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MILK FAT RETENTION DURING THE PRODUCTION OF SOME RIPENING CHEESES

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Milk fat retention in cheese was determined during the production of six various types of cheese, Ementalski, Gouda, Mazurski, Tylżycki, Warmiński and Jeziorański, at different dairy plants (DP-A, ... DP-F), depending on the technological and technical conditions of the production process, taking into account seasonal changes in milk composition.

A statistical analysis of the results showed that in all cheese types the levels of milk fat recovery in cheese was not affected by the season. An analysis of particular production processes revealed statistically significant differences (at a confidence level of α=0.05) only in the case of Ementalski cheese produced at DP-B, for which the level of milk fat retention in cheese was higher in the summer than in the winter. In the other cases no statistically significant differences were found. An analysis of milk fat retention in all types of cheese throughout the year and in the summer and winter production cycles indicated that the level of milk fat recovery in cheese was related to cheese type. This suggests that the production technology and technical equipment had stronger effects on milk fat recovery in cheese than the chemical composition of milk. A comparison of the statistical values calculated for Ementalski cheese produced at DP-A and DP-B, and for Tylżycki cheese and Warmiński cheese produced at DP-E, confirmed that the technical equipment used at a cheese dairy had a greater influence on milk fat transfer than the production technology.

INTRODUCTION

Fat accounts for 15% to 30% of dry matter in cheese milk, whereas in ripening cheeses – for 20% to 60%, depending on their type. This indicates that milk components contribute to the formation of the mass of the final product to a different extent.

The retention of milk dry matter components in cheese is a result of interactions of numerous complementary factors, such as the chemical composition of milk [Fox, 1993; Macedo & Malcata, 1997; Varnam & Sutherland, 1994], conditions of milk collection and storage [Martley & Crow, 1993], heat treatment [De Jong & Linden, 1992; Lau *et al.*, 1990; Sharma & Dalgleish, 1994], type of coagulating enzyme and starter [Crow *et al.*, 1993, 1994; Fox & Stepaniak, 1993; Fox & McSweeney, 1996], production technology and technical equipment used at a cheese dairy [Emmons, 1993].

The aim of the present study was to determine milk fat retention in cheese during the production of some ripening cheeses, as dependent on the technological and technical conditions of the production process, taking into account seasonal changes in milk composition.

MATERIALS AND METHODS

The experiment was performed on six types of cheese, *i.e.* Ementalski cheese produced at two dairy plants, DP-A and DP-B on two different production lines, Gouda cheese produced at DP-C, Mazurski cheese produced at DP-D, Tylżycki cheese and Warmiński cheese produced at DP-E and Jeziorański cheese produced at DP-F.

The level of milk fat retention was determined taking into consideration the main technological parameters of the production process. The amounts of processing milk, cheese produced, whey and fat (fat units) were calculated for particular months and added up, to obtain annual values, separately for the summer and winter production cycles. These data provided the basis for determining the level (%) of milk fat transfer to cheese and whey, and fat loss (%) in the production process.

The above data were compared with the fat content of processing milk, which enabled to calculate the mean monthly fat content (%) of processing milk, amount (L) of milk required to produce 1 kg of cheese, and the number of fat units (fat units) in processing milk per kg of cheese.

The calculations were performed using "Winstat" and "Statistica PL" software. The results and working hypotheses were verified statistically by an analysis of variance for a design with single classification. This procedure was applied to test the fixed effects model hypothesis for single cross orthogonal classification. It was assumed that the observed values of the parameter Y in "k" independent samples, for the sample size "n", fulfill the equation:

$$Y_{ij}=\mu+\alpha_i+e_{ij} \ (i=1, 2, 3, ..., k, \quad j=1, 2, 3, ..., n,)$$

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where: Y_{ij} – j-th observation in the i-th group, μ – total mean, α_i – main effect of the i-th group, and e_{ij} – random errors with distributions N (0, δ).

In the case of statistical differences between the means, the values were divided into homogenous groups by the Duncan test.

RESULTS

The mean levels of milk fat retention during the production of Ementalski cheese at DP-A in the summer and winter were almost identical, despite considerable fluctuations observed in particular months (from 86.35% in April to 90.87% in September). The highest levels of fat transfer from milk to cheese were recorded in September, February and January (90.87%, 90.62% and 90.37% respectively), and the lowest – in April, October and August (86.35%, 87.60% and 87.86%).

Despite comparable fat concentrations in processing milk (from 2.87% in February to 2.98% in July), the number of fat units per kilogram of cheese in this kind of milk differed significantly, ranging from 27.21 in April to 33.67 in October. In the months in which the number of fat units per kilogram of cheese in milk was the lowest (April, June, July), milk utilisation per kilogram of cheese was also lower (below 10 liters). In the other months milk utilization per kilogram of cheese ranged between 11.38 to 11.61 liters.

The mass balance of milk fat was analyzed in the process of Ementalski cheese production at DP-B. The level of milk fat retention in cheese was much lower (annual mean 82.76%) than during Ementalski cheese production at DP-A (annual mean 89.19%). The average level of fat transfer from milk to cheese was slightly higher in the summer than in the winter (83.57% *vs*. 81.95%). The lowest level of milk fat recovery in cheese was recorded in April (80.12%), and the highest – in June (84.13%).

Certain differences were found in the technology of Ementalski cheese production at the above dairy plants. At DP-A the production process was characterized by a lower (by 2°C) temperature of milk pasteurization, an over twofold higher addition of $CaCl_2$ and a higher (by 2–3°C) temperature of cheese curd scalding and drying; the other technological parameters were comparable.

The highest level of milk fat recovery in cheese (on average 93.22%), accompanied by the lowest fluctuations throughout the year (from 92.53% in June to 93.76% in January), was observed during Gouda cheese production at DP-C.

The fat content of processing milk ranged over the year from 2.65% in July to 2.91% in May. In consequence, also the amount of milk (L) and fat units per kilogram of cheese fluctuated slightly only, and was by 0.15% and 0.22% higher in the summer, compared with the winter production cycle.

Differences in milk fat retention in Mazurski cheese produced at DP-D were significantly greater than in the case of Gouda cheese. The maximal levels of fat recovery in cheese of this type were recorded in May and September (over 87.3%), whereas minimal – in October (82.93%). In the winter fat retention was on average by nearly 0.6% higher than in the summer.

A comparison of milk fat balance during the production of Tylżycki cheese and Warmiński cheese at DP-E indicated different retention levels. These differences seemed non-significant in the summer and winter. Over the entire experimental period, fat transfer from milk to Tylżycki cheese was at a level of 2.26%, reaching the maximum in January (87.71%) and the minimum in August (85.45%). Similar differences in milk fat retention were observed in the production of Warmiński cheese. The highest levels of fat recovery in cheese were recorded in May and December (88.02% and 87.06%), and the lowest – in September and November (84.54% and 85.20%). Differences between the boundary values of milk fat recovery were greater than in Tylżycki cheese, and amounted to 3.48%. Mean fat retention in Tylżycki cheese was by 0.65% higher than in Warmiński cheese.

The raw materials used for cheese production at DP-E had identical chemical composition and microbiological quality. Since the same enzymatic coagulants were used, and temperature and milk coagulation time were identical, curd firmness could not affect the level of milk fat recovery in cheese. The slightly higher fat retention in Tylżycki cheese may be related to small differences in the production technology. During the production of Tylżycki cheese, the curd was divided into finer grains. Certain differences were also recorded in the temperature of technological water added during the process, whey acidity after water addition and after cheese curd drying. Thus, it may be assumed that the factor determining the level of fat transfer from milk to cheese could be the difference in the fat content of processing milk (3.35% in Warmiński cheese and 3.43% in Tylżycki cheese). The production of 1 kg of Tylżycki cheese required more fat units contained in milk and a lower amount of milk (L), in comparison with Warmiński cheese.

In the case of Jeziorański cheese, produced at DP-F, the higher level of milk fat recovery (on average 88.41%) resulted most probably from a slightly different chemical composition, especially a higher water content, as compared with Tylżycki cheese and Warmiński cheese. In the winter, in comparison with the annual mean, milk fat retention in cheese was higher, and fluctuated considerably in particular months. The highest milk fat recovery (over 90%) was observed in March and December, and the lowest (86.27%) – in June. It should be noted that the higher water content of this type of cheese, in relation to the other ones, was the reason for a lower level of milk utilization per kg of cheese (on average 8.85 L).

DISCUSSION

The retention of milk dry matter components in cheese is affected by the chemical composition of milk. Bazydło & Sokołowski [1999], who estimated monthly fluctuations in the concentrations of milk fat and milk protein, found that fat content varied within a greater range than protein content, and that there was no unequivocal correlation between the levels of these two components.

The level of milk fat recovery in cheese depends also on the proportions of fat and casein [Macedo & Malcata, 1997; Morison, 1997]. According to Emmons [1993], milk condensation is followed by changes in its composition caused by component concentration, which enables fat retention in the curd.

The high fat content of processing milk reduces fat retention in cheese [Emmons, 1993; Lou & Ng-Kwai-Hang, 1992]. Saito [1991] and Tunick *et al.* [1993] demonstrated that homogenisation (5–10 MPa) leads to a decrease in the fat content of whey (even to 0.1%).

An analysis of milk fat retention during the production of some ripening cheeses revealed a high variation, both in the whole groups of cheeses and within particular cheese types. However, no distinct seasonal changes in the utilisation of milk and fat units per kilogram of cheese were observed. The production of Swiss type cheeses required larger amounts of milk and fat units in the winter than in the summer. This difference was greater in the case of Ementalski cheese produced at DP-B (0.34 L and 1.36 fat units) than at DP-A (0.1 L and 0.29 fat units). The reversed tendency was recorded during the production of Dutch type cheeses and Swiss-Dutch type cheeses: the utilisation of milk and fat units per kilogram of cheese was higher in the summer than in the winter (on average by 0.19 L milk and 1.0 fat units).

The levels of milk component recovery in cheese are also related to microbiological quality, especially to the presence of psychrotrophic bacteria. In this case a decrease in cheese yield is proportional to the counts of psychrotrophic bacteria, and correlated with degradation of protein and fat [Varnam & Sutherland, 1994].

Żuraw *et al.* [1994], who studied season-related changes in the yield of Gouda cheese, reported considerable seasonal differences in the retention of milk dry matter components in cheese. For the fat content of cheese, ranging between 26.7% and 28.4%, and the water content of cheese, ranging from 42.05 to 43.8%, milk utilisation per kilogram of the final product ranged from 9.13 L to 10.12 L. The highest cheese yield (9.13 L to 9.45 L milk per kg cheese) was recorded from November to April, whereas the lowest – between July and August (9.97; 10.12 L milk per kg cheese). These authors also confirmed the effects of various inocula on the recovery of milk dry matter components in cheese. In the case of a bulk starter the mean concentrations of fat and protein in whey were 0.1% and 0.83 - 0.87% respectively, while in the case of the DVS concentrate these values were 0.09% and 0.70–0.72%.

The retention of milk dry matter components in cheese depends also on coagulants. Many known proteinases cause milk protein coagulation, but the majority of these enzymes show too high proteolytic activity in relation to coagulating activity, which results in a lower cheese yield or cheese defects [Fox & Law, 1991; Fox & Stepaniak, 1993; Fox *et al.*, 1993].

No clear correlations were found between the yield and retention of milk fat, and the technology of cheese production. In this experiment the highest level of milk fat recovery in cheese (93.22%) was observed during the production of Dutch type cheese (Gouda) and Jeziorański cheese (88.41%) that belongs to soft cheeses. In the group of Swiss-Dutch type cheeses the average level of milk fat retention was 86.31%, with a dispersion of 0.65%. During the production of Swiss type cheeses the annual mean level of fat transfer from milk to cheese ranged from 89.19% to 82.76% (on average 85.97%).

It may be concluded that neither production technology nor seasonal changes in the chemical composition of milk affected milk fat retention in cheese in one and the same way. The properties of rennet curd, such as firmness and syneresis, were not dependent on changes in the chemical composition of milk, either. This corresponds to the results obtained by Hurtaud *et al.* [1993]. Dajnowiec *et al.* [1997] analysed the effects of various milk protein concentrates added to milk on rennet curd firmness. Despite a similar course of coagulation, the curds differed in firmness.

Milk fat retention levels were very similar in Tylżycki cheese (annual mean – 86.62%) and Warmiński cheese (85.97%), produced on the same production line at the same dairy plant – DP-E, and significantly different in two types of Ementalski cheese (89.19% and 82.76%). This suggests that milk fat retention in cheese, as well as cheese yield, are related primarily to technical conditions. As for technological factors, milk fat recovery in cheese was considerably affected by curd firmness, modified during Ementalski cheese production at different dairy plants by pasteurization temperature, different levels of $CaCl_2$, scalding temperature and drying temperature.

Fat and protein transfer from milk to whey is also affected by the type of coagulator, cutting knife structure, speed and shear force. According to Emmons [1993], there exists the so called optimum of curd firmness, during which cutting does not cause curd tearing.

A statistical analysis of the results showed that in all cheese types the levels of milk fat recovery in cheese was not affected by the season (Table 1). An analysis of particular production processes (Table 2) revealed statistically significant differences (at a confidence level of α=0.05) only in the case of Ementalski cheese produced at DP-B, for which the level of milk fat retention in cheese was higher in the summer than in the winter. In the other cases no statistically significant differences were found. An analysis of milk fat retention in all types of cheese throughout the year (Table 3) and in the summer and winter production cycles (Tables 4 and 5) indicated that the level of milk fat recovery in cheese was related to cheese type. This suggests that the production technology and technical equipment had stronger effects on milk fat recovery in cheese than the

TABLE 1. Comparison of the levels of milk fat recovery in cheese depending on the season (regardless of cheese type).

Factor	Sample size (n)	Level of milk fat recovery in cheese – mean values ($\bar{x}_.$)	Standard deviation (s)	Coefficient of variation (v)
A. Summer	7969	87.5167	2.9890	3.42
B. Winter	5074	87.6130	3.4799	3.97

Results of analysis of variance:
Null hypothesis H_0: The level of fat milk recovery in cheese is not affected by the season.
Significance level α=0.05
Value of F statistics – 0.0181;
Probability of exceeding the value of F statistics – 0.8932
No grounds for rejecting the null hypothesis H_0.

TABLE 2. Comparison of the levels of milk fat recovery in cheese depending on the season.

Factor	Sample size (n)	Level of milk fat recovery in cheese – mean values ($\bar{x}$)	Standard deviation (s)	Coefficient of variation (v)
Ementalski cheese produced at DP-A.				
A. Summer	742	89.1750	1.2351	1.39
B. Winter	522	89.1983	1.6715	1.87

Results of analysis of variance:
Null hypothesis H_0: The level of fat milk recovery in cheese is not affected by the season.
Significance level $\alpha=0.05$
Value of F statistics – 0.0008
Probability of exceeding the value of F statistics – 0.9786
No grounds for rejecting the null hypothesis H_0:

Factor	Sample size (n)	Level of milk fat recovery in cheese – mean values ($\bar{x}$)	Standard deviation (s)	Coefficient of variation (v)
Ementalski cheese produced at DP-B.				
A. Summer	446	83.5650	0.4835	0.58
B. Winter	417	81.9450	1.2982	1.58

Results of analysis of variance:
Value of F statistics – 8.2042
Probability of exceeding the value of F statistics – 0.0163
The null hypothesis H_0: should be rejected and the alternative hypothesis H_1: should be accepted
Results of the Duncan test A > B*

Factor	Sample size (n)	Level of milk fat recovery in cheese – mean values ($\bar{x}$)	Standard deviation (s)	Coefficient of variation (v)
Gouda cheese produced at DP-C.				
A. Summer	1393	93.1217	0.3960	0.43
B. Winter	1027	93.3133	0.4699	0.50

Results of analysis of variance:
Value of F statistics – 0.4625
Probability of exceeding the value of F statistics– 0.5836
No grounds for rejecting the null hypothesis H_0:

Factor	Sample size (n)	Level of milk fat recovery in cheese – mean values ($\bar{x}$)	Standard deviation (s)	Coefficient of variation (v)
Mazurski cheese produced at DP-D.				
A. Summer	1125	86.0550	1.7279	2.01
B. Winter	961	86.6433	0.4084	0.47

Results of analysis of variance:
Value of F statistics – 0.4359
Probability of exceeding the value of F statistics – 0.6587
No grounds for rejecting the null hypothesis H_0:

Factor	Sample size (n)	Level of milk fat recovery in cheese – mean values ($\bar{x}$)	Standard deviation (s)	Coefficient of variation (v)
Tylżycki cheese produced at DP-E.				
A. Summer	2097	86.6783	0.6437	0.74
B. Winter	1131	86.5617	0.6692	0.77

Results of analysis of variance:
Value of F statistics – 0.0947
Probability of exceeding the value of F statistics – 0.7646
No grounds for rejecting the null hypothesis H_0:

Factor	Sample size (n)	Level of milk fat recovery in cheese – mean values ($\bar{x}$)	Standard deviation (s)	Coefficient of variation (v)
Warmiński cheese produced at DP-E.				
A. Summer	1170	86.2700	1.2112	1.40
B. Winter	505	86.0250	0.8419	0.98

Results of analysis of variance:
Value of F statistics – 0.1218
Probability of exceeding the value of F statistics – 0.7361
No grounds for rejecting the null hypothesis H_0:

Factor	Sample size (n)	Level of milk fat recovery in cheese – mean values ($\bar{x}$)	Standard deviation (s)	Coefficient of variation (v)
Jeziorański cheese produced at DP-F.				
A. Summer	996	87.7517	1.1831	1.35
B. Winter	511	89.0750	1.0586	1.19

Results of analysis of variance:
Value of F statistics – 0.0662
Probability of exceeding the value of F statistics – 0.0685
No grounds for rejecting the null hypothesis H^0:

** – statistically significant differences at $\alpha=0.01$, * – statistically significant differences at $\alpha=0.05$.

TABLE 3. Comparison of the levels of milk fat recovery in cheese depending on the cheese type (regardless of season).

Factor (cheese type/ dairy plant	Sample size(n)	Level of milk fat recovery in cheese – mean values ($\bar{x}$)	Standard deviation (s)	Coefficient of variation (v)
1. Ementalski / DP-A	1264	89.1867	1.4012	1.57
2. Ementalski / DP-B	863	82.7550	1.2602	1.52
3. Gouda / DP-C	2420	93.2158	0.4247	0.46
4. Mazurski / DP-D	2086	86.3492	1.2359	1.43
5. Tylżycki / DP-E	3228	86.6200	0.6290	0.73
6. Warmiński / DP-E	1675	86.1720	1.0331	1.20
7. Jeziorański / DP-F	1507	88.4133	1.2740	1.44

Results of analysis of variance:
Null hypothesis H_0: The level of fat milk recovery in cheese is not affected by the cheese type
Significance level $\alpha=0.05$
Value of F statistics – 104.3913
Probability of exceeding the value of F statistics – 0.0000
The null hypothesis H_0: should be rejected and the alternative hypothesis H_1: should be accepted
Results of the Duncan test
1, 3, 7 > 2, 4, 5, 6**
3 > 1, 7**
4, 5, 6 > 2**
** – statistically significant differences at $\alpha=0.01$,
* – statistically significant differences at $\alpha=0.05$.

TABLE 4. Comparison of the levels of milk fat recovery in cheese depending on the cheese type during the summer production cycle.

Factor (cheese type/ dairy plant	Sample size(n)	Level of milk fat recovery in cheese – mean values ($\bar{x}$)	Standard deviation (s)	Coefficient of variation (v)
1. Ementalski / DP-A	742	89.1750	1.2351	1.39
2. Ementalski / DP-B	446	83.5650	0.4835	0.58
3. Gouda / DP-C	1393	93.1217	0.3960	0.43
4. Mazurski / DP-D	1125	86.0550	1.7279	2.01
5. Tylżycki / DP-E	2097	86.6783	0.6437	0.74
6. Warmiński / DP-E	1170	86.2700	1.2112	1.40
7. Jeziorański / DP-F	996	87.7517	1.1831	1.35

Results of analysis of variance:
Null hypothesis H_0: The level of fat milk recovery in cheese is not affected by the cheese type.
Significance level $\alpha=0.05$
Value of F statistics – 46.3876
Probability of exceeding the value of F statistics – 0.0000
The null hypothesis H_0: should be rejected and the alternative hypothesis H_1: should be accepted
Results of the Duncan test
1, 3 > 2, 4, 5, 6**
3 > 1, 7**
4, 5, 6 > 2**
7 > 4, 6*
** – statistically significant differences at $\alpha=0.01$,
* – statistically significant differences at $\alpha=0.05$.

chemical composition of milk. A comparison of the statistical values calculated for Ementalski cheese produced at DP-A and DP-B, and for Tylżycki cheese and Warmiński

TABLE 5. Comparison of the levels of milk fat recovery in cheese depending on the cheese type during the winter production cycle.

Factor (cheese type/ dairy plant	Sample size (n)	Level of milk fat recovery in cheese – mean values ($\bar{x}$)	Standard deviation (s)	Coefficient of variation (v)
1. Ementalski / DP-A	522	89.1983	1.6718	1.87
2. Ementalski / DP-B	417	81.9450	1.2982	1.58
3. Gouda / DP-C	1027	93.3133	0.4699	0.50
4. Mazurski / DP-D	961	86.6433	0.4084	0.47
5. Tylżycki / DP-E	1131	86.5617	0.6692	0.77
6. Warmiński / DP-E	505	86.0250	0.8419	0.98
7. Jeziorański / DP-F	511	89.0750	1.0586	1.19

Results of analysis of variance:
Null hypothesis H_0: The level of fat milk recovery in cheese is not affected by the cheese type.
Significance level $\alpha=0.05$
Value of F statistics – 70.2184
Probability of exceeding the value of F statistics – 0.0000
The null hypothesis H_0: should be rejected and the alternative hypothesis H_1: should be accepted
Results of the Duncan test
1, 3, 7 > 2, 4, 5, 6**
3 > 1, 7**
4, 5, 6 > 2**
** – statistically significant differences at $\alpha=0.01$,
* – statistically significant differences at $\alpha=0.05$.

cheese produced at DP-E, confirmed that the technical equipment used at a cheese dairy had a greater influence on milk fat transfer than the production technology.

Numerous factors influence the levels of milk fat retention in cheese to a different extent. The results of this study permitted to put these factors in order. It was found that the technical equipment used at a cheese dairy had the greatest effect on milk fat recovery in cheese, followed by the production technology and milk composition.

It follows that an improvement in production efficiency, reflected by an increase in cheese yield, is dependent not only on raw materials and technological conditions, but also on the proper selection of technical equipment, used in the production process at cheese dairies as well as at previous stages, including milk collection and preparation for cheese production. It seems that a thorough evaluation of the effects of particular units of technical equipment on milk fat retention in cheese is possible in model systems only.

CONCLUSIONS

1. No clear correlations were found between the yield and retention of milk fat in various types of ripening cheeses and the production technology, seasonal and regional changes in the chemical composition of milk.

2. There is a direct causal relationship between fat transfer from milk to cheese and the properties of milk used for cheese production. Milk fat recovery in cheese is also affected by the technological conditions at successive stages of milk processing. However, the key determinant of fat retention is technical equipment at a cheese dairy.

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RETENCJA TŁUSZCZU MLEKOWEGO W PROCESIE PRODUKCJI WYBRANYCH RODZAJÓW SERÓW DOJRZEWAJĄCYCH

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Określono retencję tłuszczu mlekowego do sera podczas przemysłowej produkcji sześciu różnych rodzajów serów: ementalskiego, goudy, mazurskiego, tylżyckiego, warmińskiego oraz jeziorańskiego, produkowanych w zakładach: ZM-A, ... ZM-F, zależnie od technologicznych i technicznych uwarunkowań przebiegu procesu produkcyjnego z jednoczesnym uwzględnieniem wpływu sezonowych zmian w składzie mleka.

Przeprowadzona, statystyczna analiza uzyskanych wyników oznaczeń retencji tłuszczu mlekowego wykazała, że w obrębie wszystkich badanych serów (tab. 1) stopień przejścia tłuszczu do sera nie jest uzależniony od pory roku. Analizując zaś poszczególne procesy produkcyjne (tab. 2) wykazano statystycznie istotne różnice (przy poziomie ufności α=0.05) jedynie w przypadku sera ementalskiego wytwarzanego w ZM-B, dla którego stopień retencji tłuszczu do sera w okresie letnim był większy niż w okresie zimowym. W pozostałych analizowanych przypadkach nie stwierdzono statystycznie istotnych różnic. Przeprowadzona dalej analiza retencji tłuszczu w obrębie wszystkich badanych rodzajów serów i na przestrzeni całego roku (tab. 3) oraz w letnim i zimowym okresie produkcyjnym (tab. 4 i 5) wykazała, że stopień przejścia tłuszczu do sera zależy od rodzaju produkowanego sera. Wskazuje to na większy wpływ stosowanej technologii oraz wyposażenia technicznego poszczególnych serowni na retencję tłuszczu do sera niż skład chemiczny mleka. Z kolei porównanie obliczonych wartości statystycznych przy produkcji sera ementalskiego w ZM-A i ZM-B oraz serów tylżyckiego i warmińskiego wytwarzanych w ZM-E wskazuje na znacznie większy wpływ na retencję tłuszczu technicznego wyposażenia serowni od stosowanej technologii.