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QUALITY ASSESSMENT OF NATURAL YOGHURTS OFFERED IN RETAIL TRADE

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ABSTRACT

The aim of the study was to assess the sensory, physicochemical and microbiological quality of natural yoghurts offered in the Szczecin market, provided by the three largest domestic producers. The following physiochemical parameters were determined in the tested yoghurts: pH, titratable acidity, colour (CIEL a*, b*) and basic chemical composition. We assessed the appearance and colour, consistency and smell and taste of natural yoghurts. The studies also included the number of cells of the desired and harmful bacterial microflora. The best sensory quality, which consisted of colour, taste, smell, consistency and appearance was shown by yogurts with a high fat content. The content of protein and fat found in the tested samples was in line with the standard, however a reduced sugar content was observed. In all three tested products, no normative number of viable cells of desired bacterial microflora was observed in two weeks before the expiration date. The hygienic quality of fermented products was very good, and no presence of mould, yeast and *Enterobacteriaceae* bacteria was noted.

Key words: natural yoghurt, quality: physicochemical, sensory, microbiological

INTRODUCTION

Yoghurts are one of the most popular dairy products on the food market due to their biological and nutritional value [Brodziak and Król 2016]. According to the definition adopted by FAO/WHO, yogurt is a fermented milk product obtained through acidifying milk with yoghurt bacteria cultures (*Lactobacillus delbruecckii* ssp., *bulgaricus* and *Streptococcus salivarius* ssp. *thermophilus*). In case of new generation yoghurts, also *Lactobacillus acidophilus* and *Bifidobacterium* strains are added [Nowak et al. 2010].

At the moment of consumption, 1cm^3 of yogurt should approximately contain 1×10^7 of live microorganisms [Kapka-Skrzypczak et al. 2012].

Health-related qualities and organoleptic features of natural yoghurts like palatability, consistency or aroma reflect their quality and play a leading role in the choice of product by a customer.

The consumers find yoghurts to be a significant part of the diet, as the annual consumption of yoghurts is estimated at 7–8 kg per individual. Fruit yoghurts have the highest share in consumption, while the faster growth rate of consumption is observed in segment of potable and natural yoghurts, which is related to the changing requirements and expectations of consumers [Rój and Przybyłowski 2012]. Natural yoghurts are identified as a "healthier" alternative to cream [Wichrowska and Wojdyła 2014].

Production of fermented milk beverages is a complex process and even slight inadvertences can cause product defects. Proper selection of raw material and lactic acid bacteria, use of top-quality additives, adherence to the technological regime and ensuring the highest hygiene standards are crucial requirements that guarantee a high organoleptic and physicochemical characteristics of fermented milk beverages [Baranowska et al. 2010]. Therefore, it is necessary to understand and control the factors that determine yoghurt quality, vital to meet the expectations, needs and requirements of consumers.

For this reason, the aim of our study was to assess the sensory, physicochemical and microbiological quality of natural yoghurts offered by the three largest producers located in Szczecin city market.

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MATERIAL AND METHODS

The research material included natural yoghurts purchased in retail trade in Szczecin. The yoghurts tested in our research were produced by the three largest producers of fermented beverages located in the Polish market. The research material consisted of 90 yoghurts samples (30 separate packages of each producer) with a net weight of 150 to 180 g: brand I (1.5% fat), brand II (3.0%), brand III (3% fat). All yogurts were purchased with a 14-day shelf-life date. Yoghurts were stored in 4°C, in a refrigeration cabinet. From of the each purchased batch of yoghurts of a specific brand we took 10 packages for physicochemical assessment, 10 packages for sensory tests and 10 packages for microbiological analysis. Microbiological and physicochemical tests were performed the next day after purchasing.

The following physiochemical parameters were determined in yogurt samples: pH, titratable acidity, colour and basic chemical composition. The colour assessment was carried out using the MiniScan XE Plus 45/0 camera, with a 31.8 mm diam. measuring port. We referred to CIE L* a* b* scale, D65 illuminate and standard 10°C observer (CIE, 1976) were used. The pH measurement was performed using a combined glass electrode and a Cyber Scan pH meter. Evaluation of total acidity in Soxhlet-Henkel grades was performed using the standard method (PN-75/A-86130, 1975). The acidity of examined products was determined at room temperature, and the final result was the arithmetic mean of two parallel measurements.

Additionally, the chemical composition of yoghurts was determined: dry matter content, sugars, total protein and fat [Krełowska-Kułas 1993]. The Kjeldahl method was used to determine the total protein content, and the fat content was measured with the Röse-Gottlieb method. The Bertrand method was used to determine the content of sugars (lactose). The dry matter content was determined by drying at 130°C.

Our study was also focused on microbiological evaluation of natural yoghurts. For the microbiological tests, 1 gram of yogurt was transferred to 9 ml of sterile saline. The suspension was shaken, and decimal dilutions were made. One ml of suspension from each of the dilutions was inoculated into the following media: MacConkey Agar, XLD Medium (to identify Gram-negative *Enterobacteriaceae* bacteria), Baird-Parker Agar (to identify *Staphylococcus* bacteria), Edwards Medium (to identify streptococci) and MRS Agar (to isolate *Lactobacillus* spp.). The cultures were incubated under aerobic conditions at 37°C for 24 hours. After that time the colonies were counted with consideration to the previously made decimal dilutions (PN 93/A-860334-08, PN 93/A-860334-15). The number of yeast

Table 1. Five-point evaluation pattern [Pieczonka, 1995]

Tabela 1. Schemat oceny 5-punktowej [Pieczonka, 1995]

Point scale Skala punktów	Quality feature Cecha jakości		
	Appearance and colour Wygląd i barwa	Consistency Konsystencja	Smell and taste Smak i zapach
5	The colour is white or characteristic for the used additives, with visible small particles Barwa biała lub charakterystyczna dla użytych dodatków, z widocznymi drobnymi ich cząstkami	Uniform, dense, slightly ductile, palpable small particles of additives Jednolita, gęsta, lekko ciągliwa, wyczuwalne drobne cząstki dodatków	Pure, aromatic, characteristic for yogurt and harmonized, slightly sour Czysty, aromatyczny, charakterystyczny dla jogurtu i zharmonizowany, lekko kwaśny
4	The colour is white or less characteristic for the used additives, with visible single but too large particles Barwa biała lub mniej charakterystyczna dla użytych dodatków, widoczne pojedyncze zbyt duże ich cząstki	Uniform, dense, slightly ductile, palpable small particles of additives Jednolita, gęsta, lekko ciągliwa, wyczuwalne drobne cząstki dodatków	Pure, aromatic, characteristic for yogurt, slightly sour Czysty, aromatyczny, charakterystyczny dla jogurtu, lekko kwaśny
3	The colour is slightly changed, a large amount of too small particles Barwa nieco zmieniona, duża ilość zbyt słabo rozdrobnionych dodatków	Uniform, too thin, ductile, palpable larger particles of additives Jednolita, zbyt rzadka, ciągliwa, wyczuwalne większe cząstki dodatków	Unclean, less characteristic, less aromatic, sour Nieczysty, mniej charakterystyczny, mało aromatyczny, kwaśny
2	The colour is clearly changed Barwa wyraźnie zmieniona	Uniform, too thin, ductile, palpable larger particles of additives Jednolita, zbyt rzadka, ciągliwa, wyczuwalne większe cząstki dodatków	Clearly changed, strongly acidic Wyraźnie zmieniony, silnie kwaśny
1	Unusual colour, detestable appearance Barwa nietypowa, wygląd odrażający	Incomplete, whey drip Niejednolita, odciek serwatki	Unusual, strange Nietypowy, obcy

and mould cells was determined in reference to the Polish Standard (PN-93/A-860334-07). The results of all microbiological determinations were expressed as CFU/g.

Sensory analysis was performed with a five-point scale according to Pieczonka [1995]: 1 point-disqualifying rate, 5 points-very good rate. The appearance, colour, consistency, smell and taste of natural yoghurts were evaluated. Sensory analysis was carried out by a five-person team verified in terms of sensory sensitivity, according to PN-ISO-4121 [1998].

Statistical analysis of the results was performed with the Statistica 10 software. We calculated the mean values and standard deviation and carried out a one-way analysis of variance. The Duncan test was used to estimate the differences between the experimental groups.

RESULTS AND DISCUSSION

Sensory assessment

The results of organoleptic evaluation did not show statistically significant influence of the tested yogurt brand on appearance, colour and consistency. In all the three cases, the tested beverages were rated with the highest score: 5.0 points (Table 1). All yoghurts were characterized by white colour, and their consistency was uniform and dense, which proves a high quality of evaluated yoghurts. The results stay in line with opinion of Shukla and Jain [1991] and Fortuna et al. [2001] and, for whom a good yogurt is characterized by a smooth surface, a firm clot and a consistency with no clumps felt in mouth.

The tested yoghurts differed in taste and aroma (Table 1). Significantly the best taste ($P \leq 0.01$) was found in brand II (4.83 points) as compared to brand III (4.65 points) and brand I (3.92). Fat content was related to the taste – the more fat there was, the higher was the taste rating (Tables 1 and 3). Nevertheless, taste of all yoghurt samples was described as pure, aromatic and slightly sour. In fragrance, the highest note ($P \leq 0.01$) was given to brand III (4.65 pts), while the other two yoghurts (brand I and II) were rated identically (4.33 pts). It should be emphasized that the examined beverages were characterized by an aromatic and characteristic fragrance.

Yoghurts owe their characteristic taste and smell primarily to the products of lactic fermentation such as lactic acid, acetaldehyde and acetoin [Biliaderis et al. 1991, Kowal and Libudzisz 2000].

The examined yoghurts showed no variations in taste and smell, and these parameters in all the tested samples were appropriate.

Physicochemical evaluation

Titratable acidity of the examined fermented beverages ranged from 46.56 to 52.68°SH and there were no statistically significant differences between the samples (Table 2). The values we measured were slightly higher than those required by the Polish Standard PN-83/86061 (from 35 to 48°SH). In similar studies performed by Wichrowska and Wojdyła [2014], the authors assessed physicochemical quality of selected natural yoghurts of various producers and found that all the tested yoghurts represented a correct titratable acidity (from 38.1 to 44.25°SH) after 7 days of storage.

The lowest titratable acidity was found in the product with 1.5% fat content (brand I), and the highest in products with 3% fat content (brand II and III) (Table 2 and 3). Similar results were obtained by Bonczar and Wszołka [2002], who showed that after fourteen days of storage the highest titratable acidity characterized the fat-free yoghurts. Change in acidity of yogurt results from the presence of yoghurt bacteria in the final product, which show diversified acidifying, proteolytic and lipolytic activity. During the maturing and storage of yoghurts, the bacteria use milk compounds, however, the rates and ranges differ. As the shelf life of tested products was only two weeks, we expected that the acidity of yogurt will increase during the storage, which would be consistent with the literature reports [Kisza et al. 1993, Imhof et al. 1994, Bonczar and Wszołek 1997, Sady et al. 2007, Cais-Sokolińska et al. 2009, Mituniewicz-Małek et al. 2010, 2013, Wichrowska and Wojdyła 2014]. According to Mituniewicz-Małek et al. [2013] changes in the acidity of acidified milk during refrigerated storage are caused by fermentative activity of microorganisms included in inoculants, which in 4°C still digest lactose, although much slower than in the optimal temperature recommended for the growth of lactic acid bacteria.

The observed pH values were in accordance with the standard. Brand I yoghurt had significantly ($P \leq 0.01$) higher pH (4.43) than yoghurts of the other two brands (4.48 and 4.49 for II and III, respectively) (Table 2). The pH values measured in our study were similar to those observed by Wichrowska and Wojdyła [2014] in yoghurts from the retail trade after a weekly storage period.

The brightness of colour (L*) in tested natural yogurt samples ranged from 93.77 to 94.34, and our statistical analysis showed no significant differences in this parameter. According to Rój and Przybyłowski [2012], natural yoghurts show the differences in brightness parameter (L*) depending on the declared fat content, which however has not been confirmed in this study. The a* parameter (change in colour from green to magenta) took negative values for all the examined yogurt samples, ranging from –1.50 to –2.21. The b* parameter (change in colour from blue to yellow) took positive values for all the tested samples of yoghurts in range from 9.76 to 11.03.

The brand I yoghurt was characterized by the highest protein content (5.13%) as compared to brand II (4.72%)

Table 1. Sensory evaluation of yoghurts from 3 different producers (pts)

Tabela 1. Ocena sensoryczna jogurtów pochodzących od 3 różnych producentów (pkt)

Trait Cecha	Producer Producent					
	I		II		III	
	x	s	x	s	x	s
Appearance and colour, pts Wygląd i barwa, pkt	5.00	0.00	5.00	0.00	5.00	0.00
Consistency, pts Konsytencja, pkt	5.00	0.00	5.00	0.00	5.00	0.00
Taste, pts Smak, pkt	3.92A	0.19	4.83B	0.24	4.65C	0.27
Aroma, pts Zapach, pkt	4.33A	0.48	4.33A	0.24	4.65B	0.27

Letters A, B, C denote significant differences between experimental groups $P \leq 0.01$.
Literami A, B, C oznaczono różnice istotne na poziomie $P \leq 0,01$.

Table 2. Physicochemical evaluation of yoghurts from 3 different producers

Tabela 2. Ocena fizykochemiczna jogurtów pochodzących od 3 różnych producentów

Trait Cecha	Producer Producent					
	I		II		III	
	x	s	x	s	x	s
pH	4.43A	0.02	4.48B	0.02	4.49B	0.04
Titratable acidity, °SH Kwasowość miareczkowa, °SH	46.56	0.54	49.32	0.38	52.68	0.54
L*	94.04	0.14	93.77	1.03	94.34	0.03
a*	–2.21	0.08	–1.40	0.06	–1.90	0.03
b*	10.75	0.40	9.76	0.26	11.03	0.18

Letters A, B denote significant differences between experimental groups $P \leq 0.01$.
Literami A, B różnice istotne na poziomie $P \leq 0,01$.

Table 3. Evaluation of chemical composition of yoghurts from 3 different producers

Tabela 3. Ocena składu chemicznego jogurtów pochodzących od 3 różnych producentów

Trait Cecha	Producer Producent					
	I		II		III	
	x	s	x	s	x	s
Dry matter, % Sucha masa, %	13.8	0.39	12.9	0.23	14.5	0.27
Protein, % Białko, %	5.13	0.13	4.72	0.10	4.65	0.12
Sugars, % Cukry, %	4.57	0.06	2.40	0.09	4.26	0.05
Fat, % Tłuszcz, %	1.43	0.03	2.97	0.05	2.65	0.06

and brand III (4.65%) (Table 3). Our measures of protein content did not differ from those given by yoghurt producers (Table 4), and were in accordance with the Polish Standard (PN-A-86061: 2002/Az1).

The percentage of fat in evaluated yoghurts was close to that declared by yoghurt producers on the product labels (Table 4). The largest amount of fat was found in brand II yogurt (2.65%), and the smallest fat content was found in brand I sample (1.43%) which most probably was the reason to the fact that the taste of this yogurt was worse when compared to the other two. According to Żbikowska and Żbikowski [1995], the higher fat content

increases the final clot volume and limits syneresis, which results in the consistency of yogurt being more attractive to the consumer. In the tested yoghurts, the texture was evaluated very highly regardless of the fat content (5 points). We found a decrease in sugar content in the tested yoghurts (Table 3 and 4). The highest sugar content was measured in brand I and III yoghurts (4.57% and 4.26% respectively), in comparison to brand II yoghurt (2.40%). Fluctuations in sugar content in the analysed yoghurts can be explained by the fermentative activity of microorganisms included in the inoculants, which at 4°C still digest lactose [Cais-Sokolińska et al. 2009]. The content of dry matter in the tested yoghurts ranged from 12.9% to 14.5% (Table 3).

Microbiological quality

Microbiological analyses were made the next day after the purchase, and the yogurts were about two weeks of shelf life. The highest content of *Lactobacillus* bacteria was recorded in brand III yoghurt: 9.8×10^5 CFU $\cdot$ g^{-1}. In the other two brands, the content of *Lactobacillus* was similar and ranged from 9.3×10^5 CFU $\cdot$ g^{-1} to 9.4×10^5 CFU $\cdot$ g^{-1} (Table 5). The number of *Streptococcus* bacteria was also determined in the examined yogurts. The number of these bacteria present in the samples right after the purchase was from 4.48×10^3 CFU $\cdot$ g^{-1} to 5.8×10^3 CFU $\cdot$ g^{-1}. No infections with moulds, yeasts and *Enterobacteriaceae* bacteria were observed.

Table 4. Chemical composition of yoghurts declared by the producer on the product label

Tabela 4. Skład chemiczny jogurtów deklarowany przez producenta na etykiecie

Trait Cechy	Producer – Producent		
	I	II	III
Protein, % – Białko,%	5.1	4.9	4.6
Sugars, % – Cukry, %	7.3	4.2	5.8
Fat, % – Tłuszcz, %	1.5	3.0	3.0

Table 5. Microbiological quality of yoghurts from 3 different producers, CFU $\cdot$ g^{-1}

Tabela 5. Jakość mikrobiologiczna jogurtów pochodzących od 3 różnych producentów, j.t.k. $\cdot$ g^{-1}

Microorganisms Drobnoustroje	Producer – Producent		
	I	II	III
Lactobacillus	9.30×10^5	9.40×10^5	9.80×10^5
Streptococcus	4.83×10^3	2.80×10^3	5.80×10^3
Candida	–	–	–
Aspergillus	–	–	–
Enterobacteriaceae	–	–	–

Fermented milk beverages should be characterized with an appropriate content of live typical (and possibly additional) cells in the final shelf-life. The requirements of FAO/WHO and FIL/IDF expect their minimal concentration at 10^7 CFU $\cdot$ g^{-1} [Kudełka 2005]. In all the tested brands, there was no normative number of live cells noted two weeks before the expiration date. This result is not consistent with the studies on the quality of natural yoghurts in the Warsaw market by Orzechowska et al. [2002]. These authors report that the number of *Lactobacillus* bacteria below the normative value of 10^7 was found in 40% of the tested natural yoghurts, and in *Streptococcus* bacteria, only in 10% of the products. Sosnowska and Kurek [2012], analysing the quality of natural yoghurts in the Lublin market, noted that all the tested products contained the required number of live cells typical for the yogurt microflora, and in many products this number exceeded the required quantity by 2–3 orders of magnitude. Also Pluta et al. [2001] analysing the quality of natural yoghurts on the domestic market in 1995-2001 showed that in 97% of the tested samples the characteristic microflora occured in the number of 10^7. Kycia and Krysiński [2014], who assessed the microbiological and hygienic quality of goat milk yogurts also showed that 84.3% of the tested samples met the requirements for the number of typical yoghurt microorganisms, specified in the Codex Alimentarius standard, throughout the shelf life of the products.

The viability of lactic bacteria in fermented and cool-stored milk depends on many factors, including the time and temperature of fermentation, storage conditions of the final product, its acidity, content of dry matter and sugars, access to bacterial nutrients, presence of oxygen, and the type and species and strain of lactic acid bacteria used in fermentation Mituniewicz-Małek et al. [2013].

Studies performed by many researchers clearly define that storage time affects the number of microflora typical for yoghurts. Sady et al. [2007] showed that levels of *L. bulgaricus* and *S. thermophilus* increased slightly up to the 3rd day of storage, and then decreased to the lowest level on day 14th. In addition, they observed that the number of bacilli was decreasing slower than streptococci. In fresh products, the ratio of *L. bulgaricus* to *L. thermophilus* was 1:1.46, while after 14 days it changed into 1.23:1. This change is related to the advancing acidification that happens during the cool storage (*S. thermophilus* is less tolerant to high acidity). Similar results were obtained by Laye et al. [1993] and Beal et al. [1999], whereas Kneifel et al. [1993] and Barrantes et al. [1996] did not observe any significant changes in the number of bacteria during yoghurt storage. Moreover, Cais-Sokolińska and Pikul [2001] reported the effect of storage temperature on a decrease in the number of lactic acid microorganisms. The number of cells was decre-

asing slower in yogurt stored at 6 ±1°C in comparison to when it was stored at a higher temperature (10 ±1°C).

CONCLUSIONS

1. The best sensory quality, which consisted of colour, taste, smell, consistency and appearance was found in brand II and III yoghurts, with a high fat content (about 3%).
2. The active acidity of all the tested yoghurts was proper and ranged from 4.43 to 4.49.
3. The titratable acidity of brand II and III yoghurts ranged from 49.32 to 52.68°SH, and was not consistent with the Norm.
4. The measured content of protein and fat in the tested samples yoghurts was proper, however a reduced sugar content was observed.
5. In all the tested products of three brands, no normative number of live cells was recorded two weeks before the expiration date.
6. The hygienic quality of all the fermented products was very good, and no presence of mould, yeast and *Enterobacteriaceae* bacteria was noted.

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OCENA JAKOŚCIOWA JOGURTÓW NATURALNYCH DOSTĘPNYCH W HANDLU DETALICZNYM

STRESZCZENIE

Celem badań była ocena jakości sensorycznej, fizykochemicznej i mikrobiologicznej jogurtów naturalnych obecnych na rynku szczecińskim, pochodzących od trzech największych producentów krajowych. W zakupionych jogurtach oznaczono następujące parametry fizykochemiczne: pH, kwasowość miareczkową, barwę (CIEL a*, b*) oraz podstawowy skład chemiczny. Oceniono wygląd i barwę, konsystencję, zapach i smak jogurtów naturalnych. Badania obejmowały również ilość komórek żywych mikroflory pożądanej i szkodliwej. Najlepszą jakością sensoryczną, na którą składała się barwa, smak, zapach, konsystencja i wygląd charakteryzowały się jogurty o wysokiej zawartości tłuszczu. Oznaczona w ocenianych jogurtach zawartość białka i tłuszczu była zgodna z normą, natomiast odnotowano obniżoną zawartość cukru. We wszystkich badanych produktach trzech marek, nie odnotowano normatywnej liczby żywych komórek mikroflory pożądanej, na dwa tygodnie przed upływem terminu ważności. Jakość higieniczna produktów fermentowanych była bardzo dobra, nie odnotowano obecności pleśni, drożdży oraz bakterii z rodzaju *Enterobacteriaceae*.

Słowa kluczowe: jogurt naturalny, jakość: fizykochemiczna, sensoryczna, mikrobiologiczna.