MultiScan MS 20

Studying the gelation process during yogurt formation at different temperatures

- To understand the effect temperature has on the gelation point and the quality of yogurt

Yogurt has become one of the most popular dairy products in recent years. A variety of tastes and textures are developed to meet the customers' requirements for yoghurt products. In this design process, it is of great importance to understand the formation of yoghurt. Yogurt is made by the gelation of milk using bacteria. Through the coagulation of casein micelles, a gel network is formed at the temperatures between 42 °C and 45 °C. The temperature plays an important role in the gelation process, as it significantly affects the gelation point and therefore the quality of the yogurt when it comes to, for example, mouth feel. This process is usually studied by measuring pH-values. However, these values can only offer little information in the real gel formation process.

The MultiScan (MS 20) *from DataPhysics Instruments is a* ***compact and versatile measuring device*** *for optical stability and aging analyses. It can study* ***gelation processes easily and provide additional information about stability issues*** *in yogurt design. In this application note, we study the effects of temperature on the gelation process and its impact on yogurt quality.*

Fig. 1: Yogurt is a well-liked dairy product.

Keywords: MultiScan 20 ▪ Stability Analysis ▪ Yogurt Formation ▪ Gel Formation ▪ Gelation point ▪ Gelation Process

Technique and Method

The MultiScan MS 20 (Fig. 2) from DataPhysics Instruments is the measuring device for automatic optical stability and aging analysis of liquid dispersions and the comprehensive characterisation of time- and temperature-dependent destabilisation mechanisms. It consists of a base unit, to which up to six ScanTowers with temperature-controlled sample chambers can be connected. The ScanTowers of the MS 20 can be individually controlled and operated at different temperatures between 4 °C and 80 °C.

With its integrated software MSC, the MS 20 is an ideal partner for stability analyses, since even the slightest changes within dispersions can be detected and evaluated.

Thus, MS 20 is an ideal device for studying the gelation process and other stability issues in yogurt design.

Experiment

To make yoghurt, 100 mL of full fat milk were put in a beaker and heated to 38 °C for 5 min. 2 g yogurt ferment, containing the bacteria Streptococcus Thermophilus and Lactobacillus Bulgaricus, were added to the pre-heated milk and stirred gently with a glass rod for 2 min. The treated milk mixture was poured in three transparent glass vials (each 25 mL) and measured in the towers of an MS 20 at T = 42 °C, 45 °C (6 h) and 48 °C every 2 min for 12 h, respectively. The measured zone was between 0 mm (bottom of the vial) and 57 mm (top of the vial). Notably, the **three measurements** were carried out **simultaneously**, thanks to the possibility to **measure up to six samples with individual settings using just one MS 20**.

Fig. 3 shows the sample vials and their quality control test at the end of the measurement at 42 °C, 45 °C and 48 °C, respectively.

Fig. 2: DataPhysics Instruments stability analysis system MultiScan MS 20 with six independent Scan Towers

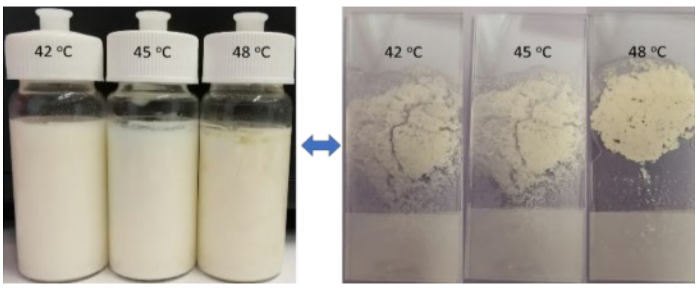

Fig. 3: The sample vials (left) and their quality control test (right) at the end of the measurement at 42 °C, 45 °C and 48 °C, respectively.

Results

Fig. 4 plots the relative backscattering intensities against the position for the gelation process during yogurt formation at 42 °C. The colour-coding of the curves indicates the time at which they were recorded, from red (start of the measurements, t = 0 s) to purple (end of the measurements). The backscattering diagram in Fig. 4 shows that the backscattering increased globally first and then stayed constant at 42 °C. This indicates that the gelation process occurred; afterwards, the mixture stabilised in its gel state.

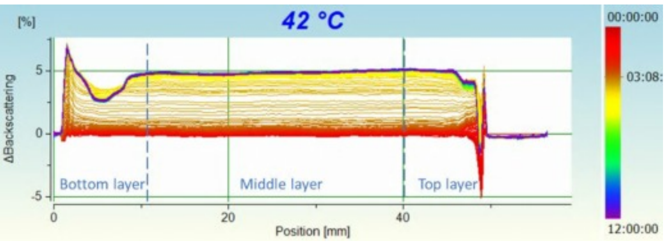

Fig. 4: Backscattering intensity diagram of yogurt formation at 42 °C

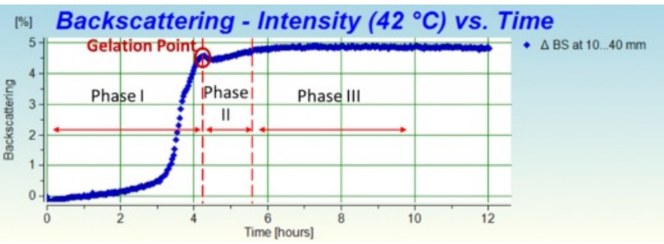

Fig. 5: Kinetics of flocculation in gelation process at 42 °C

Using the vast analytical capabilities of the MSC software, the changes of backscattering intensities can be analysed, resulting in the kinetics of flocculation in the milk gelation process (Fig. 5). The backscattering intensities increase in Phase I due to the coagulation of the system and increases of particle sizes. In addition, the flocculation caused by bacteria growth could increase volume fraction, which could increase the backscattering intensities further. In Phase II of the gelation process, a slight decrease of the backscattering is observed, because the bacteria have stopped growing. The corresponding peak is the gelation point. The backscattering intensities remain stable in Phase III, suggesting that the gel network formation has ended.

To have a better understanding of the effect of the temperature on the gelation process and therefore yogurt quality, the yogurt formation was also tested at 45 °C and 48 °C. As displayed in Fig. 6, the backscattering intensities increases globally first and then decreases over time, especially at a higher temperature (48 °C). This indicates that a gel network is formed, but it is possibly damaged over time at high temperature. This is consistent with the observations at the end of measurements. One can see a clear phase separation in the top layer of the sample at 48 °C (Fig. 3 left); and the particles of the yogurt formed at at 48 °C are larger and harder, which influences the yoghurt's texture negatively (Fig. 3 right).

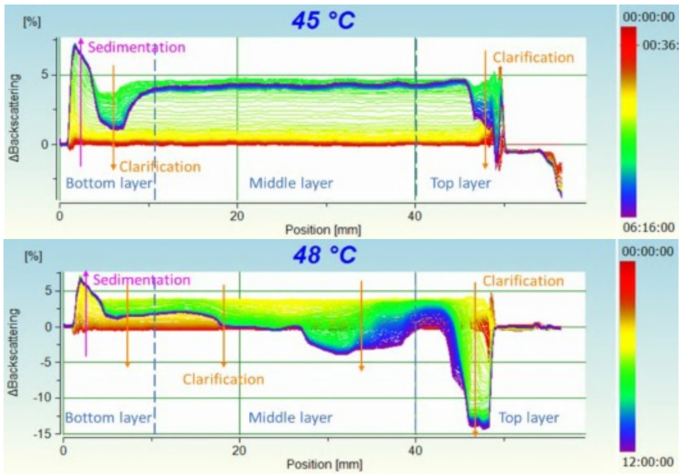

Fig. 6: Backscattering diagram of yogurt formation at 45 °C and 48 °C

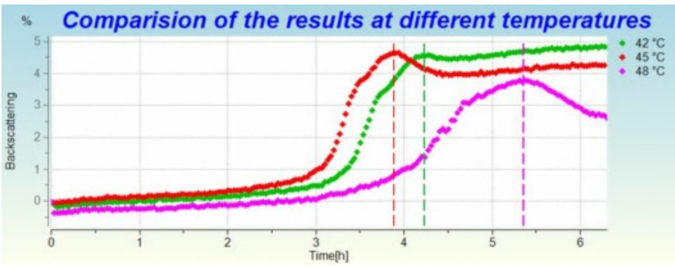

Fig. 7: Kinetics of flocculation in gelation process at different temperatures

Thanks to the overlay function of the MSC software, the difference between gelation processes at different temperatures can be displayed directly and simply. Fig. 7 shows that the casein micelles coagulate faster and the gelation point comes sooner when it is carried out at the proper temperature (45 °C), which is useful for optimising the temperature for fermentation processes.

Furthermore, from the change in backscattering intensities, possible destabilisation mechanisms after the gelation point can be deduced, as summarised in Table 1. This is very helpful to give food designers directions for optimising producing processes and product formulations.

Table 1: Phenomena and possible destabilisation mechanisms after the gelation point during yogurt formation at different temperatures

Temperature	Bottom layer	Middle layer	Top layer
42 °C	-	-	-
45 °C	Sedimentation; Clarification	-	Clarification
48 °C	Sedimentation; Clarification	Clarification	Clarification

Summary

MS 20 stability analysis system and its corresponding MSC software provide an **easy, fast and reliable way** to study the **gelation process and destabilisation mechanisms of yogurt formation**. **Changes can be detected sensitively and objectively**, which enables the food designer to anticipate and quantify **stability issues**, thus enabling time- and cost-effective product development.