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TEXTURE PROFILE OF KEFIR AND YOGURT WITH MODIFIED CONFIGURATION OF PROTEINS

PROFIL TEKSTURY KEFIRU I JOGURTU O ZMIENIONYM UKŁADZIE BIAŁEK

Abstract

Background. The composition of processed milk and technical and technological conditions of its further processing in the production of fermented milk have a significant impact on the development of its texture. The aim of this study was therefore to assess texture profile of kefir and yogurt made from skimmed milk with varying proportions of casein and whey protein, being an indicator of its quality.

Material and methods. Kefir and yogurt with a 14.5% content of dry matter were prepared with an addition of skim milk powder and whey protein concentrates with varying proportions of protein. Selected texture parameters were measured using a TA.XT-*plus* texture analyser and the Texture Exponent E32 software using back extrusion.

Results. It was found that the greater the whey protein content, the lesser the firmness of model kefir and yogurt from skimmed milk. Regardless of the ratio of casein to whey protein (CN : WP) it was found that after 21 days kefir and yogurt from skimmed milk are firmer than immediately after production, and only yogurt exhibits greater cohesiveness. The viscosity index of yogurts with the smallest ratio of casein to whey protein (1 : 1.9) after 21 days was by 52% higher than it was after production. In the yogurt with the greatest CN : WP ratio (1 : 0.2) the viscosity index increased by 33%.

Conclusions. The greater the proportion of whey protein to casein, the lesser its firmness and cohesiveness and the looser the consistency of kefir with 14.5% dry matter. The viscosity index of kefir with WPC 80 was 70% lower than that with SMP. No differences in texture were found between kefir from unthickened milk and that from thickened milk with the largest share of whey protein.

Keywords: kefir, yogurt, fermented milk, whey protein concentrates, texture

Bierzuńska, P., Kaczyński, Ł. K., Cais-Sokolińska, D., Kulczyński, B. (2017). Texture profile of kefir and yogurt with modified configuration of proteins. Nauka Przyr. Technol., 11, 1, 107–114. http://dx.doi.org/10.17306/J.NPT.00168

Introduction

Texture of kefir and yogurt, i.e. fermented dairy products, is a resultant of many factors, the most important of which include the composition of processed milk, particularly protein content, and technological process parameters (Krzeminski et al., 2014; Salvador and Fiszman, 2004). Total protein content in kefir or yogurt has to be min. 2.7% (Global Food Mate, 2013). At present the number of commercially available products with an increased protein content is growing and consumers are much more aware of health benefits connected with their incorporation into the daily diet (Antunes et al., 2004). Thus, the content of milk solids in processed milk is frequently enhanced by milk evaporation, introduction of skim milk powder (SMP) or other milk protein preparations. Thickening based on membrane technologies or an addition of SMP does not disturb natural proportions between major milk proteins, i.e. casein and whey proteins (Evans et al., 2010). In turn, the introduction of milk protein preparations, e.g. whey protein concentrates, may significantly alter the course of fermentation, as well as firmness, consistency and cohesiveness of kefir or yogurt (Gustaw and Nastaj, 2007; Krzeminski et al., 2014; Torres et al., 2011).

Literature sources on the subject present characteristics of fermented milk with varying fat and protein contents, produced with an addition of whey proteins (Luck et al., 2013; Smithers, 2008). Most of these studies concern microstructure and physical properties (Krzeminski et al., 2011), as well as sensory attributes (Tomaschunas et al., 2012). The aim of this study was to analyse texture of kefir and yogurt obtained from skimmed milk with an increased protein content at an altered casein to whey protein ratio. In this way the effect of fat on instrumentally measured texture parameters was eliminated.

Material and methods

The input material comprised commercially pasteurised skimmed milk from the Wielkopolska region (Western Poland) containing 9.1% dry matter (DM). Milk solids content was increased from 9.1% to 14.5% by adding skim milk powder (SMP; SM "Gostyń", Gostyń, Poland) or whey protein concentrates: WPC 35, WPC 65, WPC 80 (SM "Spomlek", Radzyń Podlaski, Poland) of varying protein contents. In this way protein content in processed milk exceeded that in input milk (3.4%). Additionally, thanks to the introduction of WPC the proportions of casein and whey proteins in processed milk were changed. The composition and amounts of added SMP and WPC are given in Table 1 and on their basis the ratio of casein to whey proteins (CN : WP) in fermented milk was calculated.

Total nitrogen content was determined according to Kjeldahl (ISO 8968-1: 2014, 2014) using the Kjeltec System 1026 apparatus (Tecator, Örebro, Sweden). The content of casein (CN) was determined using a method proposed by Svanborg et al. (2015). The content of whey protein (WP) was calculated based on the dependence: WP = (NCN − NPN) × 6.38, where the index value of 6.38 is used to calculate protein contents in milk and dairy products. Contents of water, lactose and minerals were determined using standard methods (Cunniff and Association of Official Analytical Chemists, 1995).

Bierzuńska, P., Kaczyński, Ł. K., Cais-Sokolińska, D., Kulczyński, B. (2017). Texture profile of kefir and yogurt with modified configuration of proteins. Nauka Przyr. Technol., 11, 1, 107–114. http://dx.doi.org/10.17306/J.NPT.00168

Table 1. Basic chemical composition of used milk protein preparations (%)

Milk protein preparation	Moisture	Protein	Lactose	Ash
WPC 35	4.19^{A}	35.81^{A}	40.52^{C}	6.92^{C}
WPC 65	3.82^{A}	64.75^{B}	17.22^{B}	5.43^{B}
WPC 80	3.44^{A}	79.43^{C}	1.46^{A}	1.14^{A}
SMP	3.19^{A}	35.14^{A}	51.72^{D}	6.86^{C}

WPC – whey protein concentrate, SMP – skim milk powder.
Different letters in columns denote statistically significant differences at $\alpha = 0.05$.

Milk fermentation – production of kefir and yogurt samples

Processed milk with an increased solids content was re-pasteurised (73°C for 17 s in a plate pasteuriser), followed by cooling to the temperature of lactic acid fermentation of 37°C (production of yogurt) or combined lactic acid – alcohol fermentation of 23°C (production of kefir). Kefirs were produced directly from processed milk using a MT 432 ANV freeze-dried starter culture by Sacco (Cadorago, Italy) added at 12.5 units per 25 l of milk. It was a mixture of mesophilic bacterial strains: *Lactococcus lactis* subsp. *lactis*, *Lactococcus lactis* subsp. *cremoris*, *Lactobacillus plantarum* and *Lactobacillus casei*, and yeast: *Kluyveromyces fragilis* (*Kluyveromyces marxianus* subsp. *marxianus*). In the production technology of yogurts the used starter culture was a mixture of thermophilic bacteria *Streptococcus thermophilus*, *Lactobacillus acidophilus* and *Bifidobacterium animalis* subsp. *lactis*, commercially available as Lyofast SAB 440B by Sacco (Cadorago, Italy), added at 10 units per 25 l processed milk.

Fermentation was run at 23°C (kefirs) or 37°C (yogurts) until pH 4.45 was reached. A two-step cooling to 15°C for max. 15 min was applied, the product was poured to unit containers of v = 150 ml and further cooled to 6°C. Samples were produced on a pilot plan scale using factory-scale equipment (n = 8). They were tested 24 h after the completion of fermentation (day 0) and at 10 and 21 days of cold storage, i.e. at 3 ±0.5°C.

Profile texture analyses

Texture parameters, i.e. firmness, consistency, cohesiveness and the viscosity index, were measured using a TA.XT-*plus* texture analyser by Stable Micro Systems (Surrey, UK) compatible with the Texture Exponent E32 software version 4.0.9.0 by back extrusion. Samples were placed inside a cylinder of Ø = 50 mm (75% filled). The A/BE attachment with compression disc (Ø = 35 mm) was used. The measurement conditions were a distance of 30 mm, pre-test 1.0 $mm \cdot s^{-1}$, and post-test 10.0 $mm \cdot s^{-1}$.

Statistical analysis

Significance of differences in results was verified based on inference at $\alpha = 0.05$ using the STATISTICA (version 13) software by StatSoft, Inc. (STATISTICA..., 2016). To verify the statistical hypotheses, a univariate ANOVA analysis was used.

Bierzuńska, P., Kaczyński, Ł. K., Cais-Sokolińska, D., Kulczyński, B. (2017). Texture profile of kefir and yogurt with modified configuration of proteins. Nauka Przyr. Technol., 11, 1, 107–114. http://dx.doi.org/10.17306/J.NPT.00168

Results and discussion

The addition of whey protein preparations contributed to the development of a different texture profile of kefir than it was in the case of skim milk powder addition (Table 2). The greater the share of whey proteins in relation to casein, the lower the firmness and cohesiveness and the looser the consistency of kefir with 14.5% DM immediately after production (day 0). The viscosity index of kefir with WPC 80 (CN : WP 1 : 1.9) was by 70% lower than for kefir with SMP (CN : WP = 1 : 0.2). No difference was shown between the texture profile of kefir containing 9.1% DM and the sample with DM content increased as a result of WPC 80 addition. The observed dependencies between kefirs were also shown during day 10 and after storage (day 21).

Table 2. Texture parameters of kefir made from skimmed milk with increased protein content and altered proportions of casein (CN) to whey protein (WP)

Texture	Storage (days)	9.1% DM, CN : WP 1 : 0.2	14.5% DM			
			SMP, CN : WP 1 : 0.2	WPC 35, CN : WP 1 : 1	WPC 65, CN : WP 1 : 1.6	WPC 80, CN : WP 1 : 1.9
Firmness (g)	0	17.39^{aA}	20.25^{cB}	19.15^{bA}	19.46^{bA}	17.58^{aA}
	10	17.70^{aA}	18.99^{aA}	19.18^{aA}	18.53^{aA}	18.46^{aA}
	21	18.37^{aB}	22.68^{bC}	19.37^{bA}	19.15^{bA}	18.17^{aA}
Consistency (g·s)	0	383.01^{aA}	475.94^{bA}	448.54^{bA}	434.21^{bA}	402.04^{bA}
	10	396.47^{aA}	442.33^{bA}	435.97^{bA}	420.42^{bA}	416.94^{bA}
	21	395.19^{aA}	517.01^{cB}	445.34^{bA}	436.25^{bA}	417.42^{bA}
Cohesiveness (g)	0	-11.85^{aA}	-14.17^{bB}	-13.29^{bB}	-11.69^{aA}	-11.52^{aA}
	10	-11.54^{aA}	-13.19^{bA}	-13.31^{bB}	-12.69^{bA}	-12.07^{aB}
	21	-12.02^{aB}	-13.09^{bA}	-13.71^{bB}	-12.83^{bA}	-12.24^{aB}
Viscosity index (g·s)	0	-1.76^{aB}	-5.06^{cA}	-2.07^{bB}	-1.51^{aA}	-1.57^{aA}
	10	-1.67^{aB}	-5.32^{bA}	-1.46^{aA}	-1.69^{aB}	-1.96^{aB}
	21	-1.24^{aA}	-5.67^{cA}	-2.67^{bB}	-1.51^{aA}	-1.70^{aA}

DM – dry matter, SMP – skim milk powder, WPC – whey protein concentrate.

Different small letters in rows and different capital letters in columns for the same texture parameter denote statistically significant differences at $\alpha = 0.05$.

When analysing all kefirs it was found that as a result of storage samples with added SMP, in which CN : WP was 1 : 0.2, were firmer (Table 2). Those kefirs after 21 days had greater consistency than immediately after production. Consistency of kefirs with

Bierzuńska, P., Kaczyński, Ł. K., Cais-Sokolińska, D., Kulczyński, B. (2017). Texture profile of kefir and yogurt with modified configuration of proteins. Nauka Przyr. Technol., 11, 1, 107–114. http://dx.doi.org/10.17306/J.NPT.00168

greater whey protein contents did not change as a result of storage. Kefirs made from unthickened milk after 21 days had lower viscosity indexes than immediately after production. No such dependence was found in kefirs thickened using SMP, even though the ratio of casein to whey proteins was identical (1 : 0.2). Kefirs made from milk supplemented with WPC 80 and WPC 65 after 10 days had higher viscosity indexes than before or after storage. An opposite trend was found in kefir with WPC 35.

An increase in dry matter content from 9.1% to 14.5% in milk subjected to lactic acid fermentation by adding skim milk powder (SMP) produced a firmer and more cohesive yogurt with greater values of the consistency descriptor and the viscosity index (Table 3). Immediately after production no differences were found in texture between yogurt made from unthickened milk and that produced from milk thickened by an addition of WPC 80. In turn, when processed milk was thickened using whey protein concentrates WPC 35 and WPC 65 it was found that the greater the share of whey proteins, the lesser firm and lesser cohesive the produced yogurts and the lower their viscosity index and consistency values. The differences observed between yogurts were maintained during storage.

Table 3. Texture parameters of yogurt made from skimmed milk with increased protein content and altered proportions of casein (CN) to whey protein (WP)

Texture	Storage (days)	9.1% DM, CN : WP 1 : 0.2	14.5% DM			
			SMP, CN : WP 1 : 0.2	WPC 35, CN : WP 1 : 1	WPC 65, CN : WP 1 : 1.6	WPC 80, CN : WP 1 : 1.9
Firmness (g)	0	37.76^{aA}	49.15^{bA}	47.99^{bA}	43.81^{bA}	38.37^{aA}
	10	37.47^{aA}	49.63^{cA}	45.39^{bA}	43.65^{bA}	44.24^{bB}
	21	38.26^{aA}	55.55^{bB}	62.13^{cB}	52.23^{bB}	51.45^{bC}
Consistency (g·s)	0	955.68^{aA}	1 197.07^{bA}	1 238.89^{cA}	1 106.69^{bA}	979.28^{aA}
	10	910.48^{aA}	1 245.56^{cB}	1 235.45^{cA}	1 091.22^{bA}	1 119.99^{bB}
	21	951.11^{aA}	1 404.52^{cC}	1 422.07^{cB}	1 354.80^{cB}	1 295.11^{bC}
Cohesiveness (g)	0	–31.05^{aB}	–43.08^{cA}	–46.61^{cA}	–39.78^{bA}	–30.39^{aA}
	10	–27.26^{aA}	–43.81^{cA}	–45.53^{cA}	–38.042^{bA}	–39.12^{bA}
	21	–29.89^{aA}	–55.93^{cB}	–58.73^{cB}	–55.81^{cB}	–47.44^{bB}
Viscosity index (g·s)	0	–73.50^{aA}	–103.31^{bA}	–112.92^{cB}	–96.69^{bA}	–66.44^{aA}
	10	–65.31^{aB}	–107.10^{bA}	–111.05^{cB}	–93.14^{bA}	–95.49^{bB}
	21	–71.38^{aA}	–137.71^{cB}	–135.85^{cB}	–95.85^{bA}	–116.11^{bC}

Denotations – as in Table 2.

Bierzuńska, P., Kaczyński, Ł. K., Cais-Sokolińska, D., Kulczyński, B. (2017). Texture profile of kefir and yogurt with modified configuration of proteins. Nauka Przyr. Technol., 11, 1, 107–114. http://dx.doi.org/10.17306/J.NPT.00168

Irrespective of the ratio of casein to whey proteins it was found that after 21 days samples of yogurt made from milk thickened with an addition of SMP and WPC were firmer than immediately after production (Table 3). Firmness did not change after storage only in yogurts made from unthickened milk. Their consistency after 21 days also showed no statistically significant changes. In the case of yogurts with an addition of WPC the value of their consistency as a result of storage increased significantly. At the same time they were becoming increasingly cohesive. Yogurts with the lowest casein to whey protein ratio (1 : 1.9) after 21 days had the viscosity index greater by 52% than after production (day 0). The viscosity index in yogurt with the highest CN : WP ratio (1 : 0.2) increased by 33%.

Obtained results showed that texture parameters of fermented milk may be easily modified by changing the composition of processed milk, particularly the ratio of casein to whey proteins. This experiment confirmed earlier observations reported by Bierzuńska et al. (2016) that consistency and firmness of fermented milk increase with the increase in solids content in processed milk. In turn, an opposite dependence was obtained for firmness and consistency of yogurt. The lower the casein to whey protein ratio in yogurt made from skimmed milk, the lower the firmness and consistency. In contrast, yogurt from milk containing 1.5% fat was firmer and had a higher consistency value (Bierzuńska et al., 2016). According to Mituniewicz-Małek et al. (2011), changes in texture of fermented milk measured instrumentally are accompanied by changes in sensory attributes. The range of these changes depends mainly on the type of microflora contained in the used starter culture. A reduction of the proportion of casein to whey proteins results in a lesser intensity of typical attributes of fermented milk such as aromatic, sour and astringent (Tomaschunas et al., 2012). Tomaschunas et al. (2012) based on yogurt showed that the higher the fat content in yogurt, the lesser the effect of the casein-to-whey protein ratio. Amatayakul et al. (2006) showed that a reduction of the casein-to-whey protein ratio reduces syneresis and firmness of yogurt, with the 3 : 1 ratio being optimal. In their study Uysal et al. (2003) reported an increase in hardness of yogurts during cold storage. A study by Wróblewska et al. (2009) showed that storage time has no significant effect on the viscosity index of fermented milk. Salvador and Fiszman (2004) stated that cold storage has a considerable effect on firmness of fermented milk.

Conclusions

1. The proportion of casein to whey proteins has a significant effect on texture parameters of kefir and yogurt produced from skimmed milk.
2. The greater the whey protein content, the lesser the firmness and consistency of kefir and yogurt made from skimmed milk.
3. Irrespective of the ratio of casein to whey proteins it was found that after 21 days kefir and yogurt from skimmed milk are firmer than immediately after production, while only yogurt is more cohesive.
4. No difference in texture was found between kefir made from unthickened milk and that produced from thickened milk with the highest share of whey proteins. The same dependence was shown when analysing yogurt.

Bierzuńska, P., Kaczyński, Ł. K., Cais-Sokolińska, D., Kulczyński, B. (2017). Texture profile of kefir and yogurt with modified configuration of proteins. Nauka Przyr. Technol., 11, 1, 107–114. http://dx.doi.org/10.17306/J.NPT.00168

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PROFIL TEKSTURY KEFIRU I JOGURTU O ZMIENIONYM UKŁADZIE BIAŁEK

Abstrakt
Wstęp. Skład mleka przerobowego i warunki techniczno-technologiczne jego dalszego przetwarzania mają istotny wpływ na ukształtowanie tekstury mleka fermentowanego. Celem pracy była ocena profilu tekstury kefiru i jogurtu z mleka odtłuszczonego o różnych proporcjach kazeiny i białek serwatkowych, stanowiącego wyznacznik jego jakości.
Materiał i metody. Kefir i jogurt o zawartości suchej substancji 14,5% wytworzono z udziałem odtłuszczonego mleka w proszku i koncentratów białek serwatkowych o różnym udziale białka. Pomiaru wybranych parametrów tekstury dokonano za pomocą teksturometru TA.XT-*plus* i oprogramowania Texture Exponent E32 techniką ekstruzji wstecznej.
Wyniki. Stwierdzono, że im więcej jest białek serwatkowych w modelowym kefirze i jogurcie z mleka odtłuszczonego, tym mniejsza jest ich zwięzłość. Niezależnie od stosunku kazeiny do białek serwatkowych (CN : WP), po 21 dniach kefir i jogurt z mleka odłuszczonego są bardziej zwięzłe niż po wytworzeniu, a tylko jogurt bardziej spoisty. Jogurty o najmniejszym stosunku kazeiny do białek serwatkowych (1 : 1,9) po 21 dniach miały o 52% większą wartość indeksu lepkości niż po wytworzeniu. W jogurcie o największym stosunku CN : WP (1 : 0,2) indeks lepkości zwiększył się o 33%.
Wnioski. Im większy był udział białek serwatkowych w stosunku do kazeiny, tym mniejszą zwięzłość i spoistość oraz tym rzadszą konsystencję miał kefir o zawartości 14,5% suchej substancji zaraz po wytworzeniu. Indeks lepkości kefiru z WPC 80 był o 70% mniejszy niż kefiru z SMP. Nie stwierdzono różnicy tekstury pomiędzy kefirem z mleka niezagęszczonego a kefirem z mleka o największym udziale białek serwatkowych.

Słowa kluczowe: kefir, jogurt, mleko fermentowane, koncentraty białek serwatkowych, tekstura

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