APARATURA
BADAWCZA I DYDAKTYCZNA

Chemical composition and physicochemical properties of Camembert cheeses available in retail shops

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Keywords: Camembert cheese, chemical composition, acidity, colour parameters

ABSTRACT:

The aim of the research was the analysis of the chemical composition, acidity and colour parameters of Camembert cheeses available in retail shops. The analysed material consisted of 48 samples of ripened Camembert rennet cheese. The cheeses came from two well-known producers (brand A and B), and were purchased in the area of two provinces: Kujawsko-Pomorskie (24 pieces) and Warmińsko-Mazurskie (24 pieces). The cheeses were divided into 4 experimental groups, depending on the producer, each containing 12 samples. Quantity and quality analyses included marking the water content, total protein, fat, total acidity (°SH) and colour parameters (L*, a*, b*), and calculating the whiteness index (WI). Results showed that brand A cheeses purchased in the Warmińsko-Mazurskie province contained the highest amount of water and fat, whereas brand B cheeses purchased in both provinces had the lowest total acidity. As concerns the colour yellow, it was significantly more vivid in brand A cheeses bought in both provinces. Brand B cheeses bought in the Warmińsko-Mazurskie province had the highest L* parameter of the interior. The whiteness index (WI) calculated on the surface and in the interior of the samples was considerably higher for B cheeses purchased in both provinces, which explains their lighter colour.

Skład chemiczny oraz właściwości fizykochemiczne serów Camembert dostępnych w sprzedaży detalicznej

Słowa kluczowe: ser Camembert, skład chemiczny, kwasowość, parametry barwy

STRESZCZENIE:

Celem badań była analiza składu chemicznego, kwasowości oraz parametrów barwy serów Camembert dostępnych w sprzedaży detalicznej. Materiał badawczy stanowił ser podpuszczkowy dojrzewający typu Camembert w ilości 48 sztuk. Sery pochodziły od dwóch znanych producentów (A i B) i zostały zakupione na terenie dwóch województw, a mianowicie kujawsko-pomorskiego (24 szt.) i warmińsko-mazurskiego (24 szt.). W zależności od producenta sery podzielono na 4 grupy doświadczalne, w każdej po 12 sztuk. Analizy ilościowo-jakościowe obejmowały oznaczanie: zawartości wody, białka ogólnego, tłuszczu, kwasowości ogólnej (°SH) i parametrów barwy (L*, a*, b*) oraz wyliczono indeks jasności (WI). Na podstawie uzyskanych wyników odnotowano, że największą zawartością wody i tłuszczu charakteryzowały się sery producenta A zakupione w województwie warmińsko-mazurskim. Najniższą kwasowością ogólną odznaczały się sery Camembert marki B zakupione w obu województwach. W przypadku barwy żółtej istotnie wyższym udziałem charakteryzowała się powierzchnia serów marki A pochodzących z obu województw. Wykazano, że istotnie najwyższą wartością parametru L* miąższu odznaczały się sery producenta B zakupione w województwie warmińsko-mazurskim. Natomiast wartość indeksu jasności (WI) określona na powierzchni i w miąższu prób była istotnie najwyższa dla produktów marki B, zakupionych w obu województwach, co wskazuje na ich jaśniejszą barwę.

1. INTRODUCTION

The consumption of white mould cheeses in Poland is low (7%) as compared to other countries in the European Union with developed consumption culture of these products [1]. Additionally, those cheeses are perceived as expensive and because of their specific organoleptic features a significant number of consumers does not select them. Nevertheless, in the past few years their consumption has been slowly increasing as a result of promotional and advertising campaigns launched by producers [2, 3]. There are two kinds of mould cheeses: white mould cheeses such as Camembert and Brie and blue mould cheeses such as Roquefort [4, 5]. The increase results mainly from the fact that more and more people are buying Camembert cheese, which constitutes an important part of the mould cheese segment in Poland. Those cheeses are consumed in sandwiches, salads, casseroles and as an individual grilled snack [6]. At the same time, they belong to high calorie products with 300 kcal per 100 g for an average Camembert cheese and 360 kcal per 100 g for Rokpol. Mould cheeses contain considerably high fat levels (24.3-31.0 g/100 g). Moreover, they have high calcium content (390-600 mg/100 g) and are a rich source of complete protein (19.8-22.6 g/100 g) [2].

Mould cheeses belong to a specific group of ripened rennet cheeses which, when ripened in suitable conditions, develop exquisite flavours, aroma and texture resulting from the presence of selected microbiological bacteria and the methods of production [4, 5, 7]. The characteristic feature of this type of cheese is its soft, almost liquid texture with pale yellow colour and a white soft rind. The original Camembert is made from pasteurised cow milk and has a shape of a flat cylinder [7, 8]. Its mild, a bit salty and mushroomy flavour and an earthy aroma are the effect of the presence of *Penicillium camemberti* bacteria used during the production process. As a result of using the bacteria, the rind of the cheese is covered with soft white mould, which additionally prevents the moisture in the interior from drying [4, 5]. There are a few European countries famous for the production of excellent mould cheeses. However, the majority of traditionally produced cheeses come from France [9].

The aim of this research was an analysis of the chemical composition, acidity and colour parameters of Camembert cheeses available in retail shops.

2. METHODOLOGY OF RESEARCH

The analysed material consisted of 48 pieces of ripened Camembert rennet cheese (high fat) purchased in hypermarkets in two provinces: Kujawsko-Pomorskie and Warmińsko-Mazurskie. The cheeses came from two dairy producers (brand A and B) well-known in the Polish market, 24 samples from each one. Both brands were made from pasteurised cow milk, salt, dairy starter cultures and microbiological rennet. Brand A cheeses contained spores of *Penicillium candidum* mould plus calcium chloride serving as a stabiliser, whereas brand B cheeses apart from *Penicillium candidum* contained spores of *Geotrichum candidum*. All tested samples came in a shape of a flat cylinder with a diameter of approximately 9 cm, were 2.5 cm high and weighed 120 grams net. The tests were conducted before the expiry date declared by the producer, i.e. until May 13th 2017 and all samples came from the same batch. After the purchase, the cheeses were immediately transported in a portable isothermal fridge in the temperature of 4 ±1°C to a specialist laboratory of the University of Warmia and Mazury in Olsztyn in order to perform quality and quantity analyses.

The cheeses were pounded in a mortar into a homogenous pulp, later thoroughly mixed, so as to prepare the samples for analysis. The tests included the determination of water content by drying in the temperature of 130°C (technical method), total protein content by the Kjeldahl method, using the nitrogen conversion factor for milk protein – 6.38, fat content in Van Gulik butyrometer (technical method). The fat content was calculated with a formula: the percentage of fat as seen on the butyrometer scale × 100/100 – the water content in the cheese (in %) and the measurement of total acidity (°SH) according to PN-73/A-86232 standard [10]. The colours in Camembert cheeses were described according to parameters L*, a*, b* in CIELAB system [11] with a reflection method by MiniScan XE Plus apparatus made by HunterLab through a direct triple measurement of the rind and interior (Fig. 1 and 2), performed in the same measuring point. D_{65} source of light and 10 degree standard colorimetric observer were applied. The measurements were taken immediately after unpacking the cheeses. The apparatus was calibrated against black and white pattern before every measurement.

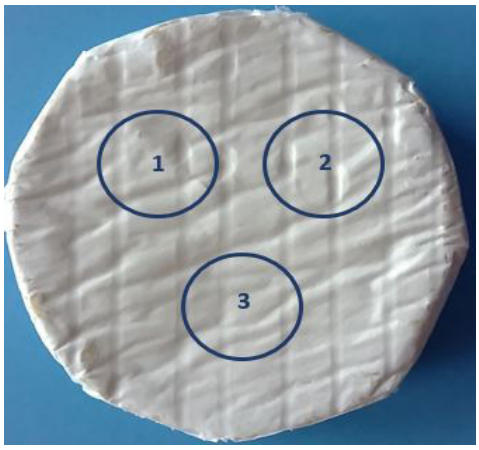

Figure 1 Measurement places of the colour for the rind of Camembert cheese (own research)

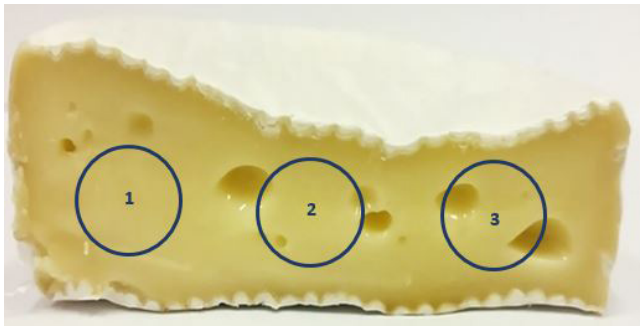

Figure 2 Measurement places of the colour at the core of Camembert cheese (own research)

In addition, the achieved L*, a*, b* parameters were used to calculate the whiteness index WI with a following formula [8]:

$$WI = 100 - \sqrt{(100 - L)^2 + a^2 + b^2}$$

The achieved results were interpreted according to statistical analysis and basic measurements were calculated ($\bar{x}$, s). The significant differences ($p \leq 0.05$ and $p \leq 0.01$) between the results of the analysed qualities in experimental groups were described with t-Student test, using a licensed software Statistica version 13.1 [12].

3. RESULTS AND DISCUSSION

Organoleptic and physicochemical properties, which have an effect on the quality of a ready product, should meet the PN-68/A-86230 standard specifications [13]. According to the aforementioned specifications, high fat Camembert cheese should contain no more than 56% of water and no less than 45% of fat in dry matter. The products meeting the abovementioned standards may win the approval of the consumers [14].

Based upon the data presented in Table 1, a significant difference ($p \leq 0.01$) was noted in the total water content (expressed in percentages) in the analysed cheese groups bought in the Warmińsko-Mazurskie province. Brand A cheeses showed the highest water content (28.34%) as compared to brand B cheeses (26.07%). No statistical differences were found between the total protein content in the tested cheeses, which amounted to an average value of 17.21%. In the performed experiment (Tab. 1) a significant difference ($p \leq 0.01$) in fat content was found in cheeses bought in the Warmińsko-Mazurskie province. Brand A samples had a considerably higher fat content (3.15% more) than brand B cheeses (43.97%). Own tests (Tab. 1) showed that brand A mould cheeses displayed higher levels of total acidity (16.80°SH) in comparison to brand B cheeses (11.80°SH), which was statistically confirmed ($p \leq 0.01$).

Own research (Tab. 2) shows that brand B cheeses purchased in the Kujawsko-Pomorskie province had a higher water content and total protein than brand A, i.e. 0.15% and 0.25% more, respectively. Despite no statistical differences, brand A mould cheeses had higher fat content (44.42%) than brand B cheeses (43.40%). The results confirm significantly ($p \leq 0.01$) higher total acidity (2.80°SH more) in brand A cheeses as compared to brand B cheeses (14.00°SH).

According to Boutrou et al. [15] the composition of the water phase in cheese changes constantly during ripening as a result of activity of numerous enzymes, including lactic and rennet enzymes, extracellular enzymes in bacteria and fungi and intracellular enzymes formed by lactic acid bacteria. The cheese matrix and water phase are dynamic systems whose composition varies depending on the type of cheese and stage of ripening. As a consequence, water in Camembert cheese is found less frequently than in Emmental cheese. In an experiment conducted by Rodriguez-Aguilera et al. [8, 16] the initial water content in mould Camembert cheeses amounted to 0.559 and 0.503 g/g of dry matter. According to Batta et alia [9], the water content in Camembert cheese amounted from 53.15% to 57.99% and the general protein content amounted from 15.43% to 18.34% in dry matter. Galli et al. [5] achieved similar results, with the water content in Camembert cheese amounting from 54.94% to 57.77%. According to Czechowska-Liszka [14] the water content in Camembert cheese (cream) amounted to 52.0% and did not exceed the value required by appropriate standards. On the other hand,

Table 1 Analysis of chemical composition and total acidity of Camembert cheese purchased in the Warmińsko-Mazurskie province depending on the producer ($\bar{x}$ ±s)

Specification	Cheese producer		p-value
	A (n = 12)	B (n = 12)	
Water content (%)	28.34^{A} ±0.78	26.86^{B} ±0.93	≤0.001
Total protein (%)	17.09 ±0.27	17.33 ±0.33	0.245
Fat in dry matter (%)	47.12^{A} ±0.91	43.97^{B} ±0.98	≤0.001
Total acidity (°SH)	16.80^{A} ±0.92	11.80^{B} ±0.47	≤0.001

A, B – mean values marked with different letters in the lines are significantly statistically different $p \leq 0.01$

Table 2 Analysis of chemical composition and total acidity of Camembert cheeses bought in Kujawsko-Pomorskie province depending on the producer ($\bar{x}$ ±s)

Specification	Cheese producer		p-value
	A (n = 12)	B (n = 12)	
Water content (%)	25.92 ±0.78	26.07 ±0.80	0.667
Total protein (%)	16.93 ±0.50	17.18 ±0.26	0.338
Fat in dry matter (%)	44.42 ±0.99	43.40 ±0.38	0.072
Total acidity (°SH)	16.80^{A} ±0.97	14.00^{B} ±0.67	≤0.001

A, B – mean values marked with different letters in the lines are significantly statistically different $p \leq 0.01$

Caldeo and McSweeney's research [17] revealed a higher content of total protein in Camembert cheese amounting to 31.89% and lower fat content amounting to 32%. 12 days after producing, the protein and fat content in Camembert cheeses amounted to 16.20% and 23.38%, respectively [18]. According to Voigt et al. [19] on the thirtieth day of ripening in the temperature of 13°C, total protein content in Camembert cheeses produced from raw (non-pasteurised) milk amounted to 19.76%. Vassal et al. [20] noted a significantly lower amount of fat, with fat content in the rind amounting to 22.23% and to 22.37% in the interior. Schlesser et al. [21] observed that the protein and fat content increases during the ripening process from an initial value of 15.8% and 21.1% to 17.2% and 24%, respectively. According to Voigt et alia [19], the fat content in Camembert cheese made from raw milk amounted to 22.59% only. According to Guizani et al. [22], the fat content in the rind and interior during a 30-day ripening process on average amounted to 47.13 g/100 g of dry matter. Research conducted by Czechowska-Liszka [14] confirms that the total acidity in the analysed Camembert cheeses (cream) amounted even to 20°SH and did not have a negative influence on their overall quality. During ripening of mould cheeses the level of acidity increases, which results from the metabolism of lactic acid and deamination of amino acids with a simultaneous release of NH^3 on the cheese surface [8].

Colorimetric measurements of dairy products provide essential information about their quality and changes occurring during their storage. Colorimetric measurements are increasingly applied during the production of dairy products in order to monitor the course of the production cycle. Quite frequently the optimisation process and the choice of suitable conditions of the technological process is based on the measurements [23]. The colour of the surface of Camembert cheeses is an important quality marker, as the rind covered with snow-white mould is associated with the characteristic flavour and aroma of those products [16]. Research (Tab. 3) made it possible to evaluate the colour parameters of the rind and interior of Camembert cheese depending on a producer purchased in the Warmińsko-Mazurskie province. As concerns parameter L*, no statistically significant differences were noted among the analysed groups of cheeses and a mean value of the rind whiteness amounted to 95.74. The research shows that the rind in brand A cheese had a significantly lower ($p \leq 0.01$) negative value of red (a* = -0.16) as compared to brand B cheese (a* = -0.27). Higher negative values of a* parameter prove that the red colour spectrum has shifted towards green. A significant difference ($p \leq 0.01$) was noted in yellow rind of brand A Camembert cheese as compared to brand B cheese. The highest b* parameter was found in the rind of brand A cheese (5.90). The results confirm that brand B cheese had a significantly ($p \leq 0.01$) higher whiteness index (WI) – 93.47 as compared to 92.65 in brand A cheese.

Own research (Tab. 3) shows that brand B samples had a significantly ($p \leq 0.01$) whiter interior with a higher L* parameter amounting to 91.07. Anal-

Table 3 Colour parameters of Camembert cheeses purchased in the Warmińsko-Mazurskie province depending on the producer ($\bar{x} \pm s$)

Specification		Cheese producer		p-value
		A (n = 12)	B (n = 12)	
Rind colour parameters	L*	95.64 ±0.51	95.84 ±0.45	0.359
	a*	-0.16^{B} ±0.07	-0.27^{A} ±0.07	≤0.001
	b*	5.90^{A} ±0.30	5.02^{B} ±0.43	≤0.001
WI *(whiteness index)*		92.65^{B} ±0.44	93.47^{A} ±0.51	≤0.001
Interior colour parameters	L*	90.20^{B} ±0.70	91.07^{A} ±0.49	0.004
	a*	1.90^{A} ±0.26	1.33^{B} ±0.09	≤0.001
	b*	20.78^{A} ±0.64	19.94^{B} ±0.60	0.007
WI *(whiteness index)*		76.94^{B} ±0.75	78.11^{A} ±0.69	≤0.001

A, B – mean values marked with different letters in the lines are significantly statistically different $p \leq 0.01$

ysis of red/green and yellow/blue tint changes in the spectrum in the interior confirm a significant ($p \leq 0.01$) influence of the producer on red and yellow content. The interior of brand A cheeses had a higher level of red and yellow tint, with a* = 1.90 and b* = 20.78, respectively as compared to brand B cheese. On the other hand, brand B cheeses had a significantly ($p \leq 0.01$) higher whiteness index in the interior (WI = 78.11) as compared to brand A (WI = 76.94), which corresponds with the higher whiteness value.

Table 4 shows results of parameters of rind and interior colour parameters in brand A and B Camembert cheeses purchased in the Kujawsko-Pomorskie province. Own research does not reveal statistical differences in whiteness (L*) and red tint (a*) in the rind of the analysed products. Mean values of L* and a* parameters were similar and amounted to 95.73 and -0.26, respectively. A significantly ($p \leq 0.01$) higher value (0.78) of yellow colour parameters in the rind was found in brand A cheeses as compared to brand B cheeses (b* = 5.26). As far as the whiteness index is concerned, brand B samples had the whitest rind (WI = 93.20) as compared to brand A (WI = 92.60), which was statistically confirmed ($p \leq 0.01$).

No statistically significant differences were observed in the whiteness of the interior in brand A and B Camembert cheeses purchased in the Kujawsko-Pomorskie province during the parameter analysis. The mean value of L* parameter amounted to 91.23 (Tab. 4). Research shows that the content of red and yellow in the interior was significantly higher ($p \leq 0.01$) in brand A samples (0.73 and 2.30 more, respectively), as compared to brand B cheeses, in which the analysed parameters amounted to 1.08 and 19.65, respectively. As concerns the whiteness index, the interior in brand B cheeses was whiter, as reflected in a significantly higher ($p \leq 0.01$) value of WI, amounting to 78.50 vs 76.24. According to Calzada et al. [4] the interior of Brie cheeses from the control group had L*, a* and b* parameters amounting to 84.60, 2.73 and 22.63, respectively, whereas the rind was very light (L* = 91.34) and had a low content of red (a* = 0.12) and yellow (b* = 6.80). The experiment conducted by Kneifel et al. [24] shows that the whiteness, the red and yellow content in the rind of Camembert cheeses were 95.7, 0.1 and 5.2, respectively. The quoted researchers confirmed higher yellow content in the interior of the analysed cheeses, which was backed up by the calculated parameters L* = 85.6, a* = 3.3 and b* = 26.9. Research conducted by Rodriguez-Aguilera et al. [8, 16] shows that the initial whiteness index calculated with L*, a* and b* parameters measured on the surface of Camembert cheeses before storing in a cool place amounted to 89.63 and 91.40 and was lower than those calculated in our own research.

4. CONCLUSIONS

The obtained results show that brand A cheeses bought in the Warmińsko-Mazurskie province had the highest content of water and fat. Brand B samples bought in the Warmińsko-Mazurskie and

Table 4 Colour parameters of Camembert cheeses purchased in the Kujawsko-Pomorskie province depending on the producer ($\bar{x}$ ±s)

Specification		Cheese producer		p-value
		A (n = 12)	B (n = 12)	
Rind colour parameters	L*	95.76 ±0.47	95.71 ±0.39	0.811
	a*	-0.26 ±0.07	-0.27 ±0.05	0.729
	b*	6.04^{A} ±0.51	5.26^{B} ±0.45	≤0.001
WI *(whiteness index)*		92.60^{B} ±0.60	93.20^{A} ±0.46	0.023
Interior colour parameters	L*	91.10 ±0.55	91.35 ±0.61	0.344
	a*	1.81^{A} ±0.11	1.08^{B} ±0.16	≤0.001
	b*	21.95^{A} ±1.04	19.65^{B} ±0.45	≤0.001
WI *(whiteness index)*		76.24^{B} ±1.14	78.50^{A} ±0.63	≤0.001

A, B – mean values marked with different letters in the lines are significantly statistically different $p \leq 0.01$

Kujawsko-Pomorskie provinces had the lowest total acidity. Despite the similarities in the whiteness in brand A and B cheeses purchased in both provinces, the rind displayed a shift from the red end to the green end of the spectrum. The lowest content of green was found in the rind of brand A cheeses purchased in the Warmińsko-Mazurskie province. As concerns the colour yellow, the rind of brand A cheeses purchased in both provinces had a significantly higher content of the colour. Brand B cheeses bought in the Warmińsko-Mazurskie province had the significantly highest L* parameter of the interior, which corresponded with the significantly lower content of red and yellow in the interior in the group. The obtained data show that red and yellow content in the interior of brand A cheeses was significantly higher in comparison with the same parameters measured in B cheeses. The whiteness index measured in the rind and in the interior of the samples was significantly highest in B samples bought in both provinces, as indicated by their whiter colour.

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