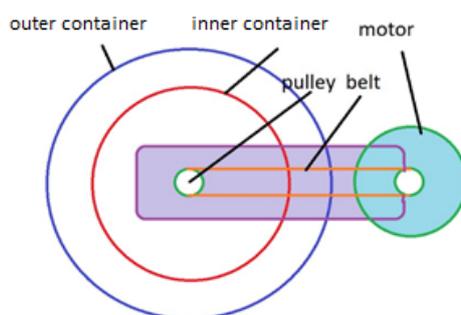


Fig. 7. The design of the stirrer motor position against the inner tube and outer tube

Rotation Sensor and Temperature Sensor

The heating of the milk is carried out evenly by using a stirrer that is rotated by a motor. Motor speed is controlled electronically and monitored by a speed sensor. The temperature that is set at the beginning can always be controlled by the electronic system with the help of temperature readings by the sensor. Figure 8 shows construction of the stirrer module.

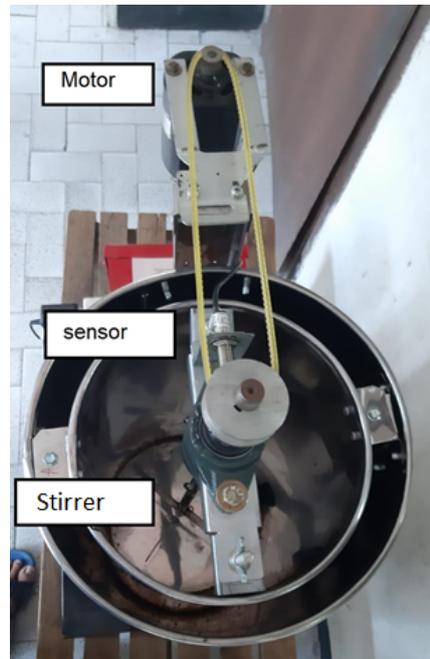


Fig. 8. Position of the stirrer motor to the inner tube and outer tube along with the rotation sensor

Motor rotation is set to be faster when the temperature is increased. The purpose of setting the motor rotation is to obtain an even temperature distribution. Motor rotation at a temperature of 60°C ranges at 75 revolutions per minute. The rotation will increase as the temperature increases. At a temperature of 80°C, the stirrer rotation is 175 revolutions per minute. The controller can be seen in Figure 9.



Fig. 9. Electronic control panel for stirrer and temperature

Results and Discussions

Results

Table 1 is a table of measurement results for the temperature of the outer tank, the inner tank, and the rotation of the stirrer motor. The temperature measured is in the range of 60°C and 80°C, according to the expected working temperature of the machine in the Pasteurization process. When the power supply is applied, the electric heater will start working. The electric heater is placed in the outer tube and works by heating water. Through the inner tube wall, the water temperature will propagate to the inner tube area containing milk. At the same time, the stirrer motor also starts to work to even out the temperature of the milk. The process of heating the milk is not carried out directly on the inner tube, to avoid direct contact between the milk and the heat source. Because when the heater is activated, the temperature of the heating element is well above the safe temperature limit for milk to maintain its nutritional content. Heating is done indirectly from the heat generated by the water in the outer tube. Water that heats up quickly around the heating element will spread its heat throughout the water. Furthermore, the hotter water temperature will propagate to the inner tube and the milk liquid.

Heating water using a heating element and stirring using an electric motor absorbs a small amount of electric power. The electric motor to rotate the stirrer uses a motor with a power of 125 Watts. While the heating element used to heat water in the inner tube has a power capacity of 300 Watts. So for 30 minutes of use, the power required is $(30/60) \cdot (125+300)$ Watt Hours, or 212.5 WH. By assuming the price of electricity per kWh is Rp. 1,500, - then the operating cost of the Pasteurization machine for one use is Rp. 318.75. If the amount of milk that is processed in one Pasteurization process is 15 liters, then a cost of Rp. 21.25 is required. The processing cost is very cheap compared to the price of one liter of milk.

Table 1. Results of measurement of temperature and speed of stirrer

No	Temperature of outer container (°C)	Temperature of inner container (°C)	Stirrer speed (rpm)
1	60	55	75
2	61	56	80
3	62	57	85
4	63	58	90
5	64	59,1	95
6	65	60,1	100
7	66	61,1	105
8	67	62,1	110
9	68	63,2	115
10	69	64,2	120
11	70	65,2	125
12	71	66,1	130
13	72	67,1	135
14	73	68,1	140
15	74	69,1	145
16	75	70	150
17	76	71	155
18	77	72	160
19	78	73,1	165
20	79	74,1	170
21	80	75	175

Discussion on Feasibility of Pasteurization Equipments

The procurement of pasteurization equipment is expected to improve the quality of cow's milk which in turn increases the selling price of the dairy product itself. The pasteurizer developed can accommodate a maximum of 13 to 15 liters of cow's milk, for each use.

With the number of dairy cows producing as many as 8 cows which in 1 day the production reaches 13 liters per cow, the ideal need for pasteurization machine is 8 units (but currently only 1 pasteurizer is available as a first step). Assuming to increase the selling price by 30 percent from Rp. 5,000,-/liter to Rp 6,500/liter as an implication of improving the quality of cow's milk, it can be seen an increase in monthly income. Monthly income after the price increase reached 18,928,000. By calculating the cost of maintaining the pasteurization machine, the net income per year after using the pasteurization machine is Rp. 112,656,000,- Financial feasibility analysis of pasteurization tools is measured through several business feasibility indicators. Business feasibility indicators used include Payback period, Net present Value (NPV), Internal rate of return (IRR). Based on the data analysis, it can be concluded that the use of a cow's milk pasteurization machine is considered financially feasible.

Payback period shows the speed of return of investment funds. The payback period contains a comparison of investment funds with annual cash flows. Based on the calculation results, the length of time required to return the investment funds for the cow's milk pasteurization

machine is around 1 week 3 days. The payback period is generally said to be financially feasible if the length of the payback period is faster than the useful life of the asset.

NPV or Net Present Value is an indicator of the potential return on an investment. The NPV value is said to be financially feasible if the value is greater than zero. The NPV value itself is obtained by discounting all cash flows to their present value. The results of the analysis of the pasteurization machine get an NPV value > 0 which means it is financially feasible. Meanwhile, the IRR (internal rate of return) is said to be feasible if the value is higher than the interest rate.

Conclusion

Based on the results of the design and realization along with the discussion of the measurement results, it can be concluded that the machine can operate with a capacity of 15 liters with temperatures between 60°C and 80°C. The rotation of the stirrer will increase as the temperature increases. The additional cost due to the use of electricity for each liter of milk of Rp. 21.25 for the maximum capacity, does not really make the price increase significantly.

The resulting innovation in the designed pasteurization system is the ease of replicating the equipment, especially for farmers who want to make similar pasteurization equipment. Another innovation is that the materials used in building pasteurization equipment are very easy to obtain and inexpensive. Easy operation is also an important point in the design of this equipment.

Contribution in the field of research is to obtain an easy and inexpensive method for designing pasteurization systems and very easy to scale up capacity. contribution to the community in the form of a pasteurization equipment system that is not patented, so that it can be imitated by anyone, especially dairy farmers, in order to improve the quality of dairy cows' milk.

In summary, the design of the pasteurization machine has been realized well and has been tried by dairy farmers. the equipment can function properly and is easy to use, and easy to be replicated by the parties who need it.

A possible improvement for future development is the creation of a system that can be adjusted for its operating mode, especially in the use of electric power. In addition, it is also possible to create a system that is easy to clean by developing a lifting mechanism for the inner tube which is easier to remove from the main tube.

Acknowledgments

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