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THE USE OF OXYGEN ABSORBERS FOR PACKAGING RIPENED CHEESE[1]

Helena Panfil-Kuncewicz, Anna Lis, Monika Majewska

Faculty of Food Sciences
Department of Dairy Science and Quality Management
University of Warmia and Mazury in Olsztyn

Key words: ripened cheese, shelf-life of cheese, vacuum packaging, modified atmosphere packaging, active packaging, oxygen absorbers.

Abstract

Oxygen absorbers (AP) were used for packaging portioned Gouda cheese. Vacuum packaged cheese (VP), cheese packaged under modified atmosphere (MAP) and cheese packaged in ambient air (control samples) were compared. Cheese samples were chill stored for 30, 60 and 90 days. The gas composition in cheese packaging was analyzed, the counts of coliform bacteria, yeasts and molds in cheese were determined, and the sensory attributes of cheese were evaluated in fresh cheese and in samples stored for 30, 60 and 90 days. The oxygen content of all types of packaging remained very low throughout the experiment, ranging from 0.00% in the packaging with oxygen absorbers to 2.67% in the control packaging. Oxygen absorbers effectively lowered the oxygen content of packaging to trace amounts. The results of microbiological analyses and sensory evaluations of stored cheese samples indicate that active packaging is nearly as effective in extending the shelf-life of ripened cheese as vacuum packaging and modified atmosphere packaging.

WYKORZYSTANIE ABSORBERÓW TLENU W PAKOWANIU SERÓW DOJRZEWAJĄCYCH

Helena Panfil-Kuncewicz, Anna Lis, Monika Majewska

Wydział Nauki o Żywności
Katedra Mleczarstwa i Zarządzania Jakością
Uniwersytet Warmińsko-Mazurski w Olsztynie

Słowa kluczowe: sery dojrzewające, trwałość serów, pakowanie próżniowe, pakowanie w modyfikowanej atmosferze, pakowanie aktywne, absorbery tlenu.

Address: Adress: Helena Panfil-Kuncewicz, University of Warmia and Mazury in Olsztyn, Oczapowskiego 7, 10-719 Olsztyn, Poland, phone: +48 (89) 523-38-83, e-mail: panfil@uwm.edu.pl
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Abstrakt

W pracy zastosowano absorbery tlenu (AP) do pakowania kawałków serów typu Gouda. Dla porównania zapakowano sery próżniowo (VP), w modyfikowanej atmosferze (MAP) oraz powietrzu (próbki kontrolne). Próbki przechowywano w warunkach chłodniczych przez 30, 60 i 90 dni. W tych odstępach czasu oznaczano skład atmosfery w opakowaniach serów, a w serach oznaczano liczę bakterii z grupy coli, liczbę drożdży i pleśni oraz oceniono cechy sensoryczne tych produktów. Wyniki badań wykazały, że w całym okresie przechowywania zawartość tlenu we wszystkich opakowaniach była bardzo niska i wahała się w zakresie 0,00% w opakowaniach z absorberem tlenu do 2,67% w opakowaniach próbek kontrolnych. Pochłaniacze tlenu skutecznie obniżały zawartość tlenu w opakowaniu do ilości śladowych. Wyniki badań mikrobiologicznych serów przechowywanych oraz zmiany cech sensorycznych tych serów wykazały, że pakowanie aktywne może być wykorzystane do pakowania serów dojrzewających prawie z takim samym skutkiem jak pakowanie próżniowe i w modyfikowanej atmosferze.

Introduction

Vacuum packaging and modified atmosphere packaging are popular packaging methods in the food processing industry (ROSENTHAL et. al. 1991, FLOROS et. al. 2000, GONZALEZ-FANDOS 2000, MORTENSEN et. al. 2003, DEVLIEGHERE et. al. 2004, PANFIL-KUNCEWICZ et. al. 2012), which are also used to package portioned and sliced ripened cheese. In vacuum packaging, excess air is pumped out and the packaging is tightly sealed. In the modified atmosphere method, excess air is removed and a neutral gas or a mixture of neutral gases is introduced to the packaging to control or destroy undesirable microflora and prevent the oxidation of cheese ingredients. Vacuum packaging is a simple technique, but it can lead to undesirable changes in the structure and appearance of cheese (SEVERINI et. al. 1998). For this reason, modified atmosphere packaging is becoming an increasingly popular alternative. The atmosphere inside packaging can be modified with the involvement of various methods, including by:

– creating a vacuum inside the packaging and reducing it with neutral gases,

– filling the packaging with neutral gas and tightly sealing the packaging,

– use of packaging materials with selective gas permeability,

– placing an inedible substance which absorbs and/or emits gas inside the packaging (PANFIL-KUNCEWICZ et. al. 2012).

The latter method is used to produce a new generation of active packaging which is becoming increasingly popular in the food processing industry. In Poland, the active packaging concept has not yet been applied in practice. In this type of packaging, various substances which absorb or release oxygen, carbon dioxide and ethylene (iron powder, ascorbic acid, calcium oxide, calcium hydroxide, oxidases, etc.) are placed inside the packaging. In the latest solutions, those substances are built into the packaging material. Attempts have also been made to use gas absorbers and emitters in cheese packaging (SUPPAKUL et. al. 2003, RODRIGUEZ-AGUILERA and OLIVEIRA 2009, PANFIL-KUNCEWICZ et. al. 2012).

The aim of this study was to evaluate the effectiveness of oxygen absorbers in extending the shelf-life of portioned ripened cheese.

Materials and Methods

The experimental materials comprised Gouda ripened cheeses supplied by three dairy plants. In the laboratory of the Department of Dairy Science and Quality Management, the products were divided into portions of approximately 150 g and were packaged in PA//PA//PE/PE-EVA bags, 70 ,m thick (as recommended by Multivac). Cheese samples were packaged in the Multivac C300 single-chamber machine with the use of four different methods: I – active packaging (AP) (the air atmosphere was modified by placing a sachet of ATCO FT 210 oxygen absorber inside the packaging), II – modified atmosphere packaging (MAP) (40% CO_2 and 60% N_2, gas volume – approximately 300 cm^3), III – vacuum packaging (VP), IV – packaging in ambient air (control samples). Packaged cheese portions were chill stored (6±0.5°C) for up to 90 days.

Samples of cheese stored for 24 hours (referred to as „fresh cheese") and for 30, 60, 90 days were analyzed to determine the percentage gas composition of packaging using the PBI-Dansensor CheckMate3 gas analyzer. Plate counts of coliform bacteria were determined on VRBL medium (Merck) according to Standard PN-ISO 4832:2007, and yeast and mold counts were determined on YGC selective medium (Merck) according to Standard PN-ISO 6611:2007. An organoleptic evaluation was performed using the grading approach, based on a six-point rating scale (1–6) (PN-ISO 4121:1998; PN-ISO 6658:1998). Five quality attributes were evaluated in the sensory analysis: color, eye formation, consistency, aroma and taste, in accordance with Polish Standard PN-68/A-86230 and IDF Standard 99C:1997. Coded cheese samples were assessed by a team of five panelists trained in sensory analysis. The results of the above analyses were expressed as mean values for three groups of cheese samples.

Data were analyzed statistically using Microsoft Excel 2007 software package, and means and standard deviations were calculated. The significance of the effects exerted by the experimental factors on the analyzed parameters was estimated by two-way analysis of variance (ANOVA) at a significance level of $p \leq 0.05$.

Results and Discussion

The gas composition of cheese packaging varied subject to the packaging method and storage time (Table 1). After 24 hours of storage, the oxygen content of control samples decreased (in comparison with air) from 21.00% to 17.90%, and carbon dioxide content increased to 5.65%. The nitrogen content was determined at 76.45%. After 30 days of storage, oxygen content decreased to 2.67%, and after 60 and 90 days, trace amounts of oxygen were determined at 0.1% and 0.02%, respectively. The drop in oxygen content was accompanied by an increase in carbon dioxide concentrations that reached 22.70%, 21.58% and 19.92% after 30, 60 and 90 days of storage, respectively. Nitrogen content, which was determined by O_2 and CO_2 concentrations, was similar to that found in air, and it ranged from 74.63% to 80.06%. The observed changes in gas composition inside the packaging resulted from the metabolic changes of cheese microflora, in particular aerobic microorganisms – yeasts and molds.

The oxygen content of packages containing oxygen absorbers was determined at 0.12% after 24 hours of storage, and oxygen was completely eliminated from samples stored for 30, 60 and 90 days. The average carbon dioxide

Table 1
Changes in the gas composition of cheese packaging subject to the packaging method and storage time

Packaging method	After 24 h			30 days			60 days			90 days		
	Gas content [%] $\bar{x} \pm s$											
	O_2	CO_2	N_2	O_2	CO_2	N_2	O_2	CO_2	N_2	O_2	CO_2	N_2
Control	17.90 ±1.09	5.65 ±1.34	76.45 ±0.25	2.67 ±2.51	22.70 ±5.74	74.63 ±3.64	0.10 ±0.10	21.58 ±4.36	78.32 ±4.43	0.02 ±0.02	19.92 ±1.89	80.06 ±1.89
AP	0.12 ±0.02	0.37 ±0.37	99.51 ±0.40	0.00 ±0.00	1.51 ±1.26	98.49 ±1.26	0.00 ±0.00	1.38 ±0.64	98.62 ±0.64	0.00 ±0.00	1.14 ±0.92	98.86 ±0.92
MAP	0.27 ±0.01	33.80 ±2.26	65.93 ±2.25	0.43 ±0.67	33.38 ±3.89	66.19 ±4.23	0.24 ±0.31	31.65 ±2.50	68.11 ±2.79	0.23 ±0.36	28.98 ±0.72	70.79 ±0.86
VP	not analyzed											

statistical results		
Type of gas	Packaging method	Storage time
Oxygen	*	*
Carbon Dioxide	*	*
Nitrogen	*	*

Explanatory notes:
Mean value + standard deviation $\bar{x} \pm$ S.D
* – statistically significant differences at $p \le 0,05$
NS – no significant differences at $p \le 0,05$

Source: Own study

content of packaging was determined at 0.37% in samples and at 1.51%, 1.38% and 1.14% in samples stored for 30, 60 and 90 days, respectively. Cheese samples in packages containing oxygen absorbers were practically stored in a nitrogen atmosphere (approximately 98.50%).

The composition of modified atmosphere in the packaging after 24-hour storage of cheese was as follows: O_2 – 0.27%, CO_2 – 33.80%, N_2 – 65.93%. During storage, no significant changes in oxygen levels were observed in the modified atmosphere, whereas CO_2 content decreased gradually to 33.38% after 30 days, 31.65% after 60 days and 28.98% after 90 days of storage. The above can be probably attributed to the dissolution of carbon dioxide in cheese and its permeation through the packaging material. The content of nitrogen inside the packaging increased with a decrease in carbon dioxide concentrations.

A statistical analysis of the gas composition of cheese packaging, depending on the packaging method and storage time, revealed significant ($p \leq 0.05$) relationships between the experimental factors and the O_2, CO_2 and N_2 content of packaging in cheese samples stored for 90 days (Table 1) .

The growth rates of the analyzed microbial populations were also affected by the applied packaging method. Coliform bacteria counts, which are an indicator of the hygienic quality of cheese, were determined at 1.93 log CFU/g in fresh cheese samples (Figure 1). In general, the growth rates of coliform bacteria in stored cheese packaged with the use of different methods (AP, MAP, VP) were somewhat lower than in control samples. None of the analyzed packaging methods had a clear influence on the proliferation of coliform bacteria.

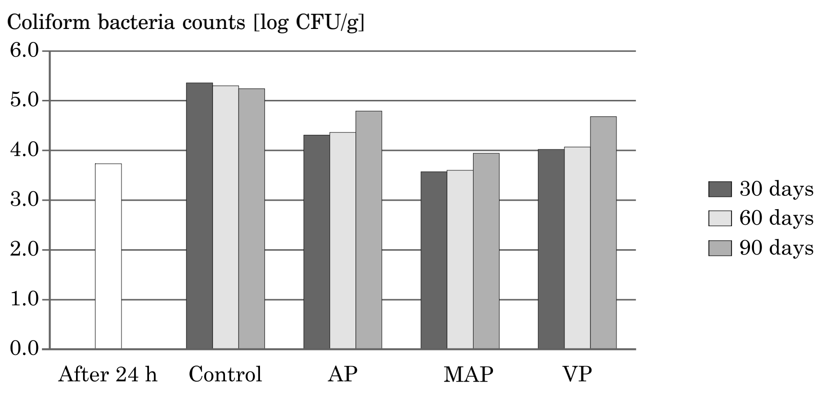

Fig. 1. Changes in coliform bacteria counts in cheese samples subject to the packaging method and storage time

Source: Own study

Greater variations were noted in yeast cell counts (Figure 2). In fresh cheese samples, the average yeast counts were determined at 4.23 log CFU/g. After 30 days of storage, the greatest increase in the number of yeast cells was observed in control samples where it reached 6.01 log CFU/g on average and remained fairly stable after 60 and 90 days of storage. The lowest increase in yeast populations was reported in cheese samples packaged under modified atmosphere. After 30 and 60 days of storage, yeast counts were similar to those determined in fresh cheese, and a minor increase in the number of yeast cells was noted only after 90 days of storage (4.77 log CFU/g on average). In cheese packaged with oxygen absorbers and under vacuum, the size of yeast populations increased steadily to 5.19 and 5.33 log CFU/g, respectively, after 90 days of storage. Modified atmosphere packaging (40% CO_2, 60% N_2) had the most inhibitory effect on the proliferation of yeasts.

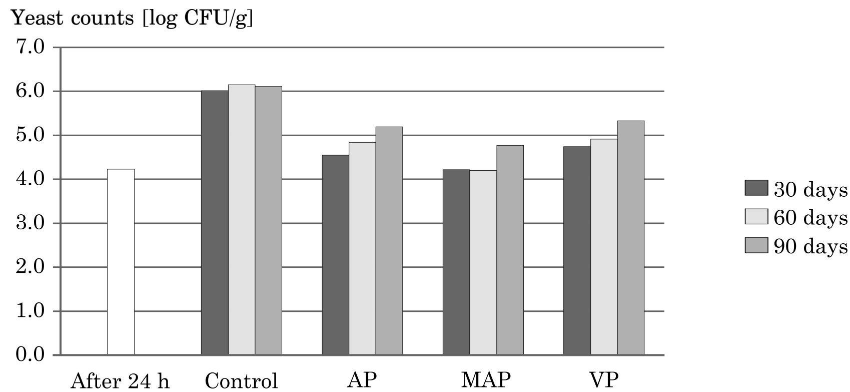

Fig. 2. Changes in yeast counts in cheese samples subject to the packaging method and storage time
Source: Own study

Changes in mold counts in stored cheese packaged with the use of different methods were similar to those noted in yeast counts (Figure 3). Average mold counts in fresh cheese samples were determined at 3.73 log CFU/g. In samples packaged in air, mold counts increased to 5.36, 5.30 and 5.24 log CFU/g after 30, 60 and 90 days of storage, respectively. The growth of molds was most effectively suppressed by modified atmosphere packaging. The number of mold filaments in samples packaged under modified atmosphere and stored for 60 days was similar to that observed in fresh cheese, and a minor increase was reported only after 90 days of storage. Vacuum packaged samples were also characterized by a small increase in mold counts in comparison with fresh cheese. In VP samples, mold counts were determined at 4.02 log CFU/g after 30 days, 4.07 log CFU/g after 60 days of storage, and an increase to 4.68 log CFU/g was reported after 90 days. In packages containing oxygen absorbers, mold proliferation proceeded at a slower rate than in control samples, but it was somewhat more intense than in MAP and VP samples.

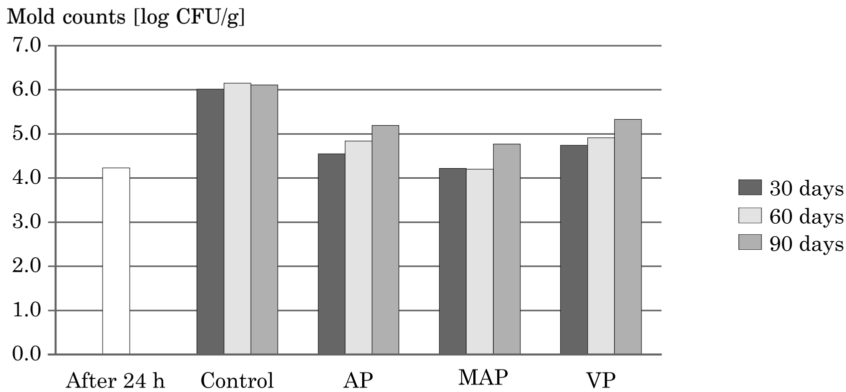

Fig. 3. Changes in mold counts in cheese samples subject to the packaging method and storage time
Source: Own study

A statistical analysis of the counts of contaminating microflora in cheese samples indicated that only the packaging method had a significant effect on yeast and mold counts in the analyzed cheeses. Storage time had no significant effect on changes in the counts of undesirable microflora in cheese samples throughout the experimental period (Table 2).

Table 2

Counts of coliforms, yeasts and molds

Statistical results		
Parameter	Packaging method	Storage time
Coliforms	NS	NS
Yeasts	*	NS
Molds	*	NS

Explanatory notes as in Table 1
Source: Own study

A sensory evaluation of cheese samples packaged by different methods revealed that the sensory attributes of cheese packaged in air deteriorated most rapidly in comparison with AP, MAP and VP samples (Table 3). In general, the above samples received similar scores in the evaluation of sensory attributes performed at 30-day intervals, and the greatest similarities were observed between packages containing oxygen absorbers and modified atmosphere packages. Vacuum packaging was somewhat more effective in preserv-

Table 3

Sensory attributes of cheese samples subject to the packaging method and storage time (days)

Weight coefficient W_w	Quality attributes	After 24 h	Control			AP			MAP			VP		
			30	60	90	30	60	90	30	60	90	30	60	90
		statistical measures $\bar{x} \pm s$												
0.15	color	4.30 ±0.36	4.10 ±0.52	4.17 ±0.15	3.57 ± 1.37	4.33 ±0.35	4.27 ±0.55	4.27 ±1.10	4.00 ±0.78	3.70 ±1.11	3.50 ±0.92	4.33 ±0.31	4.47 ±0.45	4.80 ±0.20
0.15	eye formation	4.07 ±0.12	4.13 ±0.23	4.17 ±0.21	4.03 ±0.06	4.37 ±0.35	3.87 ±0.81	4.00 ±0.00	4.40 ±0.17	4.13 ±0.32	4.17 ±0.29	3.83 ±0.12	4.00 ±0.10	3.80 ±0.10
0.25	consistency	4.23 ±0.59	4.47 ±0.45	4.43 ±0.67	4.03 ±0.81	4.47 ±0.45	4.50 ±0.46	4.37 ±0.71	4.33 ±0.35	4.47 ±0.42	4.40 ±0.44	4.50 ±0.40	4.87 ±0.57	4.33 ±0.64
0.20	aroma	5.07 ±0.31	4.53 ±0.15	4.07 ±0.49	3.20 ±0.36	4.73 ±0.15	4.77 ±0.21	4.53 ±0.15	4.73 ±0.32	4.17 ±0.70	3.90 ±0.66	4.77 ±0.15	4.50 ±0.20	4.40 ±0.10
0.25	taste	4.77 ±0.15	3.80 ±0.10	3.53 ±0.47	2.57 ±0.60	4.33 ±0.06	4.07 ±0.21	3.63 ±0.15	4.37 ±0.35	3.87 ±0.72	3.40 ±0.53	4.43 ±0.15	4.37 ±0.35	3.77 ±0.38
Σ=1	total score	**4.52**	**4.21**	**4.06**	**3.43**	**4.45**	**4.32**	**4.15**	**4.38**	**4.09**	**3.88**	**4.41**	**4.48**	**4.20**

statistical results

Factor	Parameter				
	color	eye formation	consistency	aroma	taste
Packaging method	NS	NS	NS	*	*
Storage time	NS	NS	NS	*	*

Explanatory notes as in Table 1
Source: Own study

ing the sensory attributes of cheese. Samples packaged with oxygen absorbers scored relatively high in respect of their taste and aroma. Sensory attributes were not significantly correlated with the microbiological quality of the studied cheese. The lowest increase in coliform bacteria, yeast and mold counts during storage was observed in samples packaged under modified atmosphere, and MAP samples received the lowest scores for taste and aroma, which could be attributed to high CO_2 concentrations inside the packaging.

A statistical analysis of the results of sensory evaluation of cheese samples revealed no significant correlations between the color, eye formation and consistency of cheese and the packaging method throughout the storage period (Table 3). The packaging method and storage time had a significant ($p \leq 0.05$) effect on the aroma and taste of stored cheese.

The results of this study suggest that active packaging, modified atmosphere packaging and vacuum packaging effectively extend the shelf-life of cheese. Modified atmosphere packaging had the most inhibitory effect on undesirable microflora, and the effectiveness of VP and AP methods in reducing the proliferation of undesirable microorganisms was only insignificantly lower.

The gas composition of cheese packaging has been studied intensively in recent years, and the reported results are often contradictory. The earliest studies demonstrated that the packaging containing 100% CO_2 effectively prolongs the shelf-life of cottage cheese, although some authors argued that high concentrations of carbon dioxide deteriorate the taste and aroma of cheese (KOSIKOWSKI and BROWN 1973, MANIAR et. al. 1994, ALVES et. al. 1996, MANNHEIM and SOFFER 1996, SEVERINI et. al. 1998, PANFIL-KUNCEWICZ et. al. 2006). Subsequent research revealed that hard and semi-hard ripened cheese is most effectively stored in a mixture of nitrogen and carbon dioxide where the proportion of CO_2 ranges from 10% to 50%. The above atmosphere inhibits the growth of undesirable microflora and slows down enzymatic changes in cheese without affecting the taste and aroma of packaged products (ELIOT et. al. 1998, PINTADO and MALCATA 2000, FAVATI et. al. 2007, PANTALEAO et. al. 2007, PAPAIOANNOU et. al. 2007). The relatively high differences in the proposed gas composition are due to the fact that a wide variety of cheeses produced in many countries and regions differ significantly in their physicochemical, microbiological and sensory attributes. Those differences are taken into account when designing the gas composition of packaging to extend the shelf-life of packaged foods.

In our study, oxygen absorbers eliminated oxygen from packages, thus contributing to an increase in nitrogen concentrations to approximately 98.50%. Carbon dioxide content was reduced below 2%. The degree to which oxygen absorbers inhibited the growth of yeasts, molds and coliform bacteria in cheese was comparable with that noted in vacuum packaging, and somewhat lower than in modified atmosphere packaging (40% CO_2 and 60% N_2). Oxygen absorbers are recommended for removing residual oxygen from modified atmosphere packages. Our findings indicate that oxygen absorbers can also be used independently for extending the shelf-life of portioned ripened cheese.

The analyzed fresh cheese was characterized by low counts of coliform bacteria, which suggests that cheese of high microbiological quality can be effectively packaged with the use of oxygen absorbers without prior atmosphere modification. The results of a sensory evaluation confirmed the above observation. It should be noted, however, that this study analyzed only three types of Gouda cheese supplied by different manufacturers. Further work involving a greater number of cheese products is needed to investigate the effectiveness of oxygen absorbers in more detail.

Conclusions

1) The gas composition of cheese packaging was affected by the packaging method and storage time.

2) Modified atmosphere packaging was most effective in reducing microbial counts in cheese.

3) Oxygen absorbers can be used independently to modify the composition of the internal atmosphere in packages of portioned ripened cheese. Their effectiveness in prolonging the shelf-life of cheese is comparable to that of vacuum packaging and modified atmosphere packaging.

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