Reduction of the particle size in fresh cheese by mechanical post-processing

Hahn, C., Sramek, M., Nöbel, S., Hinrichs, J.,
Department of Food Science and Biotechnology, University of Hohenheim

Consumer expectations on fresh cheese are governed by a creamy and smooth microstructure even for low-fat products. In addition, high storage stability is favoured. One of the main influencing factors on the microstructure of fresh cheese is the particle size.

Since there is a correlation of particle size and sensory sensation perceived in the mouth the consumer acceptance is mainly affected by the particle size distribution of a product. To simplify the issue, one can distinguish two particle classes: particles which determine the sensory sensation mainly perceived in the mouth, and particles which change this main sensory perception. To give an example: during fermentation of milk the casein micelles (100 - 300 nm) aggregate and finally form a three-dimensional network, which incorporates the whey. By stirring, microgel particles are generated. Therefore, stirred yoghurt or fresh cheese can be regarded as (concentrated) microgel particle suspension. These milk products are supposed to have a smooth, uniform and creamy structure represented by small particles (1-10 µm) in a narrow distribution; this perception is being altered by particles exceeding 100 µm. The latter mentioned particle class is sensorially recognized even in marginal volumetric fractions (Cayot et al., 2008; Sainani et al., 2004).

Companies producing fresh cheese attach great importance to provide the consumer a sensorially attractive and functional product. To give companies a guideline regarding the product properties the DLG (Deutsche Landwirtschafts-Gesellschaft) has developed an evalua-

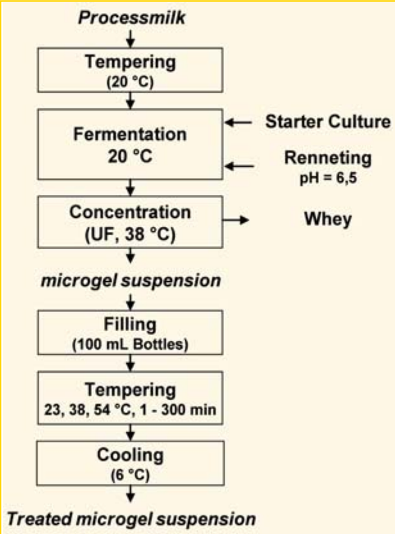

Figure 1: Experimental set-up to produce differently tempered microgel suspensions.

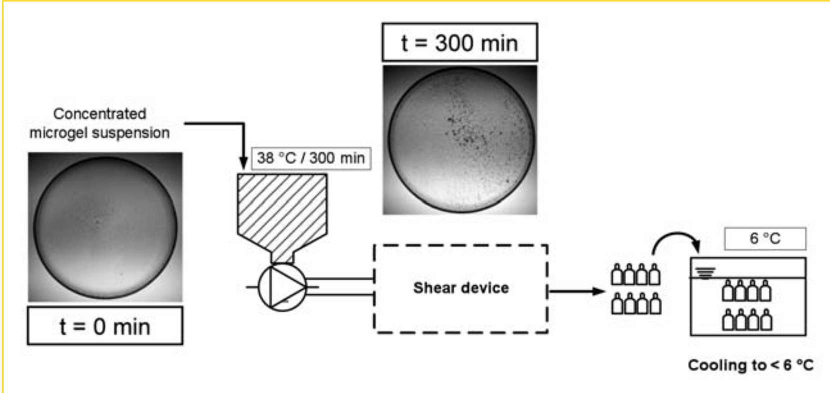

Figure 2: Experimental set up for post-processing of treated microgel suspensions (exemplarily washed out particles prior to and after temperization are shown in the picture).

tion scheme for all fresh cheese variations noting structural defects in the product. Although there have been predominantly positive results, evaluated products are criticized mainly due to 2 reasons: grainy texture and syneresis. Therefore, the question is: "Which factors influence the particle growth?" And "How can particle size in fresh cheese be reduced effectively?"

The formation of particles in fresh cheese production is an essential key element, since the nature of gels requires the aggregation of structural elements in milk leading to a transition from suspension to gel. Therefore, the manufacturer's task is it to control the particle growth so that particle size is as big as necessary but as small as needed to create the desired structure. Grainy particles can be formed and develop during manufacturing process, further processing and develop or further grow during storage (Lucey, 2004). However, in order to guarantee the absence of grainy particles, post-processing can be applied to destroy particles in advance. It has to be taken into account that all post-processing steps, e.g. pumping, cooling, stirring, to a greater or lesser extent contribute to the over-all mechanical impact on the product. Since a too heavy mechanical load can reduce storage stability, parameters of mechanical post-processing need to be adapted.

To evaluate the influence of temperature and holding-time prior to cooling microgel suspensions with a mean protein content of 8.22 ± 0.23 g/100 g (n = 12) were produced by using membrane filtration (cut off 0.1 µm) according to Bäurle et al. (1986) (Figure 1). The fermentation was carried out over night with culture F-DVS CC06 (Chr. Hansen, Nienburg), rennet was added 1 mL/100 L at pH 6.50 (Chy-Max Plus, 190 IMCU/mL, Chr. Hansen, Nienburg). Particle size distribution was measured by laser light scattering (modified from Sainani et al., 2004) and $d_{75,3}$ was chosen to represent particle growth of big particles.

Table 1 shows the $d_{75,3}$ value directly after concentration and after temperature-treatment. The particle size after concentration and therefore prior to temperature-time-treatment is constant, and related to the concentration temperature of 38 °C. This is somehow different after treatment of the sample. The particle size is increased about 2, 3, 6 times after tempering at 23, 38, 54 °C for 300 min. In addition, the higher the temperature applied the faster the particle growth and the bigger the particles. This finding allows us the defined adjustment of the particle size in order to prove the effect of mechanical post-processing.

In order to destroy particles formed in the microgel suspension, treated microgel suspensions were prepared according to Figure 1 and tempered in a vessel at 38 °C for 300 min prior to post-processing (Figure 2). The mechanical post-processing was carried out with a ro-

Temperature in °C	$d_{75,3}$ in µm*	
	After concentration (t = 1 min)	Time of tempering (t = 300 min)
23		61 ± 16
38	35.8 ± 7.5	92 ± 24
54		174 ± 16

*Mean of 5 independent experiments and 3 in device particle size measurements.

Table 1: Particle size of concentrated microgel suspensions prior and after temperature-time-treatment at different temperatures.

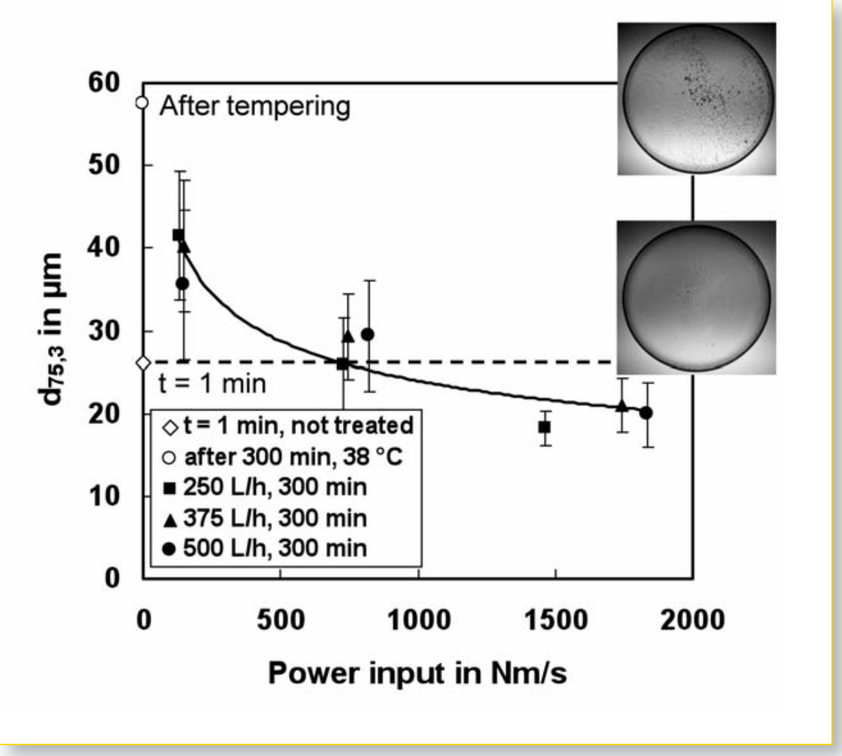

Figure 3: Reduction of particle size in fermented concentrated microgel suspensions with a rotor/stator device (Ytron-Z) (protein content 8.22 g/100 g, error bars represent the standard deviation, n = 3)

tor/stator device (Ytron-Z, Ytron Process Technology GmbH & Co. KG, Bad Endorf) and both a sensor for torque and rotation number of the device was integrated to monitor the power input during post-processing. The Ytron-Z consists of stationary and rotating tooth rims through which the microgel suspension is pumped. By varying the flow rate and the rotation number of the device the residence time and the power input was adjusted.

Figure 3 displays the influence of flow rate (250, 375, 500 L/h) and rotational number (300, 1500, 3000 min^{-1}) on the particle size after shearing. The particle size decreases with increasing rotational number. Furthermore, decreasing flow rates tend to result in decreased particle size, which can be attributed to the longer residence time in the shear gap. The reduction of particle size can be approximated by a power law function: with increasing power input the destruction of big particles is enhanced resulting in smaller particles. For this study the $d_{75,3}$ prior to temperization was chosen as a parameter for a smooth, homogeneous structure (dotted line in Figure 3); the added pictures show the visual perceptible particles. The initial $d_{75,3}$ prior to temperization is achieved by applying at least 750 Nm/s, what corresponds with a rotation number of the shear device of 1500 min^{-1}. A higher mechanical load results only in further degradation of the structure and, therefore, an increased tendency to structural defects.

From the presented results the following conclusions can be drawn:

- Temperature load forces the particle growth in concentrated microgel suspensions
- The higher the applied temperature the faster the particle growth
- Direct cooling after concentration is an useful tool to inhibit particle growth
- Mechanical post-processing with an rotor/stator-device can be applied to reduce particle size

The presented results enable fresh cheese manufacturers firstly to avoid the growing of big particles in the process. Secondly the rotor/stator-device is an useful tool that can be integrated additionally in an already established process to ensure both the reduction of big particles developed in the process and a homogeneous, smooth and creamy structure. Thus, the mechanical post-treatment is capable to compensate variations in raw material, process and final product regarding the particle size.

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