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Influence of dietary fiber addition on some properties of yoghurt

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Abstract The objective of this work was to study the effect of different dietary fibers on rheological properties of yoghurts fortified with these fibers [1, 2, 3]. Commercial fibers from apple and inulin were used. The effect of addition of dietary fibers in yoghurt [4, 5] was investigated by a rotational viscometer, Brookfield viscometer (Brookfield Engineering Inc., Model RV-DV I Prime) with RV spindles. The Brookfield viscometer DV I Prime with disk spindles represents an easy and cheap method for rheological characterization of non-Newtonian fluids, in this case of yoghurt. Syneresis and pH did not show any difference, while only apple fiber yoghurt showed colour differences compared to control.

Keywords: rheology, syneresis, dietary fiber, colour

1. Introduction

Yoghurt is produced by a fermentation process during which a weak protein gel develops due to a decrease in the pH of the milk. The pH of the milk is decreased due to the conversion of lactose to acid lactic by the fermentation culture bacteria. In the liquid milk, casein micelles are presented as individual units. As the pH reaches pH 5.0, the casein micelles are partially broken down and become linked to each other under the form of aggregated chains forming part of a three-dimensional protein matrix in which the liquid phase of the milk is immobilized. This gel structure contributes substantially due to the overall texture and organoleptic properties of yoghurt and gives rise to shear and time dependent viscosity [6].

The most frequent defects related to yoghurt texture that may lead to consumer rejection are apparent viscosity variations and the occurrence of syneresis [7].

Yoghurt rheological characterization is required for product and process development and to ensure consumer acceptability [8]. This characterization can be made using either instrumental or sensory measurements.

The firmness of yoghurt and the viscosity of just-stirred gel are greatly influenced by the amount of heat treatment the yoghurt mix receives. Heating unfolds the globular whey proteins and exposes sulphydryl groups, which react with other sulphydryl groups and disulfides and induce linkages and protein-casein aggregates [9, 10].

The gel strength of yoghurt is related to the cumulative effects of the chemical interactions. The binding of δ-lacto globulin to the casein micelle seems to be responsible for the increase of gel strength [11, 12, and 13].

The beneficial effects of fibre for human health are well known. The incorporation of fibre into yoghurts represents a means of augmenting the consumption of fibre in all sectors of the population, owing to the popularity of this foodstuff [14]. There are several records of the effect of the addition of fibres on the properties of yoghurt. Lario et al. [15] found that the addition of fibre from citric fruits caused a slight decrease in the pH of milk; these authors suggested that the fibre became warmer upon mixing and liberate acidic compounds, favouring a decrease in pH. This decrease did not affect the fermentation process of the yoghurt; however, the rheological properties of the yoghurt were modified by the addition of fibre from citric fruits and depended on the dose of this fibre: 1% fibre addition reduced yoghurt syneresis and improved textural properties, increasing gel firmness. These changes may be related to the disrupting effect of fibre in the gel, which, when this fibre dose is added, is counteracted by the high water-holding capacity of the fibre [16]. In a sensory study on the addition of fibres of bamboo, wheat and inulin no significant differences were found in comparison with the control yoghurt (without fibre), and the yoghurts were found to be acceptable by a panel of consumers [17]. In contrast, in yoghurts to which apple fibre has been added, differences in sensory and rheological characteristics have been detected in comparison with the control [18].

2. Experimental

2.1.Materials

UHT milk, *Lactobacillus bulgaricus* and *Streptococcus thermophilus* pure starter culture DI PROX 986, apple fibre and inulin provided by Enzymes & Derivates, Piatra Neamt, România, orbital shaker;

The equipment used consisted in a thermostat, a Brookfield viscometer Model RV- DV II Pro, with disk spindle, RV3, RV4, RV5, RV6 type, a digital pH meter (Metrohm, Herisau, Switzerland), a Hunter-Lab colour meter.

2.2. Sample preparation

The yoghurt samples were made using UHT milk. The milk analysis by LACTOSTAR 2005 FUNKE GERBER led to the physical and chemical parameters presented in Tabel 1.

Table1. Milk properties

PROPERTIES	VALUES
Fat, g/100g	3.30
Protein, g/100 g	3.19
Lactose, g/100 g	4.61
SNF (Solid Non-Fat), g/100 g	8.49
Freezing point, °C	- 0.5
Minerals, g/100 g	0.02
Conductivity, mS	0.89

Three samples were analysed: a yoghurt control sample (without fibre), a yoghurt sample with inulin and a yoghurt sample with apple fibre.

300 mL milk were inoculated using 0.015 g starter culture. After inoculation with starter culture, the samples were homogenised with an orbital shaker for 15 min at 100 rpm. After shaking the samples were thermostated at 42^0C for 6 hours. The apple fibre and inulin were added to the yoghurt samples in the concentration of 1%.

2.3. Syneresis and pH of yoghurts

Syneresis of analyzed yoghurt was determined using drainage method [19]. The analysis was done using a Whatman filter no 589.2 (S & S, Dassel, Germany) placed on top of a funnel. After that, approximately 25 g of the samples were spread on the paper. The drainage time and temperature were 20 min and 21°C, respectively. The percentage syneresis was calculated as (liquid weight/ initial sample weight) × 100. pH of samples was measured by a digital pH meter (Metrohm, Herisau, Switzerland).

2.4. Determination of rheological properties

Viscosity measurements were carried out on the yoghurt samples at ambient temperature (25°C), with a Brookfield viscometer (Brookfield Engineering Inc, Model RV- DV II Pro+) at 2,5; 5; 10; 20; 50; and 100 rpm with RV spindle (RV3, RV4, RV5, RV6 type). The disk spindle was used in accordance with the sample nature to get all readings within the scale. According to the Brookfield requests the samples were kept in a thermostatically controlled water bath in 300 mL of beaker with a 8.56 cm diameter for about 10 min before measurements in order to attain desirable temperature of 25°C.

First measurements were taken 2 min after the spindle was immersed in each sample to allow thermal equilibrium in the sample, and to eliminate the effect of immediate time dependence.

All data were then taken after 40 s. Each measurement was duplicated on the sample and the average value was considered. The experimental data obtained were converted to shear rate and shear stress using Mitschka relationships. The shear rate versus shear stress data were interpreted using the power law expression

$$\sigma = k \cdot \gamma^n \quad (1)$$

where:

σ – shear stress (N/m^2),

γ is the shear rate (s^{-1}),

n is the flow behaviour index, *k* is the consistency index (Ns^n/m^2).

The values for the flow behaviour index n, were obtained from plots of log shear stress versus log rotational speed; the slope of the line (if the dependence is sufficiently close to a linear one) is simply equal to the flow index of the fluid, *n*.

2.5. Instrumental colour analysis

The colour of the samples was measured using a Hunter-Lab colour meter. The colour of the yoghurts was measured directly in the samples at three different locations, after standardization with a white calibration plate (L^* = 96.9, a^* = -0.04, and b^* = 1.84). Colour was expressed in Hunter Lab units L^*, a^* and b^*, where L^* indicates lightness, a^* indicates hue on a green (–) to red (+) axis, and b^* indicates hue on a blue (–) to yellow (+) axis.

3. Results and Discussions

3.1. Syneresis and pH of yoghurts

Syneresis is an undesirable property that can be determined by various methods. In the present study syneresis was measured by means of the drainage method. The results of the syneresis experiments, pH and statistical analysis are shown in **Table 2**. The difference between the patterns of whey separation detected in different methods show that these methods determined various data [19]. The results showed that control sample had the most limited syneresis ($p < 0.05$). Syneresis determined by drainage method showed that AF sample had the most syneresis possibly because of the porous and loose gel in AF sample structure.

Table 2. Syneresis and pH of the yoghurt samples (AF = 1% apple fibre added to the yoghurt; I = 1% inulin added to the yoghurt, respectively)

Sample	Drainage method (%)	pH
Control sample	11.23 ± 1.32	4.97
AF	17.20 ± 2.33	4.83
I	15.3 ± 2.11	4.89

Values are means ± standard deviation, *n* = 3

3.2. Determination of rheological properties

Yoghurt is a non-Newtonian substance and yoghurt viscosity is an indication of a network of casein-particle aggregation leading to gelation [20, 21].

In general, addition of apple fibre and inulin increases the viscosity of yoghurt. Through addition of apple fibre and inulin, the viscosity is increased and the yoghurt reduces the tendency of destabilization by separation of components.

The variations of shear rate in the apparent viscosity are given in **Fig. 1**. Shear rate was obtained from conversion of spindle factors (torque and speed spindle) of the Brookfield viscometer (under standard measuring condition) to viscosity function, according to Mitschka, 1982. The shear rate increase from 0.3 to 20.00 (1/s) clearly demonstrated decreases in apparent viscosity, which indicated a pesudoplastic 'shear thing' characterization of gel yoghurt. Yoghurt sample with 1% inulin had the nearest viscosity to full fat yoghurt, maybe due to rearrangement of casein micelles. On the other hand, yoghurt samples with apple fiber had a higher viscosity.

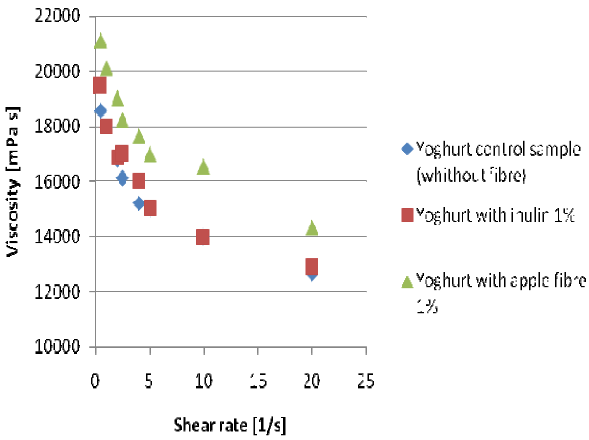

Fig. 1. Viscosity profile of yoghurt samples

3.3. Instrumental colour analysis

Colour plays an important role in food choice of consumers. L^* (whiteness) values of samples changed between 75.76 and 97.02 (**Table 3**).

Table 3. Colour parameters of yoghurts (AF = 1% apple fibre added to the yoghurt; I = 1% inulin added to the yoghurt, respectively)

Sample	L^*	a^*	b^*
Control sample	97.02 ± 0.45	-2.24 ± 0.98	12.61 ± 0.67
AF	75.76 ± 4.034	- 0.87 ± 0.77	18.34 ± 1.26
I	96.98 ± 2.3	-2.32 ± 1.22	12.89 ± 2.12

Values are means ± standard deviation, *n* = 3

Dietary fiber types were effective (P<0.05) on L^* values. L^* value of AF was lower than those of other samples (P<0.05). The a^* (red/greenness) values of samples ranged from -0.87 to -2.32 (Table 2). Dietary fiber types were effective (P<0.05) on a^* values. The highest a^* value was registered for AF. Similar results were reported for yoghurts fortified with asparagus fiber (14) and orange fiber (16). The b^* values of samples changed between 12.61 and 18.34 (Table 2). Dietary fiber types were effective on b^* values (P<0.05). Sanz et al. (14) determined that L^* values changed between 78.3 and 81.2, a^* values changed between 0.64 and 1.01 and b^* values changed between 15.97 and 18.22 for yoghurt enriched with functional asparagus fiber.

4. Conclusions

The yoghurt is a complex viscous food material due to the complexity of its nature and composition. Rheological behaviour of yoghurt is influenced by sugars, fats and water.

The determination of rheological characteristics [22, 23, 24] using Brookfield viscometer DV I Prime with disk spindles represents an easy and cheap method for rheological characterization of non-Newtonian fluids, in this case of yoghurt.

In the case of yoghurt samples obtained in the laboratory, the addition of apple fibre and inulin increases the viscosity.

When apple fiber was used in strained yoghurt, significant differences in colour and rheological behaviour were observed. Apple fibrous strained yoghurts weren't preferred because of their ragged structure, dominant apple taste and strong odour.

L^*, a^* and b^* values of apple fibrous strained yoghurts were determined to be different in comparison with control sample and inulin added yoghurts due to the structure of apple fiber.

5. References

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