Modeling of rheological characteristics of the fermented dairy products obtained by novel and traditional starter cultures

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Abstract Tree different fermented dairy products obtained by conventional and non-conventional starter cultures were investigated in this paper. Textural and rheological characteristics as well as chemical composition during 21 days of storage were analysed and subsequent data processing was performed by principal component analysis. The analysis of samples' flow behaviour was focused on their time dependent properties. Parameters of Power law model described flow behaviour of samples depended on used starter culture and days of storage. The Power law model was applied successfully to describe the flow of the fermented milk, which had characteristics of shear thinning and non-Newtonian fluid behaviour.

Keywords Kombucha · Probiotics · Yoghurt · PCA · Rheology · Storage

Introduction

Fermented dairy products have a significant role in the human diet, as a very important part of the modern life style. Recent studies investigated the possibility of kombucha application (as non-conventional starter culture) and its interesting technological and nutritional aspects in manufacturing of fermented dairy products (Hrnjez et al. 2014b; Ilić et al. 2012; Malbaša et al. 2009; Teoh et al. 2004; Vukic et al. 2014). Kombucha is a symbiotic association of yeasts (genus: *Pichia*, *Zygosaccharomyces*,

Saccharomyces, *Schizosaccharomyces*, *Saccharomycodes*, *Brettanomyces*, *Torulaspora* and *Candida*), acetic acid bacteria (genus: *Acetobacter* and *Gluconobacter*) and lactic acid bacteria (genus: *Lactobacillus* and *Leuconostoc*). Kombucha has been used for fermentation of sweetened black or green tea (*Camellia sinensis*) for centuries (Marsh et al. 2014; Teoh et al. 2004). The result of kombucha's metabolic activity is a refreshing beverage with a sour taste and various healthy compounds (Roussin 1996; Pasha and Reddy 2005; Sreeramulu et al. 2000, 2001). The lactic acid fermentation is a promising method for acquisition of bioactive compounds. Therefore, the proteolysis exhibited by new starter cultures could set a wide path for obtaining functional food (Skrzypczak et al. 2017). Furthermore, organic acids are produced by metabolic activity of starter, which reduces potential of hydrogen (pH) value and affect the rheological and textural quality of the final product.

Protein interactions and aggregations at lower pH are increased by both dissolvable colloidal calcium phosphate and reduction of net negative charge on the casein micelles (Lee and Lucey 2010; Vukic et al. 2014). At the beginning, casein micelles create strong, covalent bonds with denatured whey proteins, which concomitantly with the pH decline. It leads into chain formation and clustering through hydrophobic and electrostatic bonds during fermentation and finally creation of the yoghurt structure (Lucey 2004). Acidification rate improves balance between gel strength and commercially feasible fermentation time. Rheological studies provide better understanding of distribution of the food components and prediction of their structural changes during the manufacturing processes and storage (Koocheki and Razavi 2009). Textural characteristics of yoghurt gel result from structural changes that occur on a casein micelle due to the pH value reduction (Lee and Lucey 2010; Lucey 2004).

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Principal component analysis (PCA) is a multivariate chemometric method, commonly used to identify and explain patterns, similarities and differences in data. In addition, PCA could be used to show relationships between objects and unfounded principal components (Kadegowda et al. 2008; Kim et al. 2014). The PCA results are used to identify important experimental factors, while factor score plots were used to indicate similar, dissimilar, and typical or outlier data.

Author's previous research investigated the effect of kombucha starter culture on the gelation process, microstructure and rheological properties during milk fermentation (Vukic et al. 2014). Present study extends that research by analysing the structure recovery of fermented dairy products obtained by non-conventional starter culture—kombucha. The effects of starter culture and storage time on rheology behaviour as well as textural characteristics were investigated using PCA and rheological parameters were modelled with an aim to predict rheological behaviour of the samples.

Materials and methods

Materials

Sample production

Fermented dairy products were produced in laboratory conditions, from pasteurized (72 °C for 15 s) and homogenized milk with 2.8% fat.

The following starter cultures were used in milk fermentation:

1. Kombucha inoculum in concentration of 10%, where kombucha was cultivated from the black tea (*Camellia sinensis*—oxidized, 1.5 g/L) with saccharose concentration of 70 g/L. The tea was cooled at the room temperature and inoculum from a previous fermentation was added in concentration of 10%. Incubation was at 25 ± 2 °C for 7 days (Malbaša et al. 2009). Total number of viable cells was as follows: approximately 5×10^4 of yeast cells per mL of the reaction mixture and approximately 2×10^5 of bacteria cells per mL of the mentioned mixture (Lončar et al. 2013).
2. Probiotic starter culture, ABT-7 is lyophilized probiotic culture-*Probio-Tek*®, which contains LA-5®, *Lactobacillus acidophilus*, BB-12®, *Bifidobacterium*, *Streptococcus thermophilus* (Chr. Hansen, Hørsholm, Denmark).
3. Yoghurt starter culture is lyophilized yoghurt culture YF-L812, which contains *Streptococcus thermophilus*

and *Lactobacillus delbrueckii* ssp. *bulgaricus* (Chr. Hansen).

Commercial starters were added according to manufacturer's specification, 0.005 g/100 g. All samples were produced in triplets at 42 °C and fermentation was continued until pH = 4.5 was reached. Samples were cooled down to 4 °C and immediately analysed. Following that, the samples were homogenized by mixing, packed in polypropylene glasses and refrigerated to 4 ± 1 °C. Depending on the used starter culture, different samples were produced. The samples were labelled as K0, K7, K14, P0, P7, P14, Y0, Y7 and Y14. Letters K, Y, P indicate a starter culture used (K—kombucha, P—probiotics, Y—yoghurt) and numbers 0, 7 and 14 indicate a storage day. Samples stored at the production day, before stirring (set type), are labelled as K0, P0 and Y0.

Methods

Chemical quality

Chemical quality of fermented dairy products was tested after the production using the following methods: dry matter (DM) (ISO6731:2010-IDF21:2010 2010; determination of the total solids content (Reference Method); milk fat (MF) according to Gerber (IDF 105 2008); total proteins (TP) (IDF 20-5:2001 2001); determination of the total nitrogen content of milk by the Kjeldahl method (2001); ash (A) (IDF 90:1979 1979 Rennet caseins and caseinates); determination of ash (Reference method 1979).

pH value was determined using the pH-meter (VARIO pH SET, Germany).

Total acids were determined as titratable acidity. After removing CO₂ from the fermented samples, a sample of 20 mL was taken and titrated with 0.1 mol/L of NaOH, while phenolphthalein was used as an indicator and calculated in g/L lactic acid according to the equation:

$$m_{\text{lactic acid}}(\text{g/L}) = \frac{(V_{\text{NaOH}} \times C_{\text{NaOH}} \times M_{\text{lactic acid}} / 1000)}{\times 50}$$

Viscosity

Viscosity of samples was measured at 5 °C using a viscometer HAAKE RheoStress 600HP (Karlsruhe, Germany) with cone and plate sensor PP60Ti (gap 1 mm). Stress sweeps were elevated from 0.1 to 100 Pa to determine the linear viscoelastic range (LVR) of samples at a constant frequency of 1 Hz. The thixotropic behaviour of the fermented dairy products was evaluated by calculating the hysteresis loop area between the upward and downward flow curves. Hysteresis loop was recorded at increasing

shear rate 0–40 and 0–25 s, followed by decreasing shear rate 40–0 and 0–25 s, within 50 s of downward flow curve at controlled temperatures (4.0 ± 0.1 °C). The thixotropy was measured by RheoWin Data Manager 4 program package (Thermo Haake, Karlsruhe, Germany). Replicate measurements for each sample were performed independently.

The experimental data were described by two mathematical models: Power law model (Eq. 1) and the Herschel-Bulkley model (Eq. 2) (Rao 2007).

Power law model:

$$\tau = k\gamma^n \quad (1)$$

where τ , shear stress (Pa); γ , shear rate (1/s); k , consistency index (Pas); n , flow behaviour index (dimensionless).

The Herschel–Bulkley model:

$$\tau = \tau_0 + k(\dot{\gamma})^n \quad (2)$$

where τ , shear stress; τ_0 , yield stress; k , consistency index (Pas); $\dot{\gamma}$, shear rate (1/s); n , flow index, a power law exponent.

The coefficient of thixotropic breakdown, K_d was calculated according to the formula (Eq. 3):

$$K_d = A_{up} - A_{dw}/A_{up} \quad (3)$$

where A_{up} and A_{dw} are the areas under the ascending and the descending flow curves, respectively.

Textural properties

Textural properties, such as firmness, consistency, cohesiveness and viscosity index of produced samples, were analysed by Texture Analyser TA.HD^{plus} (Stable Micro System, England) through a single compression test by using a back extrusion cell (A/BE) disc (diameter 35 mm; distance 30 mm; speed 0.001 m/s) and an extension bar with 5 kg load cell. Options *Return to Start* was used, trigger force was 10 g.

Statistical analysis

Statistical analysis of the results was carried out with the computer software program “Statistica 12” and was expressed as a mean value, obtained by three independent experiments (ANOVA). PCA was used to identify both the main factors which control rheological quality during the storage time and the distribution of the analysed parameters. The variance eigenvalue was greater than one. The loadings (or factor scores) corresponding to the principal components were calculated from the correlation matrix (Brown 1988).

Results and discussion

Chemical composition

The chemical composition of milk and fermented dairy products is presented in Table 1. The results showed that the chemical composition, dry matter, milk fat, total proteins and sample ash produced by using different starter cultures did not differ significantly.

The fermentation time was significantly shorter in samples with yoghurt and probiotic starters compared to the ones with kombucha (Table 1) which was in accordance with earlier finding (Hrnjez et al. 2014a, b; Ilić et al. 2012, 2013; Malbaša et al. 2009; Vukic et al. 2014). The obtained results of fermentation time in kombucha samples revealed faster fermentation compared to kombucha samples obtained with lower fat content (2.0 and 0.1% respectively) as published earlier (Vukic et al. 2014; Ilić et al. 2014). During the first week of storage, the pH of yoghurt fermented dairy product was stable without significant changes, while kombucha and probiotic samples showed slight pH decrease. Probiotic and kombucha fermented dairy products had higher acidification rate compared to the yoghurt sample. At the end of the storage period, the pH values in the P, K and Y products reached 4.00, 4.10 and 4.35, respectively, which indicated products stability. These results showed that a type of starter culture influenced the post-acidification rate of final products. This aspect is important in the products' shelf life which is limited by over-acidification (Gonzalez-Martinez et al. 2002). Nevertheless, our results indicated that kombucha starter culture could ensure manufacturing of fermented dairy product with similar physicochemical characteristics and acidity as conventional yoghurt and probiotic starters (Fig. 1).

Modelling of the rheological behaviour of fermented dairy products

Flow behaviour

The viscosity is an important quality parameter that influences the sensory properties of fermented dairy products (Skriver et al. 1999). The produced fermented dairy products showed thixotropic behavior and behaved as pseudoplastic materials with a yield point and hysteresis loop, which was in accordance with previous research (De Lorenzi et al. 1995; Pakseresht et al. 2017). After production, all samples were fitted well with Herschel–Bulkely viscous model, with $R^2 > 0.96$ as presented in Table 2, which indicate a non-Newtonian fluid.

Table 1 Chemical composition of milk and fermented dairy products obtained by yoghurt, probiotic and kombucha starter cultures

Chemical characteristics	Milk	Probiotic FM (P)	Yoghurt FM (Y)	Kombucha (K)
pH	6.8 ± 0.00	4.57 ± 0.01	4.52 ± 0.03	4.54 ± 0.02
Time of fermentation	–	4 h 45 min	4 h	7 h 45 min
TTA (Lactic acid mg/mL)	–	7.38 ± 0.04	7.24 ± 0.04	7.11 ± 0.02
Dry matter (%)	11.56 ± 0.08	12.0 ± 0.02	11.91 ± 0.07	11.60 ± 0.09
Milk fat (%)	2.8 ± 0.001	2.8 ± 0.002	2.8 ± 0.001	2.8 ± 0.001
Total proteins (%)	3.08 ± 0.02	3.07 ± 0.04	2.98 ± 0.06	2.77 ± 0.05
Ash (%)	0.71 ± 0.001	0.75 ± 0.002	0.73 ± 0.003	0.69 ± 0.003

TTA Total titratable acidity

Fig. 1 pH values during the storage time; Y yoghurt, P probiotic, K kombucha

However, the samples could not fit to this model during the storage phase even though they exhibited thixotropic behaviour.

The Power law model was used to determine the effect of starter culture and storage time on rheological parameters. The Power law model fitted very well to the flow curves ($R^2 > 0.990$). During the storage time, the flow behaviour index (n) of the fermented dairy products, obtained through the Power law model as shown in Tables 2 and 3, showed characteristics of a shear thinning fluid ($n < 1$), thus confirming the non-Newtonian and shear-dependent behaviour. The consistency index changes indicated a decrease of the viscosity during the storage period. The obtained parameters of the Power law (model) function are presented in the Table 2. The values of the correlation coefficients (R^2) for the Power law models were $R^2 \geq 0.996$. During the storage period, the samples produced with kombucha and the samples produced with probiotic and yoghurt followed the same behaviour model. The previous investigation of rheological behaviour of kombucha fermented milk during fermentation process also showed same gelation process and the regression

model (Power lower model) as conventional starter culture (Vukic et al. 2014). These results indicate similar influence of the kombucha starter on casein networking pattern as the traditional starter culture.

The gel stirring significantly affected rheology and flow behaviour of the fermented dairy products as indicated in Table 2. The apparent viscosity (η) at shear rate 50 s^{-1} were between 0.481 and 0.407 Pas for kombucha, while yoghurt samples had the lowest values between 0.409 and 0.599 Pas depending on the storage time. The apparent viscosity of all samples after the production was significantly higher; 22.9, 7.0 and 4.9 Pas for P0, J0 and K0, respectively. A significant decrease in viscosity after the stirring for all types of fermented dairy products was observed, which is a consequence of a gel destruction during the stirring process.

The yield stress, i.e. the minimum stress required to make the material flow, was obtained as the starting point of the ascending curve. The flow behaviour of probiotic samples had more noticeable differences compared to kombucha and yoghurt samples, and showed higher hysteresis loop, yield stress and apparent viscosity as presented in Table 2. Therefore, it could be concluded that these results fit better to Power law model than to Herschel–Bulkely model. The results are aligned with Pakseresht et al. (2017), who also observed that Herschel–Bulkely model is not a suitable model to describe the yoghurt flow behaviour.

During the storage period from 7th to 21th day, the shear stress of the fermented dairy products obtained by different starter cultures decreased. At the 14th and 21st days, probiotic and yoghurt samples showed similar shear stress which was higher than the shear stress of the kombucha sample, as shown in Fig. 2. When a material is sheared at a constant shear rate, the viscosity of a thixotropic material will decrease over a period of time, implying a progressive structure breakdown (Abu-Jdayil 2003). In addition, the characterization of time-dependent rheological properties of food systems is important to establish relationships between the structure and the flow,

Table 2 Estimated rheological parameters of Power law and Herschel–Bulkley models describing flow curves of fermented dairy products after production and during the storage

Sample	Herschel–Bulkely ($\tau = \tau_0 + k\dot{\gamma}^n$)				Power law ($\tau = k * \dot{\gamma}^n$)			τ_0 (Pa)	η Pas	$A_{up} - A_{dw}$	K_d
	τ_0	k	n	R^2	k	n	R^2				
PO	23.39	0.43	1.39	0.960	5.76	0.76	0.986	23.39	22.980	4045 $\pm$ 25.9	0.667 $\pm$ 0.02
Y0	7.29	0.12	1.44	0.966	1.54	0.82	0.998	7.289	7.023	1290 $\pm$ 15.3	0.66 $\pm$ 0.03
K0	8.20	0.27	1.19	0.931	2.93	0.63	0.998	8.493	4.979	910 $\pm$ 15.2	0.567 $\pm$ 0.04
K7	–				1.15	0.376	0.999	0.75	0.481	16.5 $\pm$ 1.2	0.218 $\pm$ 0.01
K14					0.73	0.477	0.996	0.5	0.452	13.34 $\pm$ 1	0.190 $\pm$ 0.01
K21					0.68	0.486	0.996	0.1	0.407	11.43 $\pm$ 1.3	0.176 $\pm$ 0.02
P7					0.53	0.552	0.998	0.15	0.315	6.69 $\pm$ 0.25	0.124 $\pm$ 0.01
P14					0.87	0.505	0.997	0.15	0.49	11.89 $\pm$ 0.84	0.141 $\pm$ 0.02
P21					0.57	0.578	0.996	0.01	0.395	12.64 $\pm$ 0.48	0.180 $\pm$ 0.02
J7					1.07	0.497	0.997	0.25	0.599	15.74 $\pm$ 1.25	0.156 $\pm$ 0.03
J14					0.62	0.558	0.997	0.15	0.512	15.75 $\pm$ 1.43	0.187 $\pm$ 0.02
J21					0.77	0.535	0.996	0.1	0.409	12.35 $\pm$ 0.59	0.176 $\pm$ 0.04

All samples after production were well fitted with Herschel–Bulkely viscous model indicated a non-Newtonian fluid, with $R^2 > 0.96$ while the samples during the storage could not fit to this model, even though exhibited thixotropic behaviour. τ = shear stress (Pa), τ_0 = yield stress (Pa), $\dot{\gamma}$ = shear rate (s^{-1}), k = the consistency index (Pas), τ_0 —yield stress, η —Apparent viscosity, $A_{up} - A_{dw}$ —hysteresis loop area, K_d —coefficient of thixotropic breakdown = flow behaviour index (dimensionless)

Table 3 Textural characteristics of fermented dairy products during storage

Sample	Consistency (g s)	Firmness (g)	Cohesiveness (g)	Index of viscosity (g s)
K0	356.54	14.28	– 8.90	– 3.27
K7	342.79	12.87	– 6.53	– 1.79
K14	370.05	13.68	– 8.78	– 1.71
K21	375.96	14.20	– 9.65	– 2.30
P0	356.72	13.01	– 8.17	– 4.45
P7	344.08	12.68	– 6.27	– 1.81
P14	410.45	15.13	– 9.15	– 2.13
P21	399.07	15.68	– 9.84	– 2.22
J0	362.65	14.12	– 8.35	– 3.90
J7	338.61	12.79	– 7.66	– 2.56
J14	398.73	14.65	– 9.43	– 2.17
J21	376.24	13.97	– 9.30	– 2.25

Y yoghurt, P probiotic, K kombucha, 0–21 indication of the day of storage

and to correlate physical parameters with the sensory evaluation (Fighi and Shoemaker 1983).

The formation of a hysteresis curve reflects changes in the rheological product behaviour (Pasephol et al. 2008). The hysteresis loop area (HLA) between the curves proves that the flow behaviour of the analysed samples is time-dependent (Tárrega et al. 2004). The hysteresis loop areas for all analysed fermented dairy products during the storage time are shown in Table 2. The differences among the flow curves of analysed samples are directly related with differences among their hysteresis loop areas. The HLA value of the probiotic fermented dairy product after the

production is higher compared to the previous data where the sample had 0.1% fat content (Ilić et al. 2014). Furthermore, the kombucha fermented dairy product had higher HLA value (910 Pas) after the production compared to the kombucha sample with 0.9% fat content (450 Pas) (Ilić et al. 2014), which indicates significant influence of the fat content to the samples' structure.

The differences in hysteresis loop magnitudes of gels thixotropy were estimated as the coefficient of thixotropic breakdown, K_d , as presented with Eq. 3. The thixotropic breakdown is defined as the ratio of the hysteresis loop area and the area below the ascending shear curve (Dokic et al.

Fig. 2 Shear stress of different fermented dairy products during the storage phase: **a** samples after the production, **b** samples after 7 days, **c** samples after 14 days, **d** samples after 21 days; *P* probiotic, *Y* yoghurt, *K* kombucha

1999). The coefficient of thixotropic breakdown, i.e. the relative hysteresis area, provides a more accurate insight into the rate of internal structural breakdown when comparing systems with different viscosities (Dolz et al. 2000). Among non-homogenised fermented dairy products, the highest coefficient of thixotropic breakdown had the probiotic sample while the lowest coefficient had the kombucha sample (0.667 and 0.567, respectively). This result indicates that a higher energy is needed to destroy the structure of kombucha compared to the conventional samples. During the storage period, while the coefficient of thixotropic breakdown in products with conventional starter cultures slightly increased, it decreased in the kombucha sample, which indicated even better recovery of the kombucha gel compared to the conventional samples. According to the obtained results, the samples with probiotic starter had the highest values of viscosity and a hysteresis loop area, while the lowest value had the kombucha sample.

The analysed rheological parameters during 21 days of storage indicated better rheological stability of probiotic and also yoghurt fermented dairy products compared to the ones with kombucha sample.

Textural characteristics

Textural characteristic is an important parameter that affects fermented dairy products quality and consumer acceptance (Mudgil et al. 2017; Abou-Soliman et al. 2017). The gel structure strength, as the result of casein aggregation by pH reduction and disulphide bonding between κ -caseins and denatured whey proteins, depends on several parameters, such as a starter culture type, storage period, ingredients, and temperature (Donato et al. 2007; Pakseresht et al. 2017). The κ -fraction is more sensitive to hydrolysis by starter culture and therefore it is responsible for stabilization of the molecular structure of casein micelles (Skrzypczak et al. 2017). Firmness of all analysed fermented dairy samples increased significantly during the storage period. An incensement of firmness during the storage time is caused by stronger casein networking. Kombucha fermented dairy products had the lowest firmness and overall textural characteristics during 21 days of storage, while the highest values of textural parameters during this period had samples with probiotic starter culture. Ilić et al. (2012) used milk with different fat content (0.9 and 2.2%) and inoculum in concentration of 10 and

15% for manufacturing of kombucha fermented dairy products. They showed that samples with higher fat content had better textural characteristics (Ilicic et al. 2012). They also showed that the concentration of applied kombucha starter has no significant influence on textural characteristics of produced samples. Malbaša et al. 2014 investigated textural characteristics of kombucha fermented dairy products obtained by kombucha inoculums cultivated from various teas at the temperature of 40 and 43 °C (Malbaša et al. 2014). Their obtained results are in accordance with the results in this research and indicate insignificant influence of inoculum tea type on textural characteristics.

Probiotic fermented dairy products had lower textural characteristics compared to the probiotic samples produced from milk with 0.1% fat content (Ilić et al. 2014).

PCA of rheological parameters

Figure 3a and b shows PCA loadings and PCA scores, respectively. They are built using both textural and rheological variables. In general, the PCA analysis shows a comparison of a multidimensional textural/rheological quality of fermented milk samples produced by different starter cultures which are projected on a two-dimensional surface and described by two orthogonal factors used as dimensions (principal components-PC): PC1 and PC2. These two components were responsible for 88.84% of the total variance (62.15% for PC1 and 26.69% for PC2) and therefore they were considered significant, based on the

eigenvalues (> 1). Other obtained dimensions explained only a small proportion of variance ($< 5\%$).

From Fig. 3b, it is evident that samples are grouped by the day of production, rather than the starter culture used for the fermentation. Differences in viscosity parameters, thixotropy, apparent viscosity, index of consistency, yield stress and coefficient of thixotropic breakdown, are mostly responsible for dispersion of samples along the factor 1, i.e. for correlation values with PCA factor 1: 0.97, 0.96, 0.95, 0.94 and 0.91, respectively. Fermented dairy products after the production (Y0, P0 and K0) were grouped at positive values of the first dimension and were characterized by their viscosity parameters (Group I). This is caused by high values of the viscosity parameters before the stirring. With an increase of storage period, the differences among groups become lower. Samples after 14 and 21 days of storage are grouped at the negative values of the second dimension and were more characterized with textural variable, consistency and firmness (Group II). Along the factor 2 scale, samples are grouped by the differences in firmness and cohesiveness values by correlation values with PCA factor 2: 0.92 and 0.91, respectively. Cohesiveness is a measure of the strength of internal bonds. It is related to the consumer acceptability of yoghurt and is an important parameter for analysing the yoghurt texture (Mudgil et al. 2017). Samples after 7 days of storage are clearly separated from other samples, mostly based on cohesiveness (Group III). During further storage period (14 and 21 days), the samples are grouped based on firmness and consistency. Probiotic samples (P14 and P21) are particularly characterised by

Fig. 3 PCA analysis of textural characteristics of produced samples: **a** correlation circle as a projection of the initial variables in the factors space, **b** position of examined fermented dairy products in factorial

plane in coordinates of PCA factors 1 and 2; Groups I, II and III are defined and explained as storage dependent; Y yoghurt, P probiotic, K kombucha

firmness and consistency, which is caused by their higher values compared to samples after production and after 7 days of storage (Table 3).

PCA analysis clearly indicated a significant influence of a storage day on sample groupings and their characteristics.

Conclusion

This work showed that the PCA methodology was sufficient to determine differences among fermented dairy products obtained by conventional and kombucha starter culture. The kombucha starter culture had similar influence on rheological quality of samples as a conventional starter culture which recommends it as a potential new starter culture. The products' characteristics were related to the storage time rather than used starter culture, which caused grouping of the samples according to the day of storage. With longer storage period, the differences among groups became lower. All produced fermented dairy products behaved as thixotropic systems and pseudoplastic materials. During the storage time, the flow behaviour index (n) of the fermented dairy products, obtained through the Power law model, showed characteristics of a shear thinning fluid. Stronger differences in the flow behaviour were observed in the probiotic sample compared to the kombucha and yoghurt samples, showing higher hysteresis loop, yield stress and apparent viscosity, and overall better rheological properties.

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