MECHANISM OF WALL EFFECT ON FLUIDITY OF MILK IN A CAPILLARY

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INTRODUCTION

Milk is one of the most important and popular biofluids containing various nutrients. It is significant to investigate rheological properties of milk in a capillary to explain the milk flow on tongue and through throat for the consumer preference. In the previous papers, flow properties of milk in a capillary have been studied by viscosity measurements with various bore-sizes of capillary viscometer and photo-microscopic observation. In this paper, effects of silicone coated glass capillary tube on flow properties of milk were elucidated in comparison with the result obtained in a non-coated glass capillary tube.

EXPERIMENTAL

Fig. 1 is the schematic view of the experimental method. The apparatus used throughout this experiment was a Maronen-Belner type low shear capillary viscometer combined with a photomicroscope. Viscosity measurements were carried out with various bore sizes of capillary viscometer with continuous varying pressure head of shear stress range from 0.2 to 30dynes/cm².

Fig. 1 Vertical section of photomicroscopic system combining with a viscometer.
A. Capillary portion  B. Water bath
C. Xenon lamp  D. Condenser lens
E. Photomicroscopic camera
To take a photograph of the image of milk fat droplets flowing in a capillary, photomicroscope combined with a capillary viscometer was used. In this experiment, silicone coated glass capillary tube was used to compare with non-coated glass capillary tube. Chemical component of used silicone coating agent is a polymer of dimethyl-poly-siloxane as shown in Fig.2. This polymer chain stretches its polar oxygen binding toward the capillary wall, and hydrophobic binding of methyl radical stretches toward the center of the capillary tube. The thickness of the coated polymer layer is about 100Å.

RESULTS AND DISCUSSION

The viscosity (F/G) versus shear stress (F) plots of milks of 1% fat are shown in Fig.3. These figures (a), (b) and (c) show human fresh milk, cow's fresh milk and homogenized milk, respectively. With the sample of the concentration of milk fat, a non-Newtonian flow is observed in all ranges of shear stress, and a curve shown by dotted line obtained with skim milk is observed to be slightly non-Newtonian flow behavior. Except for this suspension of the skim milk, the viscosity of the emulsion decreases apparently 10-30% or more between the smallest capillary bore and the largest one at a given shear stress. The flow behaviors of the other sample of cow's fresh milk in various capillary bore sizes are shown in this figure. The shear dependence on the viscosity is observed markedly at a lower shear stress than at a higher stress, while the difference in viscosity due to the size of the capillary bore is marked at a high shear stress. The result of