

# Effect of production process and flavor additions on Greek yogurt

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**Abstract.** Greek yogurt has become increasingly popular among consumers in recent years because of its high protein and low fat properties. There are two main processes for the production of Greek yogurt, i.e. whey filtration process and non-whey filtration process. The whey filtration process is to separate the whey from the regular yogurt; the non-whey filtration process is to add whey protein to the regular yogurt to increase the protein content of the yogurt. In China, due to the short time of developing Greek yogurt, the utilization efficiency of whey is not high, so the production is still mainly based on non-filtered whey process. At this stage, many companies have developed various flavors of Greek yogurt to meet the consumers' demand for different flavors and tastes of Greek yogurt. In this paper, by comparing the raw material ratios and processes of plain Greek yogurt with fruit flavored Greek yogurt, rose flavored Greek yogurt and chia seed Greek yogurt, the results obtained show that the added flavor additives have a small effect on the raw material ratios of Greek yogurt production, and the nature of the added flavor additives will have an effect on the time they are added in the production, resulting in a product with uniform texture and smooth taste.

**Keywords:** Greek yoghurt, production process, flavor additives.

## 1. Introduction

Yogurt is recognized as a healthy food, with many types and brands and high market demand. In recent years, as people's living standard is improving, many chronic diseases such as hypertension, hyperglycemia and hyperlipidemia have gradually become an important cause of health hazards [1]. At the same time, people are increasingly aware of the importance of a healthy life. Therefore, Greek yogurt, which is high in protein, low in lactose and low in fat, is gaining more and more popularity.

Greek yogurt, i.e. whey-free yogurt, is traditionally made by separating whey to obtain a short, thick and creamy yogurt. Greek yogurt has richer protein and less fat than traditional yogurt, with a delicate and rich flavor and a taste between yogurt and cheese [2]. The traditional method of production is not suitable for the initial development of Greek yogurt because of the large investment in equipment, high cost and cumbersome production process. The other method is to increase the protein content by adding whey protein, recovered milk and casein in order to make the product with higher protein [3].

In the 1990s, Fage, a leading Greek dairy company, first produced and launched its whey-free yogurt with the label Greek Yogurt. The product became an instant success in Europe and the United

States, and since then Greek yogurt has become synonymous with whey-free yogurt. As of 2014, Greek yogurt accounted for 25% of the total yogurt market in the United States. For China, its time to develop Greek yogurt is still relatively short. In 2015, the newly established yogurt brand Le Pure, whose main product is whey-free yogurt, has three times more protein, calcium and active probiotics than ordinary yogurt. From November 2016 to the present, Le Pure yogurt still maintains a monthly growth of 50 to 100%, with a monthly reorder rate of 25%. In November 2017, Bright Yogurt launched the first Greek yogurt in China, focusing on 3 times protein and zero fat. Over the years, the process of making whey-free yogurt has matured, with further improvements to the traditional method of whey separation and optimal ratios for the easier-to-operate addition of whey protein [4]. At this stage, normal Greek yogurt can no longer satisfy people's desire for rich flavors and colors, therefore, in order to meet the different needs of consumers, products such as fruit and vegetable flavors, cereal flavors, and floral flavors have emerged [3, 5-6].

## **2. Key ingredients involved in making whey-free yogurt**

### *2.1. Whey*

Whey is the by-product left after the separation of milk from solids during the cheese making process. The main components of the strained whey are more than 70% lactose and about 15% protein (whey isolate, whey protein concentrate), which is a light yellow or green opaque liquid [7-8]. Whey is mainly divided into sweet whey and sour whey, of which sour whey is a by-product of Greek yogurt production. The annual production of whey in the world is about 180 to 190 million tons per year, but only 50% of whey can be reused [8]. At present, whey is mainly processed into concentrates, whey powder, whey protein drinks, etc., which are added to beverages for human consumption or poultry feeding. In addition, there is still more than half of whey discharged as waste water. Due to its high organic load, whey is often considered as an important source of pollutants for waste water in the dairy industry [7]. Therefore, the recycling of whey and the improvement of Greek yogurt preparation methods are of great importance for energy saving and sustainable development of the dairy industry.

### *2.2. Whey protein*

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### *2.3. Casein*

Casein is an important protein in milk. It is a tasteless, odorless, acidic phosphorus-containing protein that precipitates from milk at its isoelectric point (pH=4.6) at 20 degrees Celsius. Casein is mainly composed of four monomers, alpha-casein, beta-casein, gamma-casein and kappa-casein. Casein is a hydrophilic and lipophilic molecule and therefore has functional properties such as foaming, emulsification, water holding and gelation. Casein is also the most abundant protein in milk with the highest nutritional value. Therefore, casein is commonly used in food processing as a functional supplement and often as a milk substitute for infants and children. The process mainly includes filtered whey process, non-filtered whey process; according to the specific method, it can be divided into indicator fortification method, membrane concentration method and whey separation method.

### **3. Production process of whey-free yogurt**

The production process of whey-free yogurt is mainly divided into two categories: filtered whey process and non-filtered whey process; according to the specific method, it can be divided into indicator fortification method, membrane concentration method and whey separation method [12].

#### *3.1. Indicator fortification method*

This is done by adding whey protein powder (WPP) to the ingredients in order to increase the protein content of the yogurt. The heat treatment step in the yogurt production process causes denaturation of the proteins in the milk, resulting in cross-linking of protein micelles and formation of soluble protein complexes, which affect the pH of the yogurt and consequently the hardness of the yogurt [13]. Many studies have shown that the addition of WPP to hot milk can reduce the setting time of yogurt, increase the protein content of milk, improve the hardness of yogurt, and improve the tissue shape. The advantage is that there is no special requirement for cow's milk, no additional investment in equipment, and higher viscosity and water-holding capacity than normal yogurt, which is suitable for dairy companies that have just started Greek yogurt production. However, the disadvantage is that the protein content of the product produced is limited, basically around 6%, mainly because the high protein leads to an increase in the calcium content of the base material, which makes calcium ions combine with casein to form calcium caseinate particles, thus affecting the taste of the product, and the addition of phosphorus salts to balance the calcium salts can be considered in the production [14].

#### *3.2. Membrane concentration method*

The main membrane separation methods involved in the Greek yogurt making process are reverse osmosis and ultrafiltration [12].

*3.2.1. Reverse osmosis.* The operation process of separating the solvent from the solution by means of a reverse osmosis membrane under the effect of pressure difference is called reverse osmosis and is suitable for separating low molecules and ions with a diameter of 2 nm or less. Reverse osmosis can be performed at lower temperatures in many fields, but milk is often heated due to the yogurt making process to increase the efficiency of reverse osmosis. This method requires high fixed investment and requires a large area of reverse osmosis membranes, while reverse osmosis membranes require regular cleaning and maintenance, and have problems such as too short service life.

*3.2.2. Ultrafiltration.* Ultrafiltration is the filtration of solute molecules and solvents smaller than the membrane pores by using the micro-pores of semi-permeable membranes under the effect of pressure difference, while large molecules of solutes are intercepted and recovered by the membrane. The pore structure of ultrafiltration membranes ranges from 1 to 20 nm, which is suitable for retaining large molecules such as proteins, fat globules, polysaccharides, etc. The advantage of this method is that skim milk with different protein content can be obtained by changing the UF membrane pore size, but the initial investment in equipment is high and the ultrafiltration membrane is made of ceramic, which will affect the service life if left for a long time, so it is not suitable for dairy companies that produce small quantities [13].

Ozer et al. comparatively studied the characteristics of yogurt concentrates made by ultrafiltration and reverse osmosis methods in different treatment processes before and after fermentation, respectively, and concluded that the samples treated by ultrafiltration method after fermentation yielded high flavor acceptance and high overall scores, and that the ultrafiltration method is suitable for industrial production of concentrated fermented milk through analysis of product composition and growth of fermenting strains in different solids contents [12].

### **4. Greek yogurt preparation steps**

The main method of making Greek yogurt used in China at present is: Firstly, the fat is removed from raw cow's milk by standardized equipment, and the fat content should be controlled to less than 0.2%.

The skimmed milk is heated to 50°C~55°C, whey protein powder is slowly added, fully stirred to dissolve it and left to hydrate for 30min. The rested solution is homogenized at 55°C~60°C and 180~200bar pressure conditions. After homogenization, take 95°C~97°C water bath sterilization for 300s. Then lower the temperature to the optimum temperature for fermentor work, inoculate the fermentor under aseptic condition, stir well and keep warm for fermentation. After fermentation to the desired pH, break the milk and cool down to room temperature for filling [1]. For Greek yogurt with added flavor additives, the added flavor substances that are not affected by heating can be added to skim milk together with whey protein [3]. For additions where heating destroys the flavor, they should be added after the fermentation has cooled down to room temperature and is complete [5-6].

## **5. Impact of various flavor additives**

### *5.1. Without flavor additives*

The protein content of plain Greek yogurt without flavor additives in the non-filtered whey process should not exceed 8%, usually about 6%, because the high protein makes the calcium content of the base material also increase, and calcium ions will form calcium caseinate particles with the casein in the yogurt, affecting the taste of the final yogurt. In the study by SONG et al. the optimal process for plain demulcent yogurt was fermentation at 42 degrees C for 6 hours, skim milk powder added at 7%, inoculum at 4% and sucrose at 3% [2].

### *5.2. Addition of jam*

In the fruit-flavored Greek yogurt developed by su et al, the optimal process to obtain fruit-flavored yogurt was fermentation for 10 hours, with 4% addition of sucrose, 3% addition of milk powder and 7% addition of jam [5]. Compared to plain Greek yogurt, the difference in the amount of sucrose added to the fruit-flavored yogurt was less than that of the plain flavor, mainly because the addition of sucrose may have a greater effect on the taste of the yogurt than that of milk powder and jam. The amount of milk powder added was only half of that of plain Greek yogurt, excluding the effect of different milk powder brands on the state of the yogurt, and the addition of jam was also an important reason. The application of milk powder and skimmed milk powder is related to the hardness, viscosity and consistency of the yogurt, and the addition of jam as a flavoring substance in the fruity Greek yogurt also has an impact on the final consistency of the yogurt, so it is necessary to reduce the amount of milk powder during the production of fruity Greek yogurt to obtain a moderate viscosity of the Greek yogurt.

### *5.3. Addition of rose syrup*

In a study by liu et al. on rose-flavored Greek yogurt, the optimal process parameters were obtained as 7 hours of fermentation at 42 degrees Celsius, 5% inoculum, and 8% rose pulp addition [6]. The results of the study showed that compared with plain Greek yogurt, the difference in both fermentation temperature, fermentation time and inoculum amount of rose-flavored Greek yogurt was small, indicating that rose pulp had less influence on the properties of Greek yogurt such as hardness, viscosity and viscosity, and more influence on its taste and color.

### *5.4. Addition of chia seeds*

In the study of chia seed flavored yogurt developed by ma et al, the optimal process was found to be 0.3% mixed ferment, 9% sugar addition, 4% chia seed addition, and 6 hours of fermentation [3]. The results of the study showed that the amount of white sugar added during the development of chia seed Greek yogurt was about three times higher than that of plain Greek yogurt, and that the addition of chia seeds also had an effect, in addition to the different sensory evaluation criteria such as yogurt sweetness by different groups of experimenters. In plain Greek yogurt, the addition of 9% sucrose resulted in a thinner overall curd with a small amount of whey precipitation, while in chia seed Greek yogurt, the addition of chia seeds increased the total solids content in the fermentation system,

enhancing the water-holding capacity of the casein gel and thus improving the consistency of the yogurt.

## 6. Conclusion

At this stage, the development of the Greek yogurt industry in China is less than ten years old, and is later than that of European and American companies. Considering the high initial investment cost of the whey filtration process and the less mature development of the utilization of whey, the development of Greek yogurt in Chinese dairy companies is currently more suitable for non-whey filtration processes, such as the addition of whey protein and other methods. In the development of plain Greek yogurt, the best process was derived as 6 hours of fermentation at 42 degrees Celsius, 7% skim milk powder addition, 4% inoculum and 3% sucrose addition. For flavor additives such as jam and chia seeds, which have an effect on the properties of Greek yogurt, the addition of sucrose and skim milk powder can be increased or decreased to achieve a smooth Greek yogurt with good solidification. Considering the different nature of different flavor additives, for flavor additives such as chia seeds, which do not deteriorate under high temperature fermentation, can be added to the system together with sucrose, skim milk powder and whey protein, while for flavor additives such as jam and rose pulp, which may destroy their original flavor or deteriorate under high temperature, they should be added after high temperature fermentation is completed and cooled. to the system. In the future, as the process of making Greek yogurt in China becomes more mature, dairy companies should further develop the use of whey in parallel, gradually converting the production process from non-filtered to filtered whey, resulting in a more traditional high-protein, low-fat Greek yogurt. In addition, dairy companies can develop different flavors and sweetnesses of Greek yogurt to meet the different needs of consumers.

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