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Effects of hydrocolloids and processing conditions on acid whey production with reference to Greek yogurt

Rabin Gyawali [a, b, *], Salam A. Ibrahim [b]

[a] Energy and Environmental Systems, North Carolina Agricultural and Technical State University, USA
[b] Food Microbiology and Biotechnology Laboratory, 173 Carver Hall, North Carolina Agricultural and Technical State University, Greensboro, NC, 27411, USA

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ABSTRACT

Background: Greek yogurt is one of the most popular products in the overall yogurt category and has gained immense popularity due to its higher nutritional values compared to traditional yogurt. Greek yogurt is defined as a strained yogurt in which yogurt is concentrated by removing acidic whey from the solid part. This process creates large volumes of acid whey as by-product that cannot be readily utilized nor disposed of easily.

Scope and approach: The dairy industry has been seeking a solution to the problem related to acid whey production. Here, we discuss several factors, especially hydrocolloids that have the potential to limit the quantity of acid whey in Greek yogurt production by playing a major role in the water retention capacity of yogurt products. In addition, the impact of yogurt processing conditions on acid whey production is discussed.

Key findings and conclusions: Hydrocolloids, though still largely unexplored, could have potential benefit of helping to minimize acid whey production if used as additives in Greek yogurt. Moreover, through the optimization of yogurt processing conditions, acid whey production could also be reduced.

1. Introduction

Yogurt is the world's most common dairy product. Greek and Greek style yogurts (hereafter referred to as 'GY') are currently the fastest growing products in the dairy industry (Bong & Moraru, 2014). GY, also known as strained yogurt, is obtained after draining whey. GY can be manufactured using addition of hydrocolloids or by straining the natural set yogurt in cloth bags. Recently, there are other straining methods available to manufacture GY for the industrial scale production (Fig. 1) (Bong & Moraru, 2014; Özer, 2010). As a result of the draining process, GY has higher total solids and lower lactose than regular yogurt. This has contributed to increased consumption of GY and is directly related to consumer awareness of the health benefits associated with this yogurt due to its higher nutritional value (Desai, Shepard, & Drake, 2013). Due to the higher production of GY and straining process, there is increased acid whey production. The production of large quantities of acid whey has brought about both economic and environmental challenges (Bong & Moraru, 2014; Elliott, 2013; Smithers, 2015). Even though acid whey is a nutritious byproduct, it cannot be readily utilized by the food industry. The high biological oxygen demand and low pH (<4.5) further restrict the use of acid whey. In addition, there are strict regulations against the dumping of acid whey and particular care must be taken with its disposal (Elliott, 2013). Moreover, the disposal of acid whey creates additional costs for the dairy industry. We should mention here that some of GY companies are actually paying milk suppliers to use acid whey in animal feed (Elliott, 2013). The dairy industry is therefore seeking a solution to the problems associated with acid whey. Thus, the reduction of acid whey during yogurt production could directly benefit the GY industry.

Water holding capacity (WHC) is the ability of food to hold its own or added water during the application of force, pressure, centrifugation, or heating. WHC is also the ability of food to retain water against gravity and has shown to play a major role in the formation of food texture (Sahni, Gupta, & Nand, 2014). In yogurt production, WHC is one of the most important physical properties that contribute to curd stability. Hydrocolloids such as gums and proteins have been used as additives to improve the texture and quality of yogurt. These hydrocolloids have the ability to hold water

* Corresponding author. Food Microbiology and Biotechnology Laboratory, North Carolina Agricultural and Technical State University, USA.
E-mail address: rgyawali@gmail.com (R. Gyawali).

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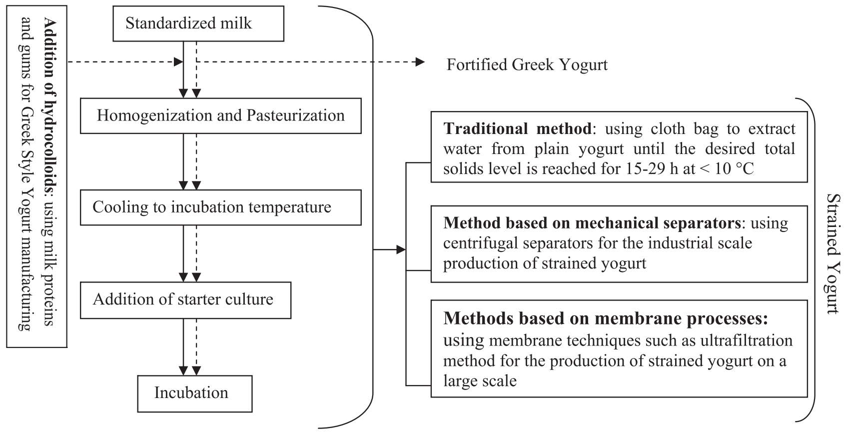

Fig. 1. Processing steps in the manufacture of Greek yogurt.

and form a gel-like structure. The WHC of yogurt is an indicator of its ability to retain serum in the yogurt's gel structure. This ability contributes to minimal whey separation which is a crucial aspect of the overall quality of the yogurt (Lee & Lucey, 2010).

Several studies have indicated the importance of hydrocolloids in yogurt quality (Akalin, Unal, Dinkci, & Hayaloglu, 2012; Saha & Bhattacharya, 2010; Soukoulis, Panagiotidis, Koureli, & Tzia, 2007; Tasneem, Siddique, Ahmad, & Farooq, 2014); however, a review of the literature revealed lack of detailed information on the factors influencing WHC. Thus, we would like to discuss and summarize several factors that could influence water holding properties. These factors include milk composition, hydrocolloids, starter culture, probiotics, and processing conditions. We believe the present discussion could contribute to a broader understanding of the minimization of acid whey production during GY manufacture under the influence of several factors discussed. Although standard definitions of terminology such as water holding capacity, water binding property, gelling property, whey separation, serum separation, and syneresis may vary, we have used this terminology interchangeably throughout the paper to simply explain water (acid whey) holding phenomena in yogurt production.

2. Milk composition

Milk composition varies due to breed, geographical location and feeding, and these variations strongly affect the manufacturing conditions, sensory quality, and nutritional properties of yogurts (Ozrenk & Inci, 2008). The composition of milk can vary depending on the season of the year. Different levels of fat and protein have been observed in milk harvested in different seasons. Ozrenk and Inci (2008), found higher milk fat, protein, and total solids in milk harvested in winter compared to summer. Such seasonal variations in milk have been reported to affect the viscosity, serum separation, and acidity in yogurt production (Sodini & Tong, 2006). For instance, low fat yogurt may be more prone to syneresis while yogurt made from full-fat milk retained a significantly higher percentage of serum within its structure that is shown to reduce syneresis (Brennan & Tudorica, 2008). Le et al. (2011) also reported that milk fat globule can help to increase the WHC of yogurt gel. The authors noted that these milk fat globules increased the firmness of yogurt and produced denser microstructures compared to nonfat yogurt and thus enhanced WHC. Milk fat also stabilizes the contraction of protein gel formed after fermentation of the yogurt mix and hinders whey separation. As a result, in yogurt with few or no stabilizers, a low fat content in milk encourages whey separation, while a high fat content prevents separation because milk fat plays an important role as a stabilizer. During the preparation of low fat or nonfat yogurt, stabilizers are used to compensate for the loss of the stabilizing effect of milk fat (Chandan & O'Rell, 2006a). The size of casein micelles also varies according to feeding regimens and individual cows, and between seasons. Glantz et al. (2010) studied the importance of casein micelle size and milk composition on milk gelation. The structure of the casein micelle is essential in the processing of milk into a gelled product such as yogurt. Smaller sizes of casein micelles were observed in milk harvested in summer compared to winter. These authors also reported that a smaller native micellar size may favor gelation characteristics in milk.

Thus, a prior knowledge of milk composition based on seasonal variations could help those in the dairy industry decide which products could be processed from milk samples received in different seasons. For example, if the protein content in milk is high, the milk can be processed to make cheese whereas if the fat content is higher, milk can be processed to produce butter (Ozrenk & Inci, 2008). Moreover, when milk protein is higher, the milk can be processed to manufacture GY, as GY is noted for its higher protein content. The study of the effect of seasonal variation on the composition of milk is clearly important to the dairy industry as well as to consumers who are looking for healthier food products.

3. Hydrocolloids

Hydrocolloids are widely used in many food products to improve quality and shelf life. They are heterogeneous group of long chain polymers commonly used to describe a range of polysaccharides and proteins (Williams & Philips, 2009a,b) and are characterized by their ability to form gels, viscous solutions, and thickeners when dispersed in water. The presence of a large number of hydroxyl (−OH) groups markedly increases the affinity of hydrocolloids to bind water molecules making these hydrocolloids hydrophilic compounds. Hydrocolloids produce a dispersion that is intermediate between a true solution and a suspension and thus exhibit the properties of a colloid. Polysaccharides and proteins are appropriately referred as 'hydrocolloids' or 'hydrophilic colloids' (Saha & Bhattacharya, 2010). The reasons for using hydrocolloids in dairy products are twofold: the binding of water and improvements in texture which otherwise suffer from wheying-off (Syrbe, Bauer, & Klostermeyer, 1998). In yogurt, particularly, variations in viscosity, syneresis, and whey production during storage are considered to be major defects. Therefore, hydrocolloids (gums and proteins) are often added to overcome such defects (Keogh & O'kennedy, 1998).

Gums are complex hydrophilic carbohydrates that are