Yield Stress and Sensorial Evaluation of Soya Yoghurts Prepared from Germinated Soybeans

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Abstract

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We used the germinated soybeans to prepare and evaluate soya yoghurts, with substantially reduced α-galactosides (AG) contents. The lower AG content allows the production of final products that do not cause flatulence. To enable us to control the final consistency and other sensory parameters of soya yoghurts, it was necessary to study the influence of the dry matter content on these quality parameters, i.e. the yield stress, appearance, flavour, taste, soya off-flavour, consistency, and overall impression. Establishing the relationships between the dry matter content and qualitative parameters allowed for an easy prediction of the optimal amount of dry matter to maximise soya yogurt quality from the sensory perspective. The optimum amount of dry matter was found to be 6.5%.

Keywords: yoghurt from soya milk; germination; yield point; sensorial parameters

List of symbols: H – mixer height (mm); D – mixer diameter (mm); τ_0 – yield stress (N/m^2); T – torque (N.m); N – speed (s^{-1})

The nutrition based on soya has recently become increasingly popular in the Czech Republic. Soya-based products, i.e. soya drinks, tofu, tempeh, soya fermented deserts, and ready-to-eat food products, have become a substantial part of the diets of those seeking healthy nutrition while consuming fewer animal food products. This move towards soya can be attributed to allergies related to animal proteins and the general shift towards vegetarianism.

Unfortunately, the consumption of soya and soya-based products is connected with digestion problems. Soya and other legumes contain substantial amounts of indigestible oligosaccharides (α-galactosides – AG). The major AGs include stachyose, raffinose, and verbascose. The absence of α-galactosidase in humans means that these components are not hydrolysed in the small intestine, but are instead degraded via fermentation in the colon by gas producing micro-organisms. These fermentative processes proceed with the release of gas that causes flatulence and the accompanying unpleasant feelings (Feng *et al.* 2008).

This problem was studied recently by our team using other legumes such as: chickpea, pea, lentil and mung beans (Kadlec *et al.* 2006a,b, 2007; Dostálová *et al.* 2007). The obtained results suggest that the amount of AG in the final products can be influenced through germination.

Assuming that germinated soya beans are used in the preparation of soya drinks and that the drinks are used in the preparation of soya yoghurt and related products, such products can be regarded as multifunctional foods containing soya proteins and probiotic cultures.

The main goal of this work was to use germinated soya beans to prepare and evaluate soya yoghurts with substantially reduced AG contents. In order to control the consistency and other sensory parameters of these yoghurts, it was necessary to study the influence of the dry matter content as related to these quality parameters.

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MATERIAL AND METHODS

Germination of soya beans. Soya beans were of Canadian origin and were delivered by the Czech company Kalma Ltd. Soya beans were soaked in water for 16 hours starting in the afternoon and lasting overnight. For germination, the wetted beans were transferred into PET bottles with perforated bottoms. The beans were germinated in wet conditions, but not under water. The beans were washed with fresh water (24–25°C) three times per day. On the fourth day, the germinated beans were used for the production of soya drink and this drink was used on the same day for the preparation of soya yoghurt. The total mass of non-germinated soya beans was 500 g and the total mass of the germinated soya beans was 1347 grams. The mass increase during germination ranged from 100% to 269%.

***Preparation of soya milk with five different amounts of dry* matter** (4, 5, 6, 7, and 8%). Samples 1, 2, 3, 4, and 5 (having the orientational dry matter contents 4, 5, 6, 7, and 8%) were prepared by the following procedure. The germinated soya beans samples weighing 170, 250, 270, 300, and 350 g were mixed with 200, 250, 270, 300, and 350 g of water. Pureed soya beans were then mixed with 685, 600, 465, 494, and 380 g of water and cooked in a special cooking vessel for 15 min at a temperature of 96.5 ± 0.5°C. The individual mixtures had a mass of 920, 1155, 1047, 1103, and 1039 g, respectively, after cooking. The mixtures were sieved using textile cloth and the soya drinks were separated from the okara (soy pulp), resulting in 852, 976, 879, 919, and 793 g of soya drink products.

Yoghurt preparation. Each resulting soya drink was heated to a temperature of 40°C. 700 g of soya milk was taken from each sample (i.e. samples 1–5). 2.1 g of dry yoghurt acid fermentation culture was added to each 700-g sample. As a starter, we used the traditional milk yoghurt acid fermentation culture (mixture of *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus*) delivered by the Milk Research Institute Prague. This culture lowers the pH of the product thus saving it against contamination by other microorganisms.

Each sample was then separated into 4 glass containers (2 were used for the sensory evaluation, and 2 were used to measure the yield stress). Altogether 20 glass containers were prepared. The containers were then placed in a heating chamber with the air temperature of 40°C. Yoghurt cultivation lasted 17.5 hours. The yoghurts were then chilled and stored in a refrigerator at a temperature of 5°C.

Yield stress measurement. The yield stress was measured using a blade mixer with four blades fitted to a rheometer shaft. The mixer had a diameter (D) of 26 mm and a blade height (H) of 26 mm and was mounted onto the rheometer shaft. The mixer was carefully inserted from above into the untreated congealed yoghurt and rotation was started. The instrument used was a rotational rheometer Rheotest type RV2 (VEB MLW Prüfgeräte-Werk, Medingen, Germany) with a rotational speed $N = 0.05$ rewind/second. The torque T (N·m) was measured from the mixer start-up and recorded on a chart recorder. The maximum torque was determined using the torque-time curve and the indicated that the static yield stress value τ_0 had been reached. This yield stress was predicted using the relationship presented by Castel-Perez *et al*. (1991).

The main assumption for the validity of this relationship is a constant radial profile of shear stress at the bottom and top of the measuring cylinder. This assumption is acceptable for measuring the yield stress.

Each sample was measured twice and the resulting values were averaged. The yield stress was measured for each yoghurt sample twice; the first measurement was taken 3.5 days after the addition of the acid fermentation culture and storage at 5°C. The second measurement was taken 10.5 days after the addition of the acid fermentation culture and storage at 5°C (i.e. 7 days after the first measurement).

Appearance

excellent — disgusting

Flavour

excellent — disgusting

Taste

excellent — disgusting

Soya off-flavour

not present — strong

Sensorial consistency

thin — thick

Total impression

excellent — disgusting

Remark:

Figure 1. Form for evaluation of sensory parameters of soya yoghurt samples

Table 1. Experimental results of yield stress as a function of dry matter content in soya yoghurts

Time of storage after drink fermentation (days)	Yield stress (Pa)		Dry matter of soya yoghurts (%)
	mean value	mean standard deviation	
3.5	160.5	0.4	4.31
	278.6	19.4	5.24
	327.8	11.7	6.21
	382.2	19.4	6.44
	713.9	11.7	7.90
10.5	164.1	–	4.34
	296.7	16.8	5.33
	417.2	2.6	6.11
	462.6	1.3	6.58
	707.5	7.8	7.78

Sensory evaluation. All sensory evaluations of the yoghurt samples were done at the same time by each evaluator. Six evaluators did the sensory evaluation of all samples tested. Each sensory parameter was evaluated using the marks on a scale for all evaluated samples at once, i.e. on each scale 5 numbers were marked that corresponded to the sample number. The form shown in Figure 1 was used for the sensory evaluation of all samples. The appearance, flavour, taste, soya off-flavour, sensory consistency, and overall impression were evaluated at the same time. The form also provided space for evaluators' remarks. The sensory evaluations of germinated-bean yogurts were done 3.5 and 10.5 days after the addition of the acid fermentation cultures to the germinated-bean soya drink and storage at 5°C.

Dry matter of samples. Three samples of soya yoghurt having a mass of about 15–17 g were weighed on an aluminium plate and this plate was placed into a hot air dryer with a temperature of 105°C. The drying continued for 24 hours. Then the plates were chilled in a desiccator, weighed, and dry matter content was determined.

RESULTS AND DISCUSSION

Yield stress as a function of dry matter. The yield stress and dry matter content determined for soya yoghurt samples are presented in Table 1. It can be seen from these results that the yield stress increases with the increasing soya yoghurt dry matter content. It is also apparent that the yield stress increases with the fermentation time while the dry matter content remaines constant.

Figure 2 shows the relationship between the yield stress and dry matter content. Yield stress wasstrongly dependent on the dry matter content of soya yoghurts

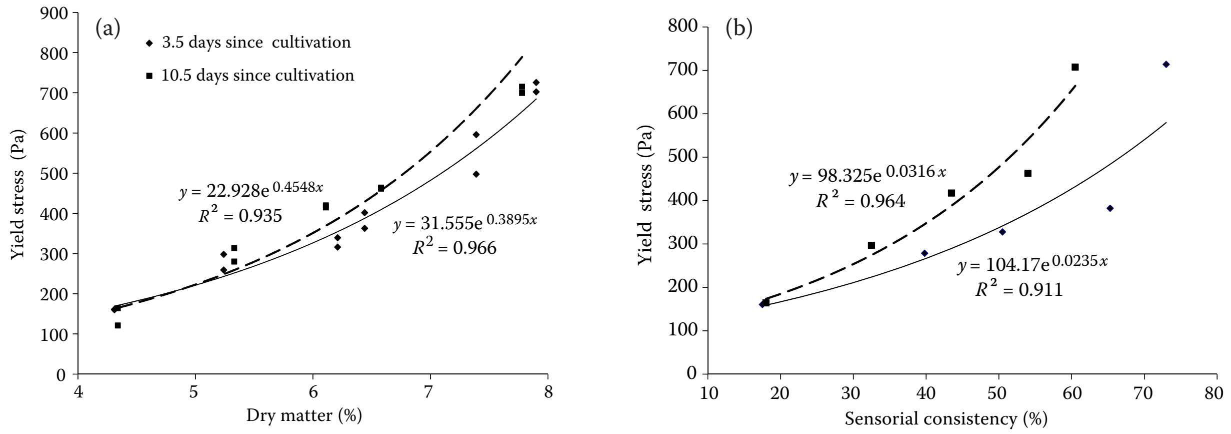

Figure 2. Yield stress relationship between (a) dry matter content and (b) sensory consistency of soya yoghurt fermented and stored for 3.5 and 10.5 days after soya drink inoculation with acid fermentation culture

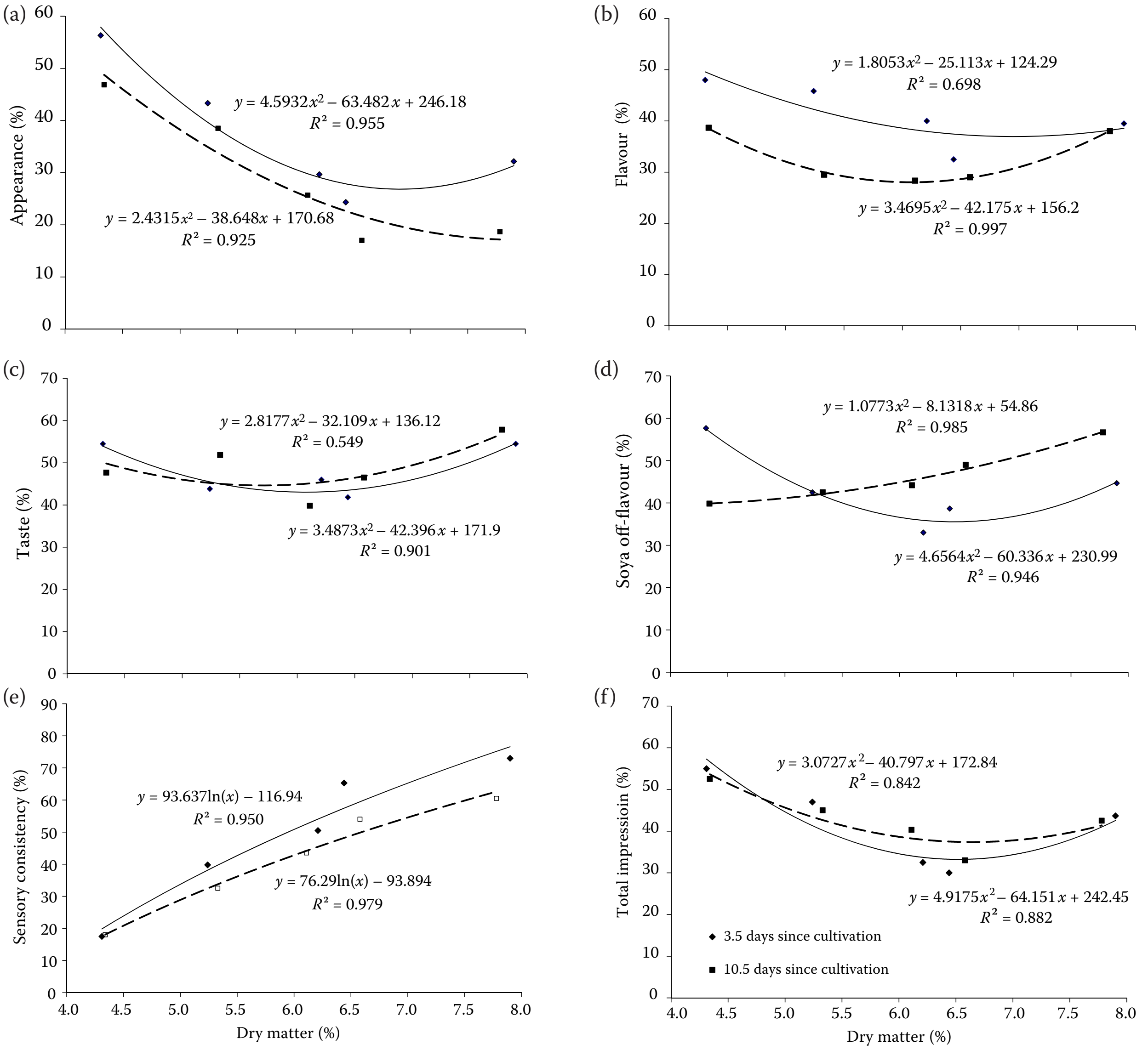

Figure 3. Relationship between soya yoghurt (a) appearance, (b) flavour, (c) taste, (d) soya off-flavour, (e) sensory consistency, (f) overall impression and dry matter content of soya yoghurt fermented and stored for 3.5 and 10.5 days after soya drink inoculation with acid fermentation culture

both 3.5 days and 10.5 days after the addition of acid fermentation culture and storage at 5°C. The yield stress vs. dry matter relationship was non-linear. The experimental data were best approximated using the exponential regression equations.

It is apparent that the yoghurt fermented and stored for 10.5 days exhibits relatively higher yield stress values than the same yoghurt fermented and stored for 3.5 days. Considering the standard deviations presented in Table 1 the differences in the mean values of the yield stress after 3.5 and 10.5 days were not statistically significant.

Yield stress as a function of sensory consistency. Figure 2b shows the relationship between the yield stress and sensory consistency of yoghurts. Both parameters correlate well with each other (relationships exhibit relatively high correlation coefficients) for both fermentation and storage times (3.5 and 10.5 days). The experimental data was best modelled using the exponential functions shown in Figure 2b. The high correlations between the measured yield stress and sensory consistency means that the sensory evaluation can be easily used as a substitute for instrumental measurements.

Dependencies of sensorial parameters of yoghurts relative to dry matter content. We calculated the relationships between the yoghurt sensory parameters and dry matter content. These relationships can help predict the optimum dry matter content of yoghurts based on their sensory characteristics.

Figure 3a shows the relationship between the yoghurt appearance and dry matter content. The experimental data was best approximated with parabolic equations, with the resulting comparisons having high correlation coefficients. It is evident from this figure that the desired yoghurt appearance improves (smaller values) with the increasing dry matter content, but only to a certain point. Beyond that point, the increasing dry matter content negatively impacts on the appearance (higher values). The pattern was more obvious with the samples fermented and stored for 3.5 days. The optimum dry matter content, from the appearance point of view, was between 6% and 7%.

Figure 3b shows the relationship between soya yoghurt flavour and dry matter content. The experimental data was best approximated by parabolic equations, with the resulting comparisons having high correlation coefficients. It is evident that the desired flavour (lower scores) is better achieved with the increasing dry matter content. However, like with the appearance, this is true only to a certain point. Beyond that point, the flavour was negatively impacted on (higher scores) by higher dry matter contents. The minimum flavour value (best flavour) was found for a dry matter content between 6% and 7% relative to the fermentation time. For the fermentation and storage time of 3.5 days, the best flavour (lowest score) was reached with a dry matter content of 6.5%, while for the fermentation and storage time of 10.5 days, the best flavour (lowest score) was reached with a dry matter content of 6%.

Figure 3c shows the relationship between the soya yoghurt taste and dry matter content. The experimental data was best approximated using parabolic equations, with the resulting comparisons having relatively high correlation coefficients. The best taste (minimum taste value) was achieved with the yoghurt dry matter content close to 6% for both 3.5 and 10.5 day fermentation and storage periods.

Figure 3d shows the relationship between the soya yoghurt soya off-flavour and dry matter content. Different relationships were found relative to the fermentation and storage times (short) 3.5 days and (longer) 10.5 days. For the short fermentation times, the minimum off-flavour was associated with the dry matter content between 6% and 7%. For the longer fermentation and storage times (10.5 days), the soya off-flavour steadily increased with the increasing dry matter content. Therefore, we cannot recommend increasing the dry matter content of soya yoghurts to values above 6.5%.

In Figure 3e can be seem the relationship between the sensory consistency of soya yoghurts and dry matter content. The sensory consistency increases steadily with the increasing dry matter content. The experimental data was best approximated using logarithmic equations, with the resulting comparison having high correlation coefficients for both fermentation and storage times, i.e. 3.5 and 10.5 days.

Figure 3f shows the relationship between the overall soya yoghurt impression and dry matter content. This important sensory parameter, for both the fermentation and storage times (3.5 and 10.5 days), was best approximated using parabolic empirical equations, with the resulting comparisons having relatively high correlation coefficients. The relationships for both fermentation and storage times show the same minimum dry matter content of about 6.5%. The dry matter content of 6.5% also produced minimum scores (desired results) for other sensory parameters: i.e. appearance, flavour, taste and soya off-flavour (in the case of soya off-flavour this was true for 3.5 days only).

CONCLUSIONS

Based on our results, we can conclude that the increasing dry matter content in soya yoghurt increases the yield stress. It is also evident that, when dry matter content is held constant, the increased yoghurt fermentation and storage time increase the yield stress. The yield stress shows a non-linear relationship with the dry matter content.

Soya yoghurt yield stress as well as sensory consistency correlates well with both fermentation and storage times. This high degree of correlation allows to substitute qualitative sensory evaluations for quantitative measurement of yogurt yield stress.

The measured sensory quality parameters of soya yoghurts prepared from germinated legumes varied based on the dry matter content. These relationships can be used to predict the optimum dry matter content of yoghurts from the point of view of their sensory acceptance by consumers. The overall impression of soya yoghurts was seen to reach a minimum for the dry matter content around 6.5%. Additionally, the same dry matter content tended to favour other sensory parameters, such as: appearance, flavour, taste, and soya off-flavour (though only for 3.5 days).

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