Development of a herbal cream mixer with a homogenizer-stirrer and circulating water cooling system

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Abstract

This paper presents a study on the development of a herbal cream mixer with a homogenizer-stirrer and circulating water cooling system. The machine is designed to address problems in the production of herbal creams and lotions by the entrepreneurs of the Thangrak Company Limited, Chiang Yuen Sub district, M\textsuperscript{uang} District, Udon Thani, Thailand. It has a capacity of around 100 liters and employs a circulating water-cooling system. The homogenizer uses a 3-horsepower electric motor to control the rotation speed of the stirring head, which in turn controls the mixer speed. The level of the machine is adjusted using an electric hoist. Cream was produced in 80 liter batches. Mixer speed was tested at four levels: 30 Hz (1,800 rpm), 35 Hz (2,100 rpm), 40 Hz (2,400 rpm) and 45 Hz (2,700 rpm). The total time of each run was approximately 30 minutes. The results showed that a temperature reduction of the ingredients from an initial temperature of around 70\textdegree C down to approximately 33\textdegree C. The process took around 1 hour and 30 minutes. From the experimental results, it was found that the product made at 1,800 rpm had a lower viscosity of around 78.4 Pa.s. The cream of this batch was not as homogenized as it should have been. However, tests at 2,100, 2,400, and 2,700 rpm produced a creamy material with increased viscosities of 94.3, 94.8 and 96.7 Pa.s, respectively. The herbal cream products made in the developed mixer with homogenizer-stirrer and a circulating water-cooling system were homogenous. They compared favorably with herbal cream products sold in the market. The designed mixer produced a cream product that is more homogenous, while the products now available on the market have separated cream and are not as well homogenized.

Keywords: Homogenizer-stirrer, Circulating water cooling system, Herbal cream

1. Introduction

Herbal creams are a group of cosmetic (skincare) products for nourishing, remediing dry skin, and addressing other skin problems. Most of these creams are in liquid form. The present community and small enterprises have a good reputation in cream production since these products rely on herbal extracts mixed in the cream. They increase the value of the cream and help to smooth skin. A herbal cream manufacturing process is needed that uses modern equipment in its manufacturing process to increase the competitiveness of these entrepreneurs. The current methods of stirring use high shear mixers,
e.g., high shear reactor, rotor-stator mixers and high shear homogenizers [1, 2]. The stirrers of these units have high rotor tip speeds of about 10 – 50 m/s, very high shear rates of 20,000 – 100,000 s$^{-1}$. The energy distribution rate is high near the stirring head [3, 4]. High energy is required for the unit operations of homogenization, dispersion, emulsification, grinding and dissolving.

The entrepreneurs of Than grak Company Limited, in Udon Thani Province, manufacture herbal cosmetic products, e.g., creams, lotions, shampoos, soaps, and other products. They are made for both retail and wholesale distribution. The average sales volume of these creams and lotions is about 4,000 bottles per month at an average price of 150 baht per bottle. Their monthly production is valued at more than 600,000 baht/month. Recently, these entrepreneurs recognized the need for innovation and improved technology for cosmetic product manufacture and processing, especially for the process used to mix the cream. The currently used equipment is antiquated, requires long processing times and has a low production capacity. Presently, the process of manufacturing herbal cosmetic cream products does not exceed 20 liters/batch. Manufacture requires five steps. The first is heating the cream mixture (coconut oil, volatile matter and herbal materials, among other ingredients), allowing them to dissolve at 45°C for 5 minutes. Then, distilled water is heated to 75°C. Next, the cream mixture is added to warm distilled water in the stirring tank. The batch is then cooled for about 30 minutes in an air-conditioned room. After that, cold stirring is done. The product cannot be stirred when it is warm because it can degrade. Stirring is done manually using a small stirrer. During the stirring process, a catalyst and enzyme are added. This step takes about 45 - 60 minutes. Finally, the cream product is placed in a manual filling machine to package the product in bottles. Then, the final product will be distributed. The production capacity of facility producing these cosmetic products is not more than 80 liters per day, i.e., four batches a day. Furthermore, it was found that the cream was not as homogeneous as other products currently available in the market. This is a result of sub-optimal mixing.

A review of recent research revealed a novel raw material mixing process using a homogenizer in the work of Bucher [5] who developed a homogenizer for processing chemical materials into a homogeneous form at a laboratory scale. André et al., [6] also used dimensional analysis considering the mixing time and energy consumption of a planetary mixer to develop a homogenization process for free-flowing powders. Ekpeni et al., [7] studied the parameters that influence the energy production of a high-pressure homogenizer (HPH) using yeast as a biomass source. This research produced a novel homogenizer stirrer.

The aim of the current research is to develop a herbal cream mixer employing a homogenizer stirrer with a circulating water cooling system to control temperature. A production capacity of about 100 liters/batch addresses the manufacturing problems in stirring cream mixtures and lotions faced by our entrepreneur clients. The time required for both the cooling and mixing steps was reduced. The product of this process is a homogeneous cream. Its production requires reduced labor in the stirring process and achieves a much higher production capacity.

2. Methodology

2.1 Design of a herbal cream mixer with homogenizer-stirrer employing a circulating water cooling system to control temperature

The developed mixer has a width × length × height of 100 × 145 × 230 cm, respectively. The capacity of this tank is approximately 100 liters. The storage tank employs a double layer construction. The outer layer cools the product by circulating a water coolant through a jacket using a ½ horsepower pump drawing a water coolant from an external tank. The homogenizer uses a 3-horsepower electric motor to control the rotation speed of the stirring head, which in turn controls the speed of the mixer. The maximum speed of the mixer is 3,000 rpm. Its level can be adjusted using an electric hoist. The components of this machine are shown in Figure 1.

Figure 2 illustrates the developed herbal cream mixer with a homogenizer-stirrer and circulating water cooling system designed and fabricated for entrepreneurs of the Thangrak Company Limited. The equipment has a modular design so it can be simply separated and moved. A controller is used to adjust
the stirring head speed. Its maximum speed is at 50 Hz producing 3,000 rpm at the exit channel of the cream product where a stainless valve is installed.

**Figure 1.** The components of the herbal cream mixer with homogenizer-stirrer with a circulating water-cooling system

**Figure 2.** The herbal cream mixer with homogenizer-stirrer and circulating water cooling system
2.2 Equipment and Materials

1) The developed herbal cream mixer with a homogenizer-stirrer and circulating water cooling system, as shown in Figure 2.
2) A cream mixture (80 liters per batch)
3) Digital thermometer (Figure 4)
4) Rotor viscometer
5) 80 mL beakers
6) Cream products
7) A cream sample that is currently available in the market
8) Stopwatch

2.3 Test of the water-cooling system

Figure 3 depicts a result of the cooling time test of the cream mixture using a vortex system. Water in the tank was pumped through the outer jacket of the vessel containing the cream mixture. Then, a mixture consisting of distilled water heated to 75°C and herbal cream ingredients (coconut oil, volatile substances, and herbal fermentation enzymes, among others) dissolved at 45°C. The time required to cool the mixture to 30 – 35°C was determined using a digital thermometer and stopwatch, as shown in Figure 4. Then the mixture was stirred using a homogenizer pin in the next process.

Figure 3. Cooling reservoir tank with vortex cooling system

Figure 4. Measuring the temperature of the cream mixture using digital thermometer during cooling
2.4 Effect of mixing speed on the viscosity and characteristics of herbal cream products

Figure 5 presents the effects of mixing speed on the viscosity and characteristics of herbal cream products. The cream was produced 80-liter batches. The mixer speed was tested at four levels: 30 Hz (1,800 rpm), 35 Hz (2,100 rpm), 40 Hz (2,400 rpm), and 45 Hz (2,700 rpm). The total time of each run was approximately 30 minutes. Afterward, the product viscosities were determined using a rotor-viscometer and compared with those of commercially available creams and the original cream of the entrepreneur.

2.5 Communication of research technology to target enterprises

The developed herbal cream mixer with a homogenizer-stirrer and circulating water cooling system was provided to the entrepreneurs of Thangrak Company Limited. They used it in the production of herbal creams and lotions to stir ingredient mixtures. This reduces manual labor and working time, as well to increase the production capacity and the quality of cream products.

3. Results and Discussion

3.1 The operability of the vortex cooling system

Figure 6 depicts/shows the results of cooling time tests of the cream mixture in a vortex cooling system. Eighty liters of the mixture were produced in each batch. After the test, the initial temperature of the mixture was around 70°C and it was reduced to 33°C, due to the cooling water circulation inside the external tank, the temperature of the cream mixture inside the internal tank was lowered further. Which is the temperature in which stirring starts. The developed process requires approximately 1 hour and 30 minutes, while the original method produces ten liters per batch, followed by 1 hour of cooling. The developed process requires a longer time, however, its production volume eight times greater. It also does not require an air-conditioned room for cooling, which can reduce the electrical expenses. The current process was operated using a small coolant tank. Increasing the volume of the coolant tank can further reduce cooling time.
3.2 The effect of mixing speed on the viscosity and characteristics of herbal cream products

Figure 7 shows the effect of stirring speed on the viscosity of the cream products manufactured in the developed herbal cream mixer. Stirring speed was examined at four levels, 30 Hz (1,800 rpm), 35 Hz (2,100 rpm), 40 Hz (2,400 rpm) and 45 Hz (2,700 rpm). In each test, stirring was done for 30 minutes. From the experimental results, the product made at 1,800 rpm showed a lower viscosity of 78.4 Pa.s. This product was not sufficiently homogenized. However, when produced at 2,100, 2,400, and 2,700 rpm, the cream products had increased viscosities of approximately 94.3, 94.8 and 96.7 Pa.s, respectively. In this study has chosen speed at 2,100 rpm. Due to the considered results of the viscosity which has no differences the speed used has no effect on stirrer vibration during processing. These creams were more homogenous as compared with herbal cream products sold in the market. The original product produced in this facility had separated cream and was not at all homogenous. Figure 8 demonstrates the physical appearance of products made by using the original and developed processes.

Figure 6. Time-temperature of the cream mixture in the developed herbal cream mixer with homogenizer-stirrer and vortex cooling system
Figure 7. Effect of mixing speed on the viscosity of herbal cream products

![Image of viscosity graph]

| Stirring speed (Hz) | Viscosity (Pa.s) |
|---------------------|------------------|
| 30                  | 75.0±2.65        |
| 35                  | 94.3±1.15        |
| 40                  | 93.7±0.58        |
| 45                  | 93.7±0.58        |

Figure 8. The characteristics of cream made by stirring using the developed machine compared with conventional stirring

Table 1. The viscosity of cream products

| Cream products                                      | Viscosity (Pa.s) | Characteristics of cream products |
|-----------------------------------------------------|------------------|----------------------------------|
| Cream products obtained from conventional stirring  | 75.0±2.65        | Not well homogenized             |
| Cream products obtained from stirring using the     | 94.3±1.15        | Homogeneous                      |
| developed machine                                   |                  |                                  |
| Citra brand cream products                          | 93.7±0.58        | Homogeneous                      |
3.3 The communication of research technology to target enterprises
The developed herbal cream mixer with a homogenizer-stirrer was shared with the entrepreneurs of the Thangrak Company Limited. They will use it in the production of herbal creams and lotions. It can increase their daily production capacity to a level of not less than 100 liters (at least two times greater), and produce creams with higher quality. The saleable cream products and the working machinery are shown in Figures 9 and 10, respectively.

![Figure 9. The saleable herbal cream products](image)

![Figure 10. The developed machinery in operation](image)

4. Conclusions
Development of a herbal cream mixer with a homogenizer-stirrer and circulating water cooling system was done to solve problems in the production of herbal creams and lotions for the entrepreneurs of Thangrak Company Limited. The machine has dimensions of width × length × height of 100 × 145 × 230 cm, respectively. The capacity of the tank is around 100 liters. The design of the storage tank was double layer. The outer layer is a jacket employing a vortex cooling system with a ½ horsepower pump drawing coolant water from an external tank. The homogenizer uses a 3-horsepower electric motor to modulate the rotational speed of the stirring head, which controls the speed of the mixer. The cream was produced at a volume of 80 liters per batch. Stirring speed was tested at four levels, 30 Hz (1,800 rpm), 35 Hz (2,100 rpm), 40 Hz (2,400 rpm) and 45 Hz (2,700 rpm). The total time for each run was
approximately 30 minutes from the beginning of stirring. The entire process requires around 1 hour and 30 minutes. However, the current design uses a small storage tank for coolant which leads to suboptimal cooling time. The size of this tank can be increased to further reduce the cooling time. From the experimental results, it was found that product made at 1,800 rpm had a low viscosity of around 78.4 Pa.s. This cream was not as homogenized as it should have been. However, when products were made at 2,100, 2,400, and 2,700 rpm, the cream had increased viscosities of 94.3, 94.8 and 96.7 Pa.s, respectively. These creams are more homogenous than the products sold in the market. The cream originally manufactured in this facility tended to separate and it was not well homogenized.

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