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Rheology Applied to Dairy Products

Vanessa Bonfim da Silva[1] and Marion Pereira da Costa[2]*

[1]Program in Animal Science of the Tropics, Escola de Medicina Veterinária e Zootecnia, Universidade Federal da Bahia, Brazil
[2]Department of Preventive Veterinary Medicine and Animal Production, Escola de Medicina Veterinária e Zootecnia, Universidade Federal da Bahia, Brazil

Food rheology consists in the science that studies the solids deformation and the liquids fluidity by the influence of applied mechanical forces [1]. When we study rheology, we need to distinguish the Newtonian and non-Newtonian fluids. The Newtonian fluid presents a viscosity system, which is independent of the rate of deformation applied. On the other hand, the non-Newtonian fluid the viscosity depends on the rate of deformation that can or cannot depend on the shear time [2]. Thus, food rheology parameters are directly related to the acceptance of the final product by consumers. However, the foods rheological behavior, such as dairy products, can be influenced by some factors as food processing, product stability, and organoleptic properties. For these reasons, the food rheology is an important analytical tool to evaluate food quality [3]. Specifically, in dairy products, the rheological proprieties can be influenced mainly by three factors: (1) raw material quality; (2) type and characteristics of ingredients used; and (3) the technological process.

Therefore, the rheological characteristics evaluation of milk and milk products can be applied for selection of raw materials and process type, beyond the quality control of the final product [4]. In milk and cream, the rheological behavior is similar to emulsions and suspensions in general. Both can exhibit Newtonian or non-Newtonian behavior depending on the composition, conditions or processes to which it may be subjected [5]. The composition of milk has a determining influence on the rheological characteristics of dairy products. The fat content has a greater effect on dairy rheology. In this way, products with high concentration of fat have different behaviors. The milk protein mainly casein also influences the viscosity of dairy products. The physicochemical properties of fat globules and proteins are the most affected of the milk constituents. However, these compounds can be modified by some factors, as thermal process and mechanical operations [6], which significantly change the rheological characteristics. Thus, certain compounds and factors can increase or decrease the rheological characteristics of milk and its semi-liquid derivatives [5].

The butter is a dairy derivative which may be defined as an emulsion of water droplets in a semisolid matrix of milk fat. The milk fat matrix is mainly responsible for the texture of butter, consisting of a three-dimensional network of fat crystals enmeshed in a liquid oil medium. When at low shear, butter behaves as viscoelastic material [6].

Fermented milk, as yogurt, exhibits a viscoelastic behavior and highly time-dependent shear thinning in flow, presenting a complex rheology. Its rheological behavior depends on the concentration, composition, and pretreatment of the milk (especially heat treatment), starter culture and incubation conditions [7,8]. In addition, some ingredients as inulin and malto-dextrin or fruit pulp can be used to increase the viscosity of goat milk yogurts [7]. The fermentation process of also influences the rheological behavior mainly when are used strains that produce exopolysaccharides can be used to increase the viscosity of the yogurt and decrease susceptibility to syneresis. Measurement of rheological properties allows the characterizing and predicting the effects of variables involved in the manufacturing process on the sensory aspect of the final product, especially its texture [5].

Sweetened condensed milk is considered a high-viscosity suspension of lactose crystals, fat globules, casein, and whey proteins in a saturated solution of lactose and sucrose, presenting rheological behavior complex and exhibiting time-dependent shear thinning. Thus, like sweetened condensed milk, Dulce de leche is also viscoelastic [5].

The ice cream consists in a dispersion of milk fat and vegetable fat in an aqueous phase containing non-fat milk solids, carbohydrate sweeteners, and a stabilizer (usually a hydrocolloid). It is thus essentially a dilute oil-in-water emulsion and in this aspect, is similar to cream. However, it presents viscosity and rheological behavior variable, because they depend on both mix formulation and processing conditions [5]. The ice cream is a frozen dairy product consumed in the frozen state; therefore the freezing and whipping processes are factors that considerably influence the development of the desired structure, texture, and palatability [9]. Still according to Bahramparvar and Tehrani [9], stabilizers, as polysaccharides, are one such ingredient, which, in spite of the low level in the formulation, impart specific and important functions to the finished ice cream, influencing its texture and acceptability.

In cheese, the milk casein content has a significant influence on the rheological properties of the rennet gel, its setting speed and its maximum firmness [10]. Hekken et al. [11] observed that high-moisture Cheddar cheeses, produced from goat's milk containing different amounts of fat, have been shown to be influenced by a protein matrix consisting mainly of β-casein and that although β-casein has been degraded during 6 months of maturation, the level of fat in the matrix had a much greater influence on the rheological properties. In the cheese production process, the coagulation interferes in the cheese production, because the cheeses obtained from milk with low coagulation capacity are more susceptible to losses in storage and can be submitted to incomplete and non-homogeneous serum drainage, generating defects in the maturation stage [12].

To conclude we tried to show how rheology may interfere with the final dairy product and how the steps in the manufacturing process significantly influence these derivatives. Thus, we perceived how each stage, from beginning to end of production is important to obtain a final product with rheological characteristics compatible with the type of dairy product.

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***Corresponding author:** Marion Pereira da Costa, M.Sc., Ph.D., Doctor of Veterinary Medicine (DVM), Department of Preventive Veterinary Medicine and Animal Production, Av. Adhemar de Barros, 500 - Ondina Salvador, Bahia, Brazil, Tel: +55-71-3283-6711; E-mail: marioncosta@ufba.br

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