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IMPACT OF MODIFIED ATMOSPHERE PACKING ON THE QUALITY OF GRATED MOZZARELLA CHEESE

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Key words: grated Mozzarella cheese, microbiological changes, MAP, packing, quality, shelf live

The aim of this study was to determine the impact of selected modified atmosphere packing variants on microbiological and physicochemical changes of grated Mozzarella cheese during its storage. The study involved microbiological and physicochemical determinations as well as organoleptic evaluation of grated Mozzarella cheese. The study material included samples of grated Mozzarella cheese obtained under industrial conditions and contaminated with microbiological inoculum of foreign microflora. The samples of cheeses were packed into bags using the following conditions: under N_2, CO_2, lowered pressure at 400 mbar, 50% CO_2/50% N_2, 70% CO_2/30% N_2. Microbiological analysis of the cheese samples involved determination of total count of microorganisms, coliform count, yeast and mould count. Physicochemical analysis of the cheese samples involved determination of water content, fat content, total nitrogen content, titratable acidity, pH. Sensory evaluation of the cheese samples was also performed.

A significant effect decreasing the development of microflora in the samples of Mozzarella cheese packing in the atmosphere of CO_2 compared to packing under lowered (400 mbar) air pressure and in the atmosphere N_2 was observed. The sensory evaluation of the grated Mozzarella cheese after 4 weeks of cold storage did not reveal any statistically significant difference between the packing variants employed. Reduced pressure air packing guarantees the quality comparable with that obtained by packing under the atmosphere of nitrogen, carbon dioxide or a mixture of these two gases, although too high a reduction of pressure (400 mbar and below) may result in clumping of the pieces of Mozzarella cheese during storage.

INTRODUCTION

Microbiological processes are a major cause of food spoilage. Preservation of a good quality of products during prolonged storage necessitates the development and implementation of numerous new food packaging systems. The packaging itself is a means of protecting the product against adverse changes during storage, transport and use. Apart from this protective function, packaging has also other functions, including the distribution, marketing, economic and ecological ones. In response to the growing demands of the consumers, but chiefly imposed by the manufacturers and distributors, new food packing techniques are introduced, such as vacuum packing, modified atmosphere packing (MAP) and controlled atmosphere packing (CAP). These techniques may substantially prolong the shelf life of many products. Modified atmosphere packing has emerged as a solution competitive to vacuum packing. It is carried out using gaseous mixtures with the composition dependent on the kind of the product to be packed, whose mixtures allow maintaining the quality of the product over prolonged periods of time. It applies especially to products whose original characteristics are not maintained by vacuum packing or are worsened during storage. The modification of the atmosphere is carried out with the use of nitrogen, carbon dioxide and oxygen. It is also possible to use nitrous oxide, carbon monoxide, sulphur dioxide or other gases. The use of the potential possibilities of the latest packing methods requires continuous research [Michniewicz, 1998; Pikul, 2000].

The vacuum technique is the most common method employed for packing of cheese in Poland. Certain types of cheese cannot, however, be packed using this method due to their specificities. These cheeses include, among others, blue cheeses, cheeses with large numbers of eyes and grated cheeses due to clumping of individual portions of the cheeses. The Mozzarella cheese is very frequently used in the grated form. During grating contamination with a foreign microbial flora may take place. Grated Mozzarella offers better conditions for the growth of mould and yeast. Several papers have been published in Polish and foreign literature regarding the impact of neutral atmosphere packing on the quality of the various types of cheese. The studies carried out in this field are unequivocal and concern different types of cheese [Alves *et al.*, 1996; Eliot *et al.*, 1998; Gonzalez-Fandos *et al.*, 2000; Pluta *et al.*, 2003].

The aim of this study was to determine the impact of selected modified atmosphere packing variants on microbiological and physicochemical changes of grated Mozzarella cheese during its storage.

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MATERIALS AND METHODS

The study involved microbiological and physicochemical determinations as well as organoleptic evaluation of grated Mozzarella cheese. The study material included three batches of grated Mozzarella cheese obtained under industrial conditions and packed in sacks, 2 kg each. After the cheeses had been transported to the laboratory, the whole mass was divided in two. The next step involved the addition of a suspension of microbiologically contaminated inoculum prepared from sterile distilled water and a wash-off obtained from the surface of blue cheese stored at room temperature and left for unwanted microbial flora proliferation to one of the two resulting one-kilogram lots of the cheese to be analysed. The purpose of contaminating Mozzarella cheese by sprying it with contaminated suspension was to inoculate it with undesirable microflora (moulds, coliform bacteria, yeasts) which might be sensitive to the kind of packing. In this way we wanted to obtain more pronounced effect of the kind of packing on this microflora during the short period of storage of Mozzarella cheese. The addition of the microbiologically contaminated inoculum was carried out using a spray dispenser, adding six measured doses into the cheese mass with intensive stirring every two doses. Each dose contained 0.4 mL of the preformed suspension of microbiologically contaminated inoculum diluted at 1:40 ratio. No microbiologically contaminated inocula were added to the other kilogram of the Mozzarella cheese. The next stage involved further division of the two one-kilogram lots of cheese into four 250-g portions packed into bags using the following methods: (A) packing by the initial use of vacuum at 20 mbar followed by the introduction of nitrogen to reach 400 mbar; (B) packing by the initial use of vacuum at 20 mbar followed by the introduction of carbon dioxide to reach 400 mbar; (C) packing under lowered pressure at 400 mbar; (D) packing by the initial use of vacuum at 20 mbar followed by the introduction of a mixture of 50% carbon dioxide and 50% nitrogen to reach 400 mbar; (E) packing by the initial use of vacuum at 20 mbar followed by the introduction of a mixture of 70% carbon dioxide and 30% nitrogen to reach 400 mbar. The packing was carried out in the MULTIVAC A 300/16 machine at the Department of Milk Biotechnology of the Warsaw Agricultural University. The packaging material consisted of laminated PE PA bags (trade name: Opalen 65). The packed samples of cheese were stored for 42 days (6 weeks) at a temperature of 10°C ±0.5°C and for the next 2 weeks (*i.e.* from day 42 to day 56 of storage) at room temperature.

Petri dish method was used to determine the number of the following groups of microorganisms in the cheese samples: total count of microorganisms (PCA agar, Merck, 30°C/72h), coliform count (VRB agar, Merck, 30°C/24h), yeast and mould count (YGC agar, Merck, 25°C/5 days). Physicochemical analysis of the cheese samples involved determination of water content (by drying at a temperature of 130°C for 30 min), fat content (by the butyrometric Gerber method), total nitrogen content (by the Kjeldahl method), titratable acidity (titration of cheese emulsion with 0.25 mol/L NaOH against phenolphthalein), pH (by electrometric method of cheese and water emulsion with the weight ratio 1:1). All the measurements were carried out in two parallel repetitions. Sensory evaluation of the cheese samples was also performed – at baseline and at week 2 and 4 of the cold storage. The sensory evaluation was carried out by a team of 5–8 panelists. The following parameters were included in the analysis: external appearance, consistency, taste and smell. The ranking scale ranged from 1 to 5 (half scores included). For the calculation of the mean score, the following weight coefficients were assumed: 0.2 for the external appearance, 0.3 for the consistency, 0.3 for the taste and 0.2 for the smell. Two-way variance analysis of the results was carried out using Statgraphics Plus v.4.1. The experiment was repeated three times.

RESULTS AND DISCUSSION

Cheese microflora is dominated by lactic acid bacteria introduced with a cheese starter. The remaining microorganisms include thermoresistant bacteria originating from the raw material remaining after pasteurisation of milk and microflora consisting in postpasteurisation contamination [Molska, 1988]. In the Mozzarella cheeses investigated in this study the baseline total mean microorganisms counts were $5.3x10^9$ CFU/g (colony forming units per gram) and $4.7x10^9$ CFU/g for the cheese samples with and without the addition of microbiological contamination, respectively. The total count of microorganisms in cheese without or with the addition of contaminated inoculum was very similar, because the purpose of contamination of Mozzarella cheese

TABLE 1. Total count of microorganisms (log CFU/g) in Mozzarella cheese samples (mean ± standard deviation).

Type of the determination	Time of the determination	Type of packing				
					Gaseous mixture N_2/CO_2 (%)	
		N_2	CO_2	Lowered pressure	50 / 50	30 / 70
Cheese samples	Baseline	9.67 ± 0.03^{a}	9.67 ± 0.03^{a}	9.67 ± 0.03^{a}	9.67 ± 0.03^{a}	9.67 ± 0.03^{a}
without the addition	After 2 weeks	9.56 ± 0.05^{b}	9.55 ± 0.04^{b}	9.56 ± 0.04^{b}	9.59 ± 0.08^{b}	9.58 ± 0.04^{b}
of microbiologically	After 4 weeks	$9.43\pm0.09^{c,d}$	9.40 ± 0.09^{c}	$9.42\pm0.04^{c.d}$	9.48 ± 0.12^{d}	$9.46\pm0.04^{c,d}$
contaminated	After 6 weeks	9.28 ± 0.21^{e}	9.19 ± 0.19^{f}	9.29 ± 0.08^{e}	$9.33\pm0.13^{e,g}$	9.36 ± 0.07^{g}
inoculum	After 8 weeks	9.00 ± 0.21^{h}	8.80 ± 0.15^{i}	8.83 ± 0.27^{i}	8.78 ± 0.07^{i}	8.82 ± 0.07^{i}
Cheese samples	Baseline	9.72 ± 0.05^{A}	9.72 ± 0.05^{A}	9.72 ± 0.05^{A}	9.72 ± 0.05^{A}	9.72 ± 0.05^{A}
with the addition	After 2 weeks	9.61 ± 0.06^{B}	9.51 ± 0.16^{C}	9.63 ± 0.06^{B}	$9.57\pm0.09^{B.C}$	9.59 ± 0.06^{B}
of microbiologically	After 4 weeks	9.47 ± 0.12^{D}	9.38 ± 0.10^{E}	9.53 ± 0.13^{D}	9.44 ± 0.14^{E}	9.45 ± 0.09^{E}
contaminated	After 6 weeks	$9.25\pm0.17^{F,G}$	$9.19\pm0.15^{F,G}$	9.39 ± 0.19^{H}	9.27 ± 0.14^{F}	$9.21\pm0.15^{F,G}$
inoculum	After 8 weeks	8.65 ± 0.16^{I}	8.67 ± 0.14^{I}	$8.71\pm0.19^{I,J}$	$8.75\pm0.02^{I,J}$	8.76 ± 0.16^{J}

a, b, c,..., A, B, C – means with different superscripts are significantly different at $\alpha=0.05$.

by inoculum from commercial blue cheese was to increase mainly the number of moulds, coliform bacteria or yeasts, to accelerate to undesirable effect of these microorganisms. The relativity high microbiological quality of Mozzarella cheese used in our study (coliform bacteria and moulds not detected in 0.1 g of cheese) has made it impossible to show the effect of different kinds of packing on its microbiological quality during storage. Cold storage of the cheese samples with subsequent storage at room temperature resulted in decreased total count of microorganisms but only by one logarithm cycle at the most (Table 1). The observed changes of the total count of microorganisms depended on the type of atmosphere used for packing. The most substantial reduction in the total count of microorganisms was observed for cheeses packed in the atmosphere of carbon dioxide, and the reduction was significantly lower (at the significance level of 0.05) than the microorganism counts in the cheese samples packed in the atmosphere of air under reduced pressure. The effect was, however, minor.

The results of these studies confirm the inhibitory action of carbon dioxide on the growth of bacteria, failing, however, to confirm the study carried out by Eliot *et al.* [1998]. The studies performed by Eliot *et al.* [1998] indicate a minor influence of modified atmosphere on the development of lactic acid and psychrotrophic bacteria. The results regarding the effect of CO_2 on the development of lactic acid bacteria are not entirely unequivocal. This group of bacteria includes numerous species of bacteria. What can be concluded, however, is that the inhibitory effect on the development of these bacteria is significantly higher when CO_2 is used than in the case of vacuum or N_2 [Eliot *et al.*, 1998]. According to Pikul [2000], the concentration of CO_2 exceeding 5% retards the growth of most of the bacteria that cause food spoilage, mainly psychrotrophic bacteria, which grow in the majority of foods subjected to cold storage. Gram-negative bacteria are generally more sensitive to CO_2 than the Gram-positive ones [Daniels *et al.*, 1985; Rosenthal *et al.*, 1991]. Haines [1980, quoted by Daniels *et al.*, 1985] reports that the concentrations of CO_2 in the range of 10 20% sufficiently inhibit bacterial growth of the genus *Pseudomonas* and *Achromobacter*. The higher the CO_2 content in the packaging, the higher the inhibitory effect on the microorganisms. Carbon dioxide possesses a strong inhibitory effect on the growth of bacteria and moulds [Michniewicz, 1998]. Its inhibitory action is particularly visible against aerobic microflora, *i.e.* the bacteria from the genera *Pseudomonas*, *Moraxella*, *Alteromonas* and *Acinetobacter*. The inhibitory effect of CO_2 increases in a linear manner with the increased content only up to approximately 50–60% [Fik, 1995]. According to some authors, CO_2 modifies the functions of the cell membrane of microorganisms and by permeating into the cells shifts intracellular pH and changes physicochemical properties of proteins [Daniels *et al.*, 1985; Fik, 1995; Eliot *et al.*, 1998]. It also directly affects the inhibition of enzymatic reactions or the reduction of their velocities. No inhibitory effect of nitrogen on the growth of microorganisms was observed. Also the atmosphere of nitrogen has no direct effect on the durability of the product packed [Pikul, 2000]. Analysing the influence of modified atmosphere on the growth of microorganisms in sliced Mozzarella cheese, Alves *et al.* [1996] observed under the atmosphere of 100% N_2 no difference in the growth of psychrotrophic bacteria in relation to the control sample, in which the composition of the gas inside the packaging was equivalent to that of the atmosphere. In both cases, the count of these bacteria initially increased and later stabilised at a certain level. A similar situation was observed with the mixture of 50% CO_2 and 50% N_2 except that the growth was less intensive. According to Rymaszewski *et al.* [1999], the most effective retardation of enzymatic and microbiological processes was observed when a mixture of 60% CO_2 and 40% N_2 was used inside the packaging.

In our study, the presence of coliform bacteria in 0.1 g of cheese was only revealed in the cheese samples containing added microbiological contamination. Their initial count was 9.6×10^3 CFU/g and during cold storage of the samples changed noticeably. The decrease in the count was not, however, a result of the type of atmosphere under which the Mozzarella cheese samples had been packed (Figure 1). The differences between cheese samples packed under CO_2 or CO_2/N_2 mixture and other kind of packing were observed after 8 weeks of storage.

The majority of moulds causing food spoilage require the presence of oxygen for their growth and seem susceptible to high concentrations of CO_2. Therefore modified atmosphere packing of foods with low values of aw, such as bakery products, which are susceptible to spoilage due to the growth of moulds, may significantly prolong their shelf lives [Pikul, 2000]. In this study the mean baseline mould count in the samples of cheeses without microbiologically contaminated inoculum was 1.7×10^2 CFU/g and further into the storage period no moulds were observed in 0.1 g of the cheeses under investigation regardless of the system of packing used. In the cheese with the added microbiologically contaminated inoculum, the mean baseline mould count was 2.4×10^3 CFU/g and remained so until week 6 of cold storage regardless of the packing system employed (Figure 2). However, during storage at room temperature (6–8 weeks), the mould count depended on the packing variant in a statistically significant manner (at $\alpha = 0.05$). After 6 weeks of storage, the mould count significantly dropped, by about one log cycle, from 2.4×10^3 CFU/g to 1.4×10^2 CFU/g after

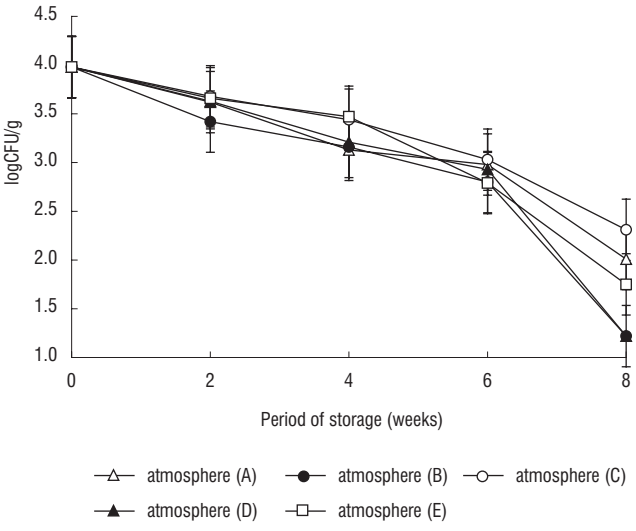

FIGURE 1. The impact of modified atmosphere packing on the coliform count in Mozzarella cheese samples with the addition of microbiologically contaminated inoculum (mean ± standard error).

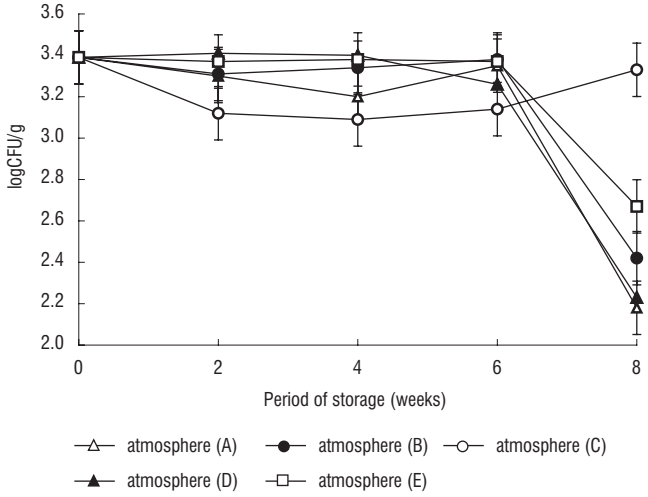

FIGURE 2. The impact of modified atmosphere packing on the moulds count in Mozzarella cheese samples with the addition of microbiologically contaminated inoculum (mean ± standard error).

8 weeks, similar for all systems of packing, excluding packing under reduced pressure air atmosphere. The cheese samples packed under reduced pressure air atmosphere showed a slight increase in the mould count from 6 to 8 week.

These findings do not confirm the study carried out by Eliot *et al.* [1998], who observed a significant inhibitory effect of carbon dioxide packing on the development of yeasts (the higher the concentration of carbon dioxide, the stronger the inhibitory effect). Similar conclusions were reached by Alves *et al.* [1996], who observed a direct relationship between the inhibitory effect on yeasts and the concentration of CO_2 in the packaging. According to Alves *et al.* [1996], nitrogen atmosphere packing has little effect on the reduction of mould and yeast growth compared to air packing.

In this study, the mean yeast count was $4.3x10^5$ CFU/g in the cheese samples devoid of added microbiological contamination and $5.5x10^5$ CFU/g in the cheese samples with added microbiological contamination. In the first 4 weeks of cold storage a rise in the yeast count was noted followed by its fall (Figure 3). The statistical analysis revealed that these changes significantly depended on the packing system. The most rapid and the strongest reduction in the yeast count was observed in cheese samples packed under the atmosphere of carbon dioxide. This confirms the findings of Alves *et al.* [1996] and Eliot *et al.* [1998]. Alves *et al.* [1996] investigated the effect of packing in the atmosphere of N_2 and a 1:1 mixture of CO_2 and N_2 on the development of yeast and observed a smaller inhibitory effect for packing in the atmosphere of N_2 than in the mixture of these gases.

The acidity of the stored cheese samples changed depending on the storage time and the packing system (Figures 4 and 5). The initial titratable acidity was 54°SH during cold storage and rose to 62–69°SH at room temperature (Figure 4). The rise of acidity was a consequence of continuing protein degradation and the formation of carbonic acid resulting from dissolution of CO_2 in water as well as a decrease in water content in the cheese samples under

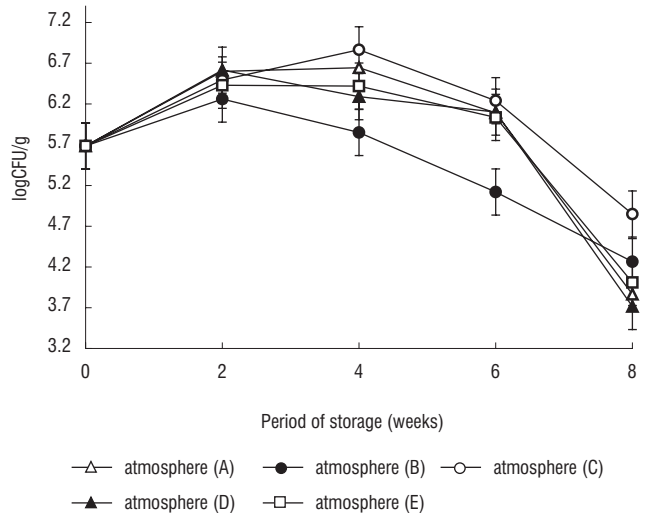

FIGURE 3. The impact of modified atmosphere packing on the yeasts count in Mozzarella cheese samples without and with the addition of microbiologically contaminated inoculum (mean ± standard error).

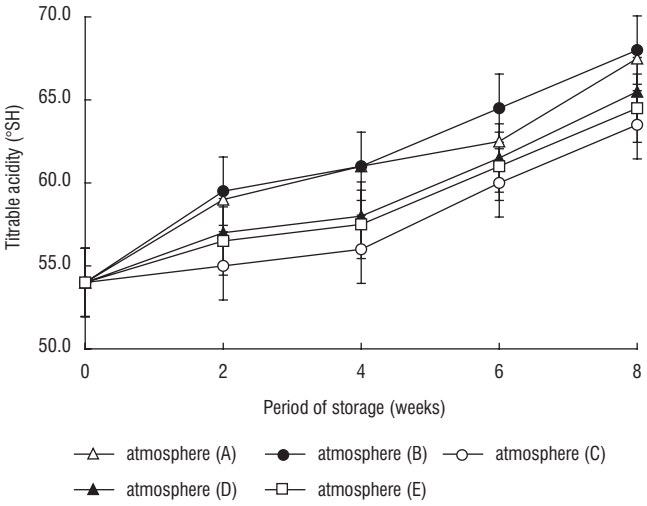

FIGURE 4. The impact of modified atmosphere packing on the titratable acidity of the Mozzarella cheese samples without and with the addition of microbiologically contaminated inoculum (mean ± standard error).

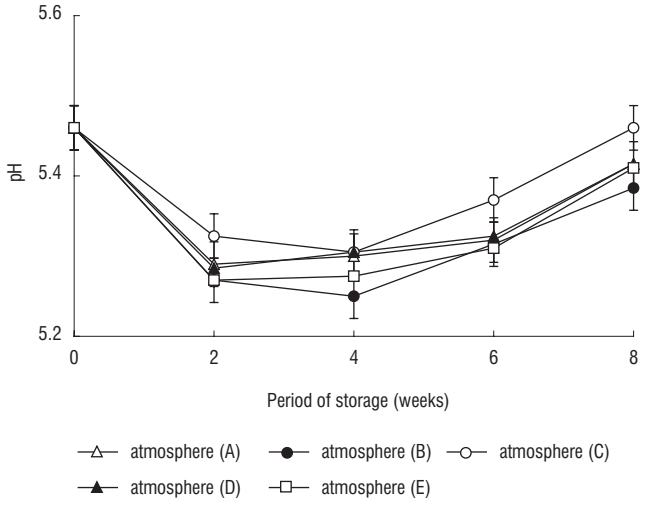

FIGURE 5. The impact of modified atmosphere packing on the pH of the Mozzarella cheese samples without and with the addition of microbiologically contaminated inoculum (mean ± standard error).

investigation. The changes of the active acidity (pH) of the investigated cheese samples were of a different nature (Figure 5). The initial pH drop was related to degradation of lactose to lactic acid. Upon exhaustion of lactose supply pH stabilised. Following 6 weeks of storage the rise in pH might have been a result of acid metabolism by certain microorganism or its neutralisation by protein degradation products. In the final stage of storage, as a result of higher (*i.e.* room) temperature, an intensive protein proteolysis might have been taking place that caused a rise in pH and total acidity at the same time. The highest increase in the acidity (a fall of pH and a rise in the titratable acidity) was observed in cheese samples packed in the atmosphere of carbon dioxide while the smallest increase was noted in cheese samples packed in the reduced pressure air atmosphere or the atmosphere of nitrogen. This confirms the data reported in the literature related to the effect of carbon dioxide on the product packed. The presence of CO_2 in food products characterised by a higher water content lowers pH of the product as a result of carbonic acid formation (due to significant water solubility of carbon dioxide). The dissolution of CO_2 in water reduces partial pressure of the gas in the mixture leading, in extreme cases, to "shrinking" the packaging around the product, which is a similar effect to that obtained as a result of vacuum packing. This effect may be balanced by introduction of a different gas, usually nitrogen, into the packaging [Czerniawski, 1999]. At higher CO_2 concentrations and high water content in the product, there is a risk of sour taste appearing in the superficial layer of the product.

In the sensory evaluation of the Mozzarella cheeses under investigation none of the samples received a score lower than 4.0. The average scores of the samples packed using the different systems were comparable and did not differ in a statistically significant manner, although after 4 weeks of cold storage the best scores were awarded to cheeses packed in the atmosphere of nitrogen and carbon dioxide mixture at 30:70 ratio (Table 2). Cheese samples packed under reduced pressure (400 mbar) air atmosphere showed first signs of clumping during storage, which were not taken into consideration while assessing the appearance after opening the samples. This negative phenomenon may, however, play a significant role in the case of commercial cheeses.

Water content in the stored cheese samples fell from the mean initial value of 51.3% to the final value of 48.3%. Grated cheeses possess an unprotected surface, which facilitates free diffusion of water from the inside of the cheese towards its surface. During storage, outdropping of water was observed on the inside of the packaging, which might have been the reason of reduced final water content in the cheese. The water loss also resulted in the apparent increase in protein and fat content in the cheese samples under investigation from the baseline values of 26.4% and 19.0%, respectively, to the final values of 28.2% and 20.0%.

CONCLUSIONS

1. A significant, although not very substantial effect was observed of packing in the atmosphere of CO_2 on the inhibition of the development of microflora compared to packing in the atmosphere of N_2 and a mixture of CO_2 and N_2.
2. The sensory evaluation of the grated Mozzarella cheese after 4 weeks of cold storage did not reveal any statistically significant difference between the packing variants employed.
3. Reduced pressure air packing guarantees the quality comparable with that obtained at packing under the atmosphere of nitrogen, carbon dioxide or a mixture of these two gases, although too high a reduction of pressure may result in clumping of pieces of Mozzarella cheese during storage.

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TABLE 2. Organoleptic analysis of Mozzarella cheese samples (mean ± standard deviation).

Type of the determination	Time of the determination	Type of packing				
					Gaseous mixture N_2/CO_2 (%)	
		N_2	CO_2	Lowered pressure	50 / 50	30 / 70
Cheese samples without the addition of microbiologically contaminated inoculum	Baseline	4.3 ± 0.2^{a}	4.3 ± 0.2^{a}	4.3 ± 0.2^{a}	4.3 ± 0.2^{a}	4.3 ± 0.2^{a}
	After 2 weeks	$4.2\pm0.1^{a,b}$	$4.2\pm0.2^{a,b}$	$4.1\pm0.3^{b,c}$	$4.1\pm0.0^{b,c}$	4.3 ± 0.2^{a}
	After 4 weeks	$4.1\pm0.1^{b,c}$	$4.2\pm0.1^{a,b}$	$4.1\pm0.1^{b,c}$	$4.0\pm0.1^{c,d}$	$4.2\pm0.1^{a,b}$
Cheese samples with the addition of microbiologically contaminated inoculum	Baseline	4.3 ± 0.2^{A}	4.3 ± 0.2^{A}	4.3 ± 0.2^{A}	4.3 ± 0.2^{A}	4.3 ± 0.2^{A}
	After 2 weeks	$4.2\pm0.5^{A,B}$	$4.2\pm0.3^{A,B}$	$4.2\pm0.2^{A,B}$	4.3 ± 0.1^{A}	4.3 ± 0.2^{A}
	After 4 weeks	$4.1\pm0.1^{B,C}$	$4.2\pm0.2^{A,B}$	$4.2\pm0.1^{A,B}$	$4.2\pm0.1^{A,B}$	4.3 ± 0.1^{A}

a, b, c, d, A, B, C, D – means with different superscripts are significantly different at $\alpha=0.05$.

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WPŁYW PAKOWANIA W ATMOSFERZE MODYFIKOWANEJ NA JAKOŚĆ TARTEGO SERA TYPU MOZZARELLA

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Celem niniejszej pracy było określenie wpływu wybranych wariantów pakowania w modyfikowanej atmosferze na zmiany mikrobiologiczne i fizykochemiczne tartego sera Mozzarella podczas jego przechowywania. Materiał do badań stanowiły próbki tartego sera Mozzarella otrzymanego w warunkach przemysłowych, do których dodano zanieczyszczenia mikrobiologiczne. Próbki serów pakowana z zastosowaniem następujących wariantów: (A) pakowanie poprzez wstępne zastosowanie próżni 20 mbar a następnie wprowadzenie azotu do 400 mbar; (B) pakowanie poprzez wstępne zastosowanie próżni 20 mbar i następnie wprowadzenie ditlenku węgla do 400 mbar; (C) pakowanie pod obniżonym ciśnieniem przy 400 mbar; (D) pakowanie poprzez wstępne zastosowanie próżni 20 mbar i następnie wprowadzenie mieszanki 50% ditlenku węgla i 50% azotu do 400 mbar; (E) pakowanie poprzez wstępne zastosowanie próżni 20 mbar i następnie wprowadzenie mieszanki 70% ditlenku węgla i 30% azotu do 400 mbar. W próbkach serów oznaczano liczbę drobnoustrojów ogółem, bakterii z grupy coli, drożdży i pleśni. Analiza fizykochemiczna próbek serów obejmowała następujące oznaczenia: zawartość wody, zawartość tłuszczu, zawartość substancji azotowych ogółem, kwasowość miareczkowa i pH. Wykonano również analizę sensoryczną próbek serów.

Stwierdzono istotny, chociaż niewielki, wpływ pakowania w atmosferze CO_2 na hamowanie rozwoju mikroflory w porównaniu do pakowania w atmosferze N_2 i mieszaninie tych gazów. Przeprowadzona analiza sensoryczna tartego sera Mozzarella po 4-tygodniowym przechowywaniu w warunkach chłodniczych wykazała brak statystycznie istotnej różnicy pomiędzy zastosowanymi wariantami pakowania. Zastosowanie pakowania w atmosferze powietrza pod obniżonym ciśnieniem zapewnia jakość porównywalną z pakowaniem w atmosferze azotu, ditlenku węgla lub mieszaniny tych gazów, jednak zbyt duże obniżenie ciśnienia może prowadzić do zlepiania kawałków sera Mozzarella podczas przechowywania.