SHORT COMMUNICATION

Effect of temperature and time on flow characteristics of paneer whey

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Abstract Whey is the fluid by-product obtained during the manufacture of products like paneer, cheese and casein. Beside water, whey contains lactose, protein, fat and ash. Whey can be converted into various types of product, viz, whey powder, lactose, high protein whey powder, demineralized whey powder, whey protein concentrate powder etc. For converting whey into these products, processing is necessary, which invariably depends on flow characteristics. Therefore, the objective of the present investigation was to determine the effect of temperature and time on flow properties of paneer whey. These properties were determined considering 3 levels of temperature (20, 25 and 30°C) and 3 time intervals (1, 2 and 3 h). 'Reynold's apparatus' set up separately and 'Pipe friction apparatus' mounted on hydraulic bench (with a sump and a measuring tank) were used in present experimentation. The effect of temperature and time on head loss due to friction was determined for flow of whey in a particular diameter pipe with a particular velocity. There was not much appreciable effect on viscous characteristics with respect to temperature, whereas the time elapsed had shown significant effect on head loss due to friction. However, there was not much appreciable effect on variation of absolute viscosity with respect to time, whereas the temperature had shown significant effect. The data generated in the present investigation can be utilized as guidelines for designing of whey based processing systems.

Keywords: Paneer whey, head loss due to friction, Reynold's number, absolute viscosity, parameters for design of whey processing system.

Introduction

India is the largest milk producer in the world and it is estimated that about 5% of milk produced in India is converted to paneer (Chandan, 2007). Paneer whey is the fluid by-product obtained during manufacture of paneer. After coagulation, when it is separated from the curd, it contains about 93.1% water, 5.1% lactose, 0.9% protein, 0.6% ash and 0.3% fat (Shendurse et al., 2009). The total world production of whey is approximately 85 million tonnes in which India contributes approximately 8 million tonnes (Mishra, 2008). Whey can be converted into a range of product, viz, whey powder, lactose, high protein whey powder, demineralized whey powder, whey protein concentrate powder, granulated high protein powder, filled high protein whey powder etc. These products can be used in infant foods, weaning foods, bakery products, confectionary products, dairy products, pharmaceutical and animal feed etc (Patel et al. 1991).

Viscosity is an important flow property which is affected by temperature and shear rate amongst others (Rha, 1975; Lewis, 1987). It is important therefore, to assess the flow properties as an aid to rheological characterization and establish the temperature dependence of these properties. The viscosity of the whey is expected to be dependent on the concentration and can also be influenced by external factors such as temperature, pH and ionic strength (Reza and Elizabeth, 1994). The measurements of viscous properties are required for all material types from fluids to semi-solids and even for solid systems such as polymers and composites. Various whey based products are prepared using whey obtained from paneer, cheese or casein. This study was undertaken to determine some flow and viscous properties of whey which can provide necessary information for the optimal design of whey handling system comprising of pumps, pipes and fittings. These
properties does not only affect energy requirement but also important for deciding whey processing parameters. Heat transfer operations may be incorrectly calculated if flow properties are not assessed properly (Rao and Anantheswaran, 1982).

**Materials and Methods**

**Preparation of paneer**

The paneer whey was obtained as a by-product of the manufacture of paneer from local market of Raipur city of Chhattisgarh state. The local sweet shop owners have adopted a typical method based on their own experiences for manufacture of paneer. For preparation of paneer, buffalo milk was taken in a batch and then filtered. After filtration, the milk was heated up to 80-90°C. The heated milk was cooled to 70°C and coagulated at this temperature with the addition of one-day-old paneer whey. The quantity of coagulant was 4-5 litres for 40 litre milk. After coagulation of milk, the curd was transferred to a muslin cloth and pressing was done. After removal of curd, a greenish fluid 'paneer whey' remains in the coagulation container. During pressing also some amount of whey was also obtained.

**Procurement of paneer whey**

This study was conducted in such a way that the wet bulb temperatures at ambient conditions were 20°C, 25°C & 30°C during the course of investigation. Therefore, in this study flow properties and their variation were determined at above temperature only. As the whey was at ambient its temperature did not vary during experimentation. The paneer whey about (60 to 70 litres) was procured in afternoon and kept in refrigerated condition at 10°C in a refrigerator. Before the experiment, the paneer whey was brought to ambient temperature. For this purpose, the paneer whey was filled in milk can having a capacity 40 liter and hot water sprinkled over the wall of the milk can with the little agitation inside the can. Sprinkling of hot water stopped when the temperature of paneer whey attained temperature equal to wet bulb temperature of ambient (i.e. 20, 25 and 30°C). The main experiment was done at intervals of 1, 2 and 3 h after initial procedure and thus the total time taken for this experiment was about 4 to 5 h. The different tests carried out before experiment was chemical test, i.e. acidity, fat & SNF (BIS: 1479, part I and part II, (1981)) and microbiological test i.e. total bacterial count (ISI (1981) SP: 18, Part XI)

Reynold's number using Reynold's apparatus

Reynold's apparatus consists of glass tube with one end having bell mouth entrance connected to water tank. The tank has sufficient capacity to store water. At the other end of the glass tube a cock is provided to control the flow. A small dye container is placed at the top of the tank. In the beginning, diameter of pipe and size of measuring tank etc. were measured. The tank was filled with paneer whey. Glass tube was partly opened so that no air is entrapped in it. Then the outlet valve of the glass tube was closed. The inlet valve of the tank was also closed, when the tank is full. Colour dye was filled in dye tank. Control valve was opened slightly and then opened the inlet valve in such a way that the water level in the tank was remained constant. Then the inlet of the dye injector was opened so that the dye stream moves at a straight line throughout the tube which shows that the flow is laminar otherwise it may be transient or turbulent. Reynold's number of paneer whey was calculated by using the following formula

\[ \text{N}_{re} = \frac{\rho V D}{\mu} \] (1)

Where;

\[ \text{N}_{re} = \text{Reynold’s number} \]
\[ V = \text{Velocity of fluid (m/s)} \]
\[ D = \text{Diameter of pipe (m)} \]
\[ \mu = \text{Absolute viscosity of paneer whey (Pa.s)} \]
\[ \rho = \text{Mass density (kg/m}^3) \]

Loss of head due to friction in viscous flow

The loss of head due to friction in viscous flow was calculated using equation

\[ H_f = 16/N_{re} \] (2)

Where;

\[ H_f = \text{Loss of head due to friction} \]
\[ N_{re} = \text{Reynold’s number} \]

Absolute viscosity using pipe friction apparatus

This apparatus consists of pipes of same material which were provided with common inlet manifold. The control valves are attached to regulate the flow, near the downstream end of the pipes. Pressure tapping are taken at suitable distance apart, between which a common multi tube manometer is connected for measurement of pressure. In this experiment the friction apparatus was mounted on hydraulic bench. The paneer whey which was already filled in sump tank, was pumped up and flown through a pipe. After removing trapped air from the friction apparatus, the constant flow of whey was maintained and pressure difference was recorded using mercury filled manometer (in cm). Absolute viscosity was measured at three level of temperature 20, 25 and 30°C and three levels of time 1, 2 and 3 h.

Absolute viscosity

Absolute viscosity of paneer whey was measured by Poiseuille
equation

$$\mu = \frac{(\Delta PR^2)}{8LV} \quad (3)$$

Where;

$\mu$ = Absolute viscosity of paneer whey (Pa.s) (1 Pa.s=10 Poise)
$\Delta P$ = Pressure drop (Pa)
$R$ = Radius of the pipe (m)
$L$ = Length of the pipe (m)
$V$ = Velocity of the fluid (m/s)

Results and Discussion

Chemical and microbial quality of paneer whey

The chemical and microbial quality of paneer whey was evaluated before the experiment. It was found varying during the entire investigation period. However, variations were within a range. The fat was found to vary between 0.1-0.3%, whereas solids not fat (SNF) was found to vary between 5 to 6%. In the present set of experiment, the whey was found to have titratable acidity between 0.38 to 0.4% with the standard plate count between 5,000 to 8,000 cfu/ml.

Effect of temperature and time on the loss of head due to friction of paneer whey

The effect of temperature and time interval for experiment on loss of head due to friction in pipe for paneer whey (H) is shown in Fig. 1.

Fig. 1 shows that the loss of head due to friction for paneer whey (at 20°C of fluid temperature) decreased from 0.0145 to 0.0135 when time interval of experiment increased from 0 to 3 h. More or less similar trends were observed when the temperature of paneer whey varied to 25 and 30°C. The decrease in head loss due to friction with increase in time might be associated with increase in density and velocity of whey. The statistical analysis of effect of time and temperature on the frictional head loss for paneer whey was also done. From the analyzed data, it was found that the temperature and combined effect of temperature and time did not show any effect but the time had shown significant effect.

Effect of temperature and time on absolute viscosity of paneer whey

The effect of temperature and time interval for experiment on absolute viscosity of paneer whey is shown in Fig. 2.

Fig. 2 shows that the absolute viscosity of paneer whey decreased from 0.015 to 0.011 Poise when the temperature of paneer whey increased from 20 to 30°C. Similarly, when the time interval of experiment increased from 0 to 3 h, it also increased from 0.012 to 0.014 Poise. The absolute viscosity of paneer whey had decreased significantly as the temperature of paneer whey increased. It may be due to reduction of cohesive forces between the molecules therefore the force of attraction between them reduces which eventually reduced the viscosity of the liquids. The cohesive forces between the molecules reduce with increase in temperature. Roopa et al. (2010) studied time dependent rheology of guava jam and reported that the viscosity of guava jam decreased with increase in temperature. Statistical analysis of effect of time and temperature on absolute viscosity of paneer whey was
also done. From this analyzed data, it was revealed that the temperature and time had shown significant effect but the combined effect of temperature and time exhibited non-significant effect.

Conclusions

The study indicated that there is not much appreciable effect on variation of flow characteristics like loss of head due to friction with respect to temperature, whereas the time elapsed had shown significant effect on it but in case of absolute viscosity, appreciable effect was noticeable with both time and temperature. Based on the results it may be concluded that both time and temperature plays important role in paneer whey processing.

References

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