APARATURA

BADAWCZA I DYDAKTYCZNA

The conductivity of the milk kefir model reduced by enzymatic hydrolysis of lactose content

ŁUKASZ K. KACZYŃSKI[1], PAULINA BIERZUŃSKA[1], DOROTA CAIS-SOKOLIŃSKA[1]

[1]DEPARTMENT OF DAIRY TECHNOLOGY, FACULTY OF FOOD SCIENCE AND NUTRITION, POZNAŃ UNIVERSITY OF LIFE SCIENCES

Keywords: conductometry, conductivity, lactose-free milk

ABSTRACT:

Measurements of electrical values reflect the dynamics for development of lactic acid bacteria. They may be, in addition to pH measurement, a tool for a technologist to monitor the fermentation process and changes taking place in the finished product, in which the microflora is still active. It was stated that with lapse of fermentation time, the conductivity of each sample of milk that has undergone the souring process increased by 1.5 times. The values of direction coefficients for the linear distribution are consistent with the dynamics of pH changes for kefirs during their production. After 24 hours of fermentation, pH for samples of this milk was 4.42, and the conductivity – 7.213 $\Omega^{-3}\cdot cm^{-1}$. Measurement of conductivity of processed milk with the lactose content of 4.7% and less than 0.01% reflects the dynamics of the souring process.

Konduktywność modelowych kefirów z mleka o obniżonej na drodze hydrolizy enzymatycznej zawartości laktozy

Słowa kluczowe: konduktometria, konduktywność, mleko bezlaktozowe

STRESZCZENIE:

Pomiary wielkości elektrycznych odzwierciedlają dynamikę rozwoju bakterii kwasu mlekowego. Stanowić mogą, obok pomiaru pH, narzędzie dla technologa w monitorowaniu procesu fermentacji i zmian zachodzących w gotowym produkcie, w którym mikroflora nadal pozostaje aktywna. Stwierdzono, że wraz z upływem czasu fermentacji konduktywność każdej z próbek mleka poddanego ukwaszeniu zwiększyła się 1,5-krotnie. Wartości współczynników kierunkowych rozkładu liniowego są zbieżne z dynamiką zmian pH kefirów podczas ich wytwarzania. Po 24 h fermentacji pH próbek tego mleka wyniosło 4,42, a konduktywność 7,213 $\Omega^{-3}\cdot cm^{1}$. Pomiar konduktywności przerabianego mleka o zawartości laktozy 4,7% i mniej niż 0,01% stanowi odzwierciedlenie dynamiki procesu ukwaszania.

1. INTRODUCTION

Electrical properties depend on the chemical composition and the degree of dissociation of electrolytes in the processed milk. They are closely related to the amount and charge of ions in the solution. Measurements of electrical values reflect the dynamics for development of lactic acid bacteria [1]. They may be, in addition to pH measurement, a tool for a technologist to monitor the fermentation process and changes taking place in the finished product, in which the microflora is still active. In the subject's literature, you can find lots of information on the electrical properties, especially the conductivity (electrical conductivity EC) of cow's milk and products made from this milk [2]. There is much less data about the processing of lactose-free milk and milk with a reduced content of lactose. Milk with a reduced or completely removed content of lactose is increasingly used in the production of fermented milk: yogurts, kefirs, acidophilus or bifidus milk. This is a new trend in the processing. It is closely correlated with innovation in the dairy industry. The interest of milk processing plants in lactose-free products is related to the increasing number of potential customers. From year to year there is a progress in the diagnosis of hipolactasia. The reduced activity or even the lack of lactase in villi of the small intestine contributes to the gastro--intestinal ailments after consumption of dairy products. The dairy sector responds to customers with hipolactasia and offers products with a reduced content of lactose [3]. Therefore, the knowledge of electrical properties of milk with a reduced content of lactose and its changes during fermentation, which is the main direction of processing of this milk, is gaining importance. The aim of the study was to determine the influence of the fermentation process and define model properties of conductivity for kefirs from the milk with a reduced content of lactose.

2. EXPERIMENTAL PART

Initial raw material for the researches was a milk with a typical content of lactose (4.7%) and milk with a reduced content of lactose by enzymatic hydrolysis (<0.01%) of fat. Milk with a content of lactose (4.7%) came from 5 different producers from EU countries and 3 different production batches (n=15). Milk with a reduced content of lactose came from 3 different producers from EU countries and 5 different production batches (n=15). Regardless of the lactose content, milk contained an average of 3.41±0.12% protein and 1.51±0.07% fat (n=30). Subsequently, the milk was subjected to souring process in the laboratory conditions in the way of lactic-alcoholic fermentation. The fermentation was carried out with the participation of mesophilic strains of lactic acid bacteria (LAB): *Lactococcus lactis subsp. lactis, Lactococcus lactis subsp. cremoris, Lactococcus lactis subsp. lactis biovar diacetylactis, Leuconostoc mesenterroides subsp. cremoris, Lactobacillus plantarum, Lactobacillus casei* and yeast: *Kluyveromyces fragilis (Kluyveromyces marxianus subsp. marxianus).* The starter cultures used were a commercial product, which were introduced in a lyophilized form at a level of 30 u.a. to 100 liters of milk, and the incubation was carried out at 22°C for 24 h. The dose of introduced cultures was selected in order that the end point of the fermentation would be a product with a pH value of 4.4-4.5. The products were poured into PS (polystyrene) packaging with a capacity for 150 g of product, and were then cooled to temperature, i.e. 5±1°C. The products were tested at 48 hours after the end of the fermentation process.

2.1 Conductivity

Measurement of conductivity (EC) for samples, which depends on changes in ion concentration, was performed with the use of electro-analytical method described by [4]. The conductivity meter CC 401 along with EC-60 sensor and a temperature sensor CT2B-121 produced by Elmetron (Zabrze, Poland) were used. The conductivity sensor was equipped with platinum electrodes covered with black of a constant = K=1 cm^{-1}. Accuracy of the measurement: > 20 $\Omega^{-3}\cdot cm^{-1}$± 0.25%.

2.2 Acidity

The pH value was measured using a CP-502 type Elmetron pH-meter (Zabrze, Poland) equipped with a ESAgP-301W type combined electrode probe by the Eurosensor company (Gliwice, Poland) consisting of a glass half-cell and a silver chloride half-cell. The measurement was carried out in accordance with the guidelines specified by Martinez-Villaluenga et al. [5].

2.3 Statistical evaluation

For the verification of statistical hypotheses, a level of significance at α=0.05 was adopted. The statistical calculations were made using StatSoft, Inc. (2011). STATISTICA (data analysis software system), version 10. The correlation coefficient significance tests were based on the assumption of normal distribution of the residual value of the *y* variable and an equal residual value variation for all values of the *x* variable. In order to eliminate deviations from Pearson's distribution linearity, which could cause an increase of the square sum of deviations from the regression line, a scatter diagram analysis was performed.

3. RESULTS AND THEIR DISCUSSION

On the basis of the experiment, it was showed significant differences of conductivity in unfermented milk with a different content of lactose (Fig. 1). Milk with a reduced content of lactose before its inoculation with a starter culture was characterized by a significant lower conductivity (4.746 $\Omega^{-3}\cdot cm^{-1}$) than milk with a typical content of lactose of 4.7% (5.204 $\Omega^{-3}\cdot cm^{-1}$).
Along with the passage of fermentation time, the conductivity of each sample of milk subjected to the souring process increased by 1.5 times. (Fig. 2 and Fig. 3). After completion of the fermentation process for the processed milk with an original content of lactose at the level of 4.7%, a significant increase in its acidity was observed. Parameters of the linear function in the carried out analysis of a cross section f_x (Fig. 1) confirm that changes in conductivity of samples during the fermentation were significantly lower in the milk with an initial content of lactose of 4.7% ($|a|_{mean}$=2.227) than in the milk without lactose ($|a|_{mean}$=2.375). The values of direction coefficients for the linear distribution are consistent with the dynamics of pH changes for kefirs during their production (Fig. 2 and Fig. 3). After 24 hours of fermentation, pH for samples of this milk was 4.42, and the conductivity 7.213 $\Omega^{-3}\cdot cm^{-1}$. These values for the lactose-free milk were respectively: pH 4.41 and conductivity 7.121 $\Omega^{-3}\cdot cm^{-1}$. High values for the normality of distribution were obtained (SW-W≥0.8829). Measurement of conductivity for the processed milk with a lactose content of 4.7% and less than 0.01% reflects the dynamics of the souring process (0.9769≤r≤0.8861). In the literature concerning the conductivity, the subject of

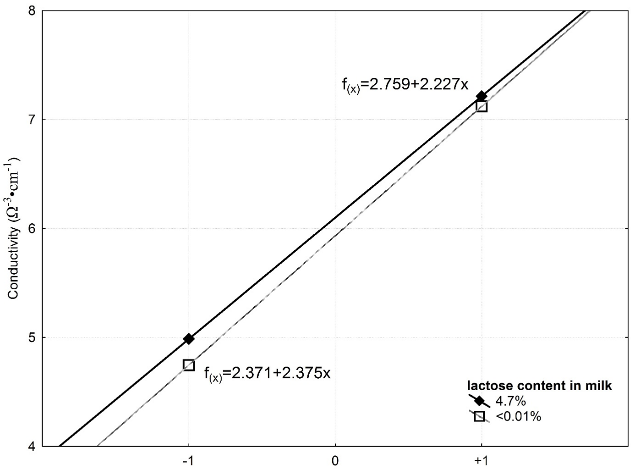

Figure 1 Analysis of course of conductivity dynamics in samples during fermentation (-1– minimum value of factor – before fermentation, +1 – maximum value of factor – after fermentation), n=15

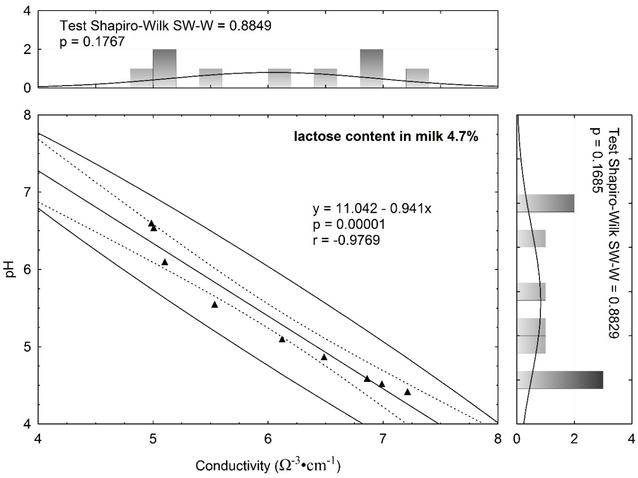

Figure 2 Analysis of interdependence between pH and conductivity in kefir which was made from milk contains 4.7% lactose, n=15

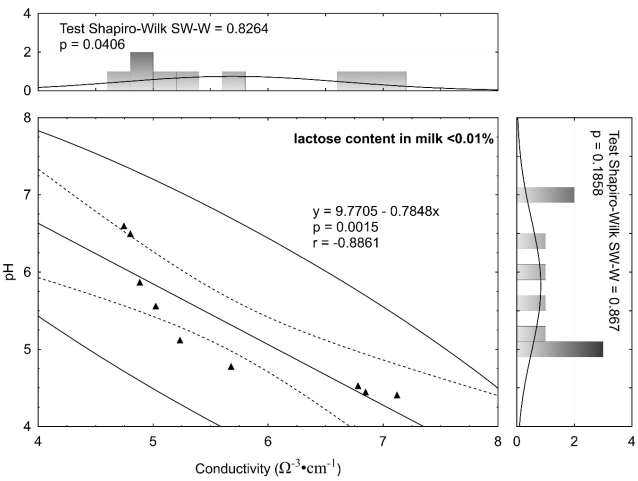

Figure 3 Analysis of interdependence between pH and conductivity in kefir which was made from milk contains ≤0.01% lactose, n=15

a comparative analysis is usually milk from different species of mammals. Park [6] showed similar values in the case of goat's milk (from 4.3 to 13.9 $\Omega^{-3}\cdot cm^{-1}$), but different from sheep's milk (3.8 $\Omega^{-3}\cdot cm^{-1}$) and cow's milk (from 4.0 to 5.5 $\Omega^{-3}\cdot cm^{-1}$). There are few examples on the effect of lactose content in milk on its conductivity. Mabrook and Petty [2] did not demonstrate the relation between the conductance and content of lactose while examining the conductance of milk as a measure of susceptibility to electrical current. Samples with different content of lactose (4.9%), but at the same fat content, had the same conductance. The authors found its correlation only with the content of fat in samples. The more fat in the milk, the lower value of conductance. And so: for whole milk (3.6% of fat), it amounted to 5.05 mS, for skimmed milk (0.1% of fat) 5.4 mS. Therefore, they confirmed the findings of previous researchers [7, 8].

The milk fermentation process contributes to significant changes in conductivity [1]. Intensive increase in the conductivity occurs due to changes in a colloidal system during the souring process, creation of casein micelles network, as well as changes in solubility of colloidal calcium and phosphorus. For example, the initial value of the conductance shown by milk [1] was significantly lower than in milk with a higher content of mineral substances and casein.

4. CONCLUSIONS

Measurement of conductometry replaces the measurement of the pH of milk. It is a reflection of the dynamics in the souring process and a tool to monitor the milk fermentation process after enzymatic removal of lactose. It was stated that with lapse of fermentation time, the conductivity of each sample of milk that has undergone the souring process increased by 1.5 times.

REFERENCES

[1] Bornaz S., Guizani N., Sammari J., Allouch W., Sahli A., Attia H., Physicochemical properties of fermented Arabian mares'milk. Int. Dairy J. 20, (2010), 500-505.

[2] Mabrook M. F., Petty M. C., Effect of composition on the electrical conductance of milk. J. Food Eng. 60, (2003), 321-325.

[3] Gudmand-Høyer E., Skovbjerg H., Disaccharide digestion and maldigestion. Scand. J. Gastroenterol. Suppl. 216, (1996), 111-121.

[4] St-Gelais D., Champagne C. P., The use of electrical conductivity to follow acidification of dairy blends. Int. Dairy J. 5, (1995), 427-438.

[5] Martinez-Villaluenga C., Frias J., Gomez R., Vidal-Valverde C., Influence of addition of raffinose family oligosaccharides on probiotic survival in fermented milk during refrigerated storage. Int. Dairy J. 16, (2006), 768-774.

[6] Park Y. W., Rheological characteristics of goat and sheep milk. Small Rumin. Res. 68, (2007), 73-87.

[7] Lawton B. A., Pethig R., Determining the fat content of milk and cream using AC conductivity measurements. Meas. Sci. Technol. 4, (1993), 38-41.

[8] Felice C. J., Madrid R. E., Olivera J. M., Rotger V. I., Valentinuzzi M. E., Impedance microbiology: quantification of bacterial content in milk by means of capacitance growth curves. J. Microbiol. Meth. 35, (1999), 37-42.