Comparison of two different rheological methods for the characterization of set yoghurt

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The objective of this study was to measure the rheological characteristics of different set yoghurts with a vane directly in the yoghurt cup “as it is” without partial destruction of the weak structure before the measurement and to compare the results with the cylinder penetration method. Two different rheologic measuring approaches were used with set yoghurts. The penetration resistance of a cylinder analysed by means of an universal testing machine and the “yield stress” determination by means of vane rheometry and small amplitude oscillatory shear measurements (SAOS) were compared. The addition of native whey protein powder (3 to 12 %) to the yoghurt milk (trial 1) caused an increasingly softer texture. The incubation of byproducts (whey and permeate concentrates) before the heating of the yoghurt milk (trial 2) entailed in an increase of the firmness. A prerequisite was that the assigned concentrates exhibited a dry matter from 20 to 25%. With both measuring methods the texture characteristics of the set yoghurts could be well characterized (trial 1 and 2). The effects of the added quantity of powder or concentrate on the values determined by the two different methods were quantified. The two measuring methods gave evidence to a good agreement. In both test series a correlation could be found of 0.9994 (trial 1) and 0.936 (trial 2) respectively, between the penetration resistance of the cylinder and the “yield stress” determination measured by the vane rheometry in a SAOS experiment.

Keywords: Yoghurt (set style), native whey byproducts, vane rheometry, cylinder penetration

1 INTRODUCTION

The coagulation of milk is a process, where physical and rheological properties of milk are changing dramatically. Milk gels are mainly formed by three processes:

1) Addition of proteolytic enzymes
2) Lowering the pH to 4.6 (under the IEP of the caseins)
3) Heating over 90°C, cooling and lowering the pH to 4.6

Process 3 is usually used for the production of yoghurt and was likewise applied in our study. Because the weak three dimensional gel structure of yoghurt is partly destroyed even at low deformation, e. g. by preparing the sample between two plates, the vane geometry together with a rheometer was established. The processing of several concentrates and/or whey powders into the yogurt milk was examined and their influence on the texture/structure was compared.
The objective of this study was to measure the rheological characteristics of varied set yoghurts with a four blade vane directly in the yoghurt cup “as it is” without partial destruction of the weak structure before the measurement and to compare the results with the cylinder penetration method.

2 MATERIAL AND METHODS

2.1 Production of the yoghurt (trial 1 and 2)

The production of the set style yoghurts was carried out in the pilot plant at ALP (Liebefeld).

- Trial 1 [1]: 2% of skimmed milk powder was added to the low fat milk before homogenization at 70°C and heating at 92°C for 5 min. After the cooling of the yoghurt milk to 46°C, 5 subsets with 0 (control), 3, 6, 9 and 12% of native whey protein powder were prepared, inoculated with 3% ALP yoghurt culture (B4) and mixed by a blender. The incubation took place in 180 g cups at 43°C until a pH value of 4.4 was reached.

- Trial 2 [2]: 1 or 2% of skimmed milk powder and/or several concentrates (1 or 2%) were added (Tab. 1) to the low fat milk before homogenization at 65°C and heating at 95°C for 10 min. Ten different subsets were produced. The incubation with ALP yoghurt culture (B1) took place in 180 g cups at 43°C for 3 h.
After cooling to 5°C the yoghurt samples (trial 1 & 2) were stored for 6 days at 5°C before the rheological measurements.

2.2 Vane Rheometry (Amplitude sweep)

Oscillatory shear measurements were performed using a Physica Rheometer (MCR 300) and the four blade vane St14. The vane was introduced into the yoghurt vertically using the dimensions recommended by [3]. The deformation was elevated from 0.001 to 100% at a constant frequency of 10 rad s^{-1} and 5°C. The yield stress was calculated from the “cross over” (G’=G’’) using the US 200 software (V2.43). The data were calculated as average of duplicate yoghurts.

2.3 Cylinder Penetration

The cylinder penetration test [4] was performed using an “Universal Testing Machine” (Zwick

Z2.5/TN1S). An acrylic glass cylinder (h = 35 mm, Ø = 25.4 mm) was introduced vertically with a constant speed of 30 mm/min for 40 mm. The force at 35 mm was calculated by the software TXPERT (V10.1). The mean of two yoghurts from the same batch was calculated.

3 RESULTS AND DISCUSSION

- Trial 1: The processing of 0 (control), 3, 6, 9 and 12% whey protein powder into the yoghurt milk just before the incubation examined the great influence of the whey protein on the texture/structure and the contents of the produced yoghurt (Tab. 2). The penetration and the amplitude sweep demonstrated very well, as expected, the increasing fluidity of the yoghurt with an increasing amount of whey protein.

The largest reduction of the force at 35 mm was determined between the variant without additive and 3% whey protein. (Fig. 1)

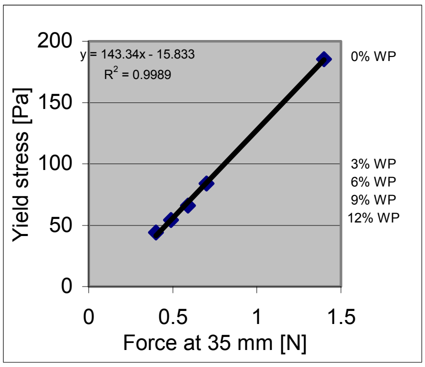

Figure 1: Correlation between force at 35 mm and yield stress (r = 0.9994).

- Trial 2: For practical reasons different concentrates of skimmed milk or milk serum as additives to increase the dry matter in yoghurt milk were compared. As a control 1% or 2% Promilk 502 was added. The addition of permeate concentrate, whey protein concentrate and the whey powder affected the structure positively. The addition of the whey concentrate (15% dry matter) led to a strong dilution of the yoghurt milk, especially for the 2% process. The result was a softer structure. (Fig. 2).

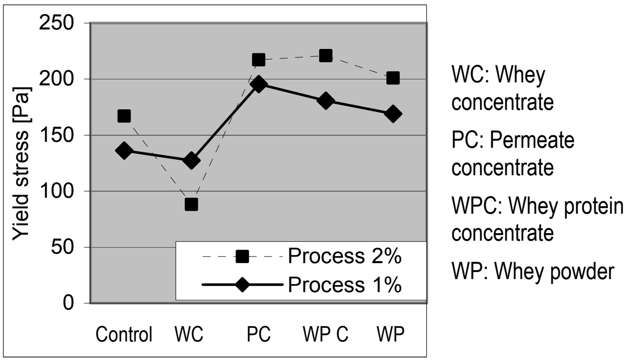

Figure 2: Yield stress determination of the different yoghurts.

For a firmer structure a dry matter of 20 to 25% of the whey concentrate was a prerequisite. With exception of whey concentrate, the process (2%) led in relation to the process (1%) to a stronger structure. The correlation of the force at 35 mm and the yield stress determination is shown in Fig. 3.

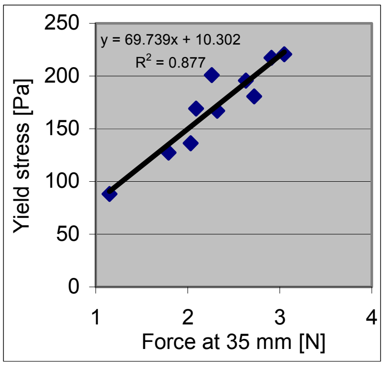

Figure 3: Correlation between force at 35 mm and the yield stress (r = 0.936)

TABLES

Table 1: Raw Materials added to 100 kg of yoghurt milk.

Test variants	Added raw material* [kg]	Total protein [kg]
Control 1% and 2% (ALP standard)	1 MP, 0.0 C 2 MP, 0.0 C	3.67 4.10
Whey concentrate 1% and 2%	1 MP, 6.8 C 0 MP, 13.6 C	3.58 3.02
Permeate concentrate 1% and 2%	1 MP, 3.5 C 0 MP, 7.1 C	4.07 4.15
Whey protein concentrate 1% and 2%	1 MP, 4.6 C 0 MP, 9.3 C	4.30 4.61
Whey protein powder 1% and 2%	1 MP, 1.0 C 0 MP, 2.0 C	4.24 4.37

* MP: Milk protein powder (Promilk 502), C: Added Concentrate

Table 2: Contents in dependence of whey protein.

Whey protein [%]	Fat [g/kg]	Total protein [g/kg]	pH-value
0 (Control)	0.58	39.5	3.97
3	0.82	63.0	4.04
6	1.05	87.1	4.14
9	1.38	108.7	4.20
12	1.57	132.2	4.25

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