Influence of Starch on the Rheological, Textural, and Microstructural Properties of Processed and Analogue Cheeses

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Processed cheese (PC) is a widely consumed dairy product and has undergone significant evolution over time, leading to various formulations aimed at enhancing texture and functionality. This review addresses the role of starch addition on PC, focusing on starch interactions with milk proteins and understanding its influence on the rheological properties, microstructure, and overall quality of PC. Our key findings indicate that starch serves as a cost-effective ingredient that can replace or supplement dairy components, improving texture and water-binding capacity while reducing formulation costs. Generally, starches containing a higher amylose content are associated with the increased hardness and decreased meltability of PC. The insights provided in this review underscore the importance of understanding starch–milk component interactions to optimize PC formulations, paving the way for future research and innovation.

milk proteins starch interactions meltability viscosity

Processed cheese (PC) was first manufactured in the early 20th century, and since then, many different varieties of PC have been developed around the world. The Code of Federal Regulations (CFR) distinguishes three different categories of PC based on the type of ingredients used, i.e., pasteurized PC, pasteurized PC food, and pasteurized PC spread. The standards of identity for pasteurized PC, pasteurized PC food, and pasteurized PC spread according to the CFR for moisture, fat, and pH are less than or equal to 40% (w/w), 44% (w/w), and 44 to 60% (w/w); more than or equal to 30% (w/w), 23% (w/w), and 20% (w/w); and more than or equal to 5.3, 5.0, and 4.0, respectively [1]. There is also a further, less-defined category termed pasteurized PC products. This category of PC products has a composition similar to the various categories of PC; however, in contrast to pasteurized PC, pasteurized PC food, and pasteurized PC spread, PC product formulations may contain ingredients such as milk protein concentrate, milk protein isolates, and casein-based ingredients [1]. The CFR does not list starch as an optional ingredient for pasteurized PC, PC food, and PC spread. However, a draft for a standard for PC was started by the Codex Committee on Milk and Milk Products, which included the use of starch as an optional ingredient [2]. The use of starch in PC products is allowed in various countries, including the United Kingdom, Germany, and France, with French legislation stating a limit for starch addition up to 20 g kg^{-1} of PC [2]. PC analogues can also be manufactured by using both dairy and non-dairy ingredients to reduce the amount of natural cheese in the product [3]. Dairy-based PC analogues can be prepared by replacing milk fat with vegetable oils, such as soy bean oil, peanut oil, palm kernel oil, corn oil, or coconut oil [4]. On the other hand, non-dairy-based PC analogues are prepared by replacing both milk fat and milk protein with vegetable oils and plant protein, respectively [4].

The process of making PC includes the selection of natural cheeses and other dairy and non-dairy ingredients such as salt, water, emulsifying salts, and acidulants, followed by grinding and blending the ingredients and heating the mixture to a specified time–temperature combination before packaging, cooling, and storage [1][5]. PC is often used in foods like pizzas, burgers, and toasted sandwiches, and the characteristics of PC, such as firmness, viscosity, and meltability, play an important role in their functionality in these applications [6].

Starch is used in several dairy products, often to improve texture and rheological properties, and it is a readily available and low-cost polysaccharide [7]. Starch can also be used in PC as an additional ingredient, as well as in the form of a direct replacement for protein or fat since these dairy ingredients contribute most to the cost of PC products [3]. The efficacy of starch in PC products depends on several factors, including its origin, concentration, proportion of amylose to amylopectin, and processing variables, including temperature, pH, and shear [7][8]. When starch is used in dairy matrices, the swelling and gelatinization of the starch can be affected by the presence of milk components, especially milk proteins, because milk proteins can also form a gel upon heating. This can also lead to competition between the starch and milk proteins for water binding and gelation when heated together [9]. Therefore, the interactions during the heating of starch in the presence of milk components are important to understand the effect on the final properties of PC.

Previous studies have investigated the use of starch in dairy systems [7] as well as milk protein–starch interactions, along with their application in extrusion-based products [10] and the influence of starch on the rheology of model dairy systems [11]. However, there is no review focusing on the interactions of starches with individual milk components and emphasizing the role of starch in shaping the texture, rheology, and microstructure of PC products. Hence, this review focuses on the interactions of milk components with starch and its impact on the properties of PC products. For this purpose, we will start in Section 2 on starch and its gelatinization. Subsequently, Section 3 will focus on the interactions between milk proteins and starch, and Section 4 will focus on how other constituents of milk, such as salts and lactose, affect starch gelatinization. The insights of these sections are subsequently applied in the application of starch in PC, which is covered in Section 5.

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