The Rehydration Ability of Whey Ingredients

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Abstract. The purpose of this research was to study the ability of whey protein concentrates (WPC) and whey permeate produced with ultrafiltration of cheese whey to rehydrate. The products studied were cheese whey concentrate with a PDM percentage of 80% (WPC-80), and cheese whey permeate, both produced under the conditions of the PJSC Dairy “Voronezhsky”. WPC-80 and the whey permeate dissolution processes were studied using microscopy. Water-impermeable hydrophobic layers were formed at the boundary, preventing water penetration into dry particles. The result was a higher dissolution time for WPC-80 compared with whey permeate. When WPC-80 came into contact with water, it initially formed an obtuse wetting angle with a slow change over time. Whey permeate reached the equilibrium wetting angle more quickly. Quick reconditioning of WPC moisture content required avoiding capillary penetration of water, which created a turbulent liquid flow. The application of these ingredients in different food industry areas can reduce the costs for finished products, contribute to cost-effectiveness, increase the total production, and reduce environmental risks.

Keywords: whey protein concentrate, whey permeate powder, water-wetting, dissolution

1. Introduction

Current market trends demonstrate an increase in the production of milk-intensive protein products, which technology associates with creating large volumes of a by-product—milk whey [1]. It contains about 50% of solids and more than 80% of whey proteins from milk, which determine its high biological value [2, 3]. Analysis of protein, carbohydrate and lipid complexes indicates significant advantages for using milk whey as a raw material for food production, making its processing highly relevant and economically feasible.

Among the most promising methods for milk whey processing there are membrane methods [4]. They are based on its properties as a heterogeneous system with a clearly defined selectivity of components by molecular weight, size and ionic strength (micro-, ultra- and nanofiltration). Drying of whey fractionation ingredients allows obtaining products with a long shelf life and high nutritional and biological value. These ingredients
are widely used in infant food, gerodietetic and sports nutrition, in confectionery for taste enrichment and as stabilizers in the production of meat and dairy products [5]. Such technological approach helps to compensate the deficit of essential substances, correct immune system functioning and increase non-specific resistance of a human body to adverse environmental conditions.

Taking into account that development of the functional products industry encourages production growth of such ingredients and the constant expansion of their application field, research has been conducted to study the ability of whey protein concentrates (WPC) and whey permeate produced with ultrafiltration of cheese whey to rehydrate. Complete and rapid rehydration of powder products is the most important characteristic of their quality. It determines the ability of whey ingredients to perform certain technological functions in food systems.

2. Materials and methods

Objects of research were cheese whey concentrate with PDM percentage of 80% (WPC-80), cheese whey permeate, produced under conditions of PJSC Dairy “Voronezhsky”.

Research methods included standard common methods accepted in research practice for assessing the recombination ability for powdered dairy products.

The process of wetting and dissolving was studied using immersion microscopy (Altami Bio 1 microscope, Canon camera adapter) with 200x magnification of the “squash” preparation. The specimen was placed on a slide, covered with a coverslip and fixed on the stage. An electronic image of the preparation was obtained with the camera adapter and AltamiBio software.

Since the main factor determining wetting ability is surface tension at the border between a dry particle and water, the limiting wetting angle for whey ingredients was measured. This indicator characterizes wetting of powder with a drop of water, overcoming the boundary tension between solid and gas phases.

The test sample was distributed over a hard surface in a uniform layer. The liquid was surfaced in such a way to neglect the effect of gravity on the drop spreading. For this purpose, a 0.1 ml water drop was placed on the prepared surface using a microsyringe. A pipette instrument was installed very close to the surface so that the drop could spread and come into equilibrium with the surface. The limiting wetting angle was measured using a goniometer.

The experiment results were processed with mathematical statistics after analyzing the data in triplicate. Graphic interpretation and data processing were carried out...
using Microsoft Office 16.0 application software package. The obtained results are characterized by high reproducibility, interoperability of the experimental data, and accurate statistical processing.

3. Results and discussion

Each particle of a powder product has a complex surface with a significant branched system of capillaries of various sizes and geometrical shapes. Therefore, it is characterized by different capillary attraction. For this reason, an important quality indicator of a dairy powder product is its ability to rehydrate. The first stage of this process is wetting. Particles in contact with liquid go to the critical state during dispersion and dissolution and then begin to detach from the powder surface and flow into the liquid. Simultaneously, a concentrated solution of the dissolved product is forming around the particles. When a dissolved particle reaches a greater density than that of water, it sinks to the bottom. In this case, moisture absorption of the powder depends on the ratio on the surface of each particle and the thickness of the hydrophobic layer of milk fat and the hydrophilic layer of whey proteins, lactose and mineral salts [6, 7, 8, 9].

WPC-80 and whey permeate dissolution processes were studied using microscopy (Figure 1). It was found that water-impermeable hydrophobic layers were formed at the boundary "WPC particle-water", preventing water penetration into dry particles (Figure 1b). The result of this phenomenon was an increase in the dissolution time for WPC-80 against whey permeate.

WPC-80 in contact with water initially forms an obtuse wetting angle (Figure 2) with a slow change over time. Whey permeate reaches the equilibrium wetting angle faster over time. Thus, WPC-80 is characterized by worse wettability in comparison with the permeate.

Since wetting occurs not only on the surface of the water: the particles lying above the water surface are also wetted due to the capillary flow of the liquid. The replacement of pore air with water under the capillary forces for WPC-80 is insufficient, and air bubbles can remain between the wetted particles. This contributes to lumps formation in a dry product, wetted and swollen on the outside and dry on the inside. Complete rehydration of this sample will be difficult even with intensive mixing. Therefore, quick reconditioning of WPC moisture content requires avoiding capillary penetration of water that creates a turbulent liquid flow.
Figure 1: Microscopy of the dissolution process of whey powder ingredients: a) cheese whey permeate; b) WPC-80.
Figure 2: Dependence of changes in the limiting wetting angle of a powder product on the duration of contact with water.

4. Conclusion

When powder contacts with water its particles begin being wetted, dispersed and dissolved. Therefore, the study of whey ingredients rehydration process nature is essential for their application in different food industry areas. This will allow for finished product cost reduction, contribute to cost-effectiveness increase at the production and reduce environmental risks.

5. Ethics Policy

The authors declare no conflict of interest.

6. Funding

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References


