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INFLUENCE OF CURD PARTICLES DRYING TEMPERATURE ON THE COMPOSITION OF CURD MADE OF MILK IN WHICH COAGGREGATES WERE FORMED

Snežana Jovanović,[1] O. Maćej[1] and M. Barać[1]

Abstract: The influence of different drying temperatures of curd particles in order to obtain curd particles with chemical composition characteristic for Dutch-type semi-hard cheeses was investigated.

The experiments were performed with heat- treated milk at 87ºC for 10 minutes to induce chemical interaction between casein and serum proteins and to form the co-called coaggregates. The curd particles were dried at 42ºC and 45ºC for 60 minutes and two types of curd, named curd A and curd B were formed afterwards.

The results of the experiments showed that the used temperatures had no significant influence on chemical composition of the curd. The average total solids of curd A was 49.09%, moisture in fat free basis (MFFB) 68.78%, protein content 22.23%, lactose content 1.55%, ash 1.98%, titratable acidity 71.70^0T and pH 6.22. On the other side, the average values for curd B were 49.40%, 68.58%, 22.74%, 1.47%, 1.94%, 75.92^0T and 6.07, respectively.

The use of different drying temperatures, as well as the other treatments (pressing, salting and ripening) provide conditions for semihard cheese producing, with the chemical composition similar to the Dutch-type semihard cheese prepared according to the traditional method.

Key words: milk, heat treatment, coaggregates, semihard cheese, drying temperature.

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[1] Snežana Jovanović, PhD., Assistant Professor, Ognjen Maćej, PhD., Professor, Miroljub Barać, PhD., Assistant Professor, Department of Food Technology and Biochemistry, Faculty of Agriculture, Nemanjina 6, 11081 Belgrade-Zemun, Serbia and Montenegro

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Introduction

The curd processing treatments essentially determine the production of cheese with defined physical properties and chemical composition specific for the different type of cheese. The curd processing includes two different phases, the phase of curd particles formation and the whey phase. The whey draining as well as molding and pressing cause their separation completely. These steps define chemical composition, macro- and microstructure of the cheese, the way of ripening and the cheese sensory characteristics.

The curd processing includes several treatments such as curd cutting, stirring or agitation, scalding, removing part of the whey and drying. The purpose of the drying treatment is the formation of the curd particles with specific chemical composition and rheological properties. The aim of the curd processing is to obtain optimal conditions for the starter culture growth, which is very important for the aroma formation during ripening (Cogan et al., 1990, Cogan et al., 1993; Engels et al., 1997; Fox et al., 1990; Konings et al., 2000; Milanović et al., 2000; Pudja et al., 1994).

Sweet casein gel formed from the milk with heat induced chemical complex of casein and serum protein (coaggregates) has properties different from the heat induced gel prepared according to the traditional procedures. Higher heat treatments that induce coaggregate formation, produce less firmness and more cross-linked curd. This curd expresses low ability to contract and to release the whey (Green and Grandison, 1993; Pearse and Mackinlay, 1989; Pearse et al., 1985; Pearse et al., 1986; Walstra, 1993; Jovanović et al, 2002).

Protein matrix of the curd formed from the milk heat treated at 85ºC for 10 minutes is composed of short, branchy chains (fine crosslinking). These curds are characterized by the lower contraction. Also, they have lower whey separation ability (Kalab, 1995). Due to the curd particles contraction, the increase of temperature accelerates sineresis directly. Unsuitable heating can cause the formation of curd particles crust and the decrease of the rate of whey releasing from the interior of a curd particles. This will produce unequalized cheese structure. Curd particles prepared at high temperatures are characterized by low acidity and higher content of calcium. Cheese prepared from these curd particles had higher elasticity (Pejić, 1959).

Maćej and Jovanović (1998) showed that heating at 87ºC, 90ºC and 95ºC for 10 minutes induced the same level of coagreggate formation. Furthermore, according to these authors the changes of milk sugar caused at 87º C were the smallest.

For these experiments milk was treated at 87^{o}C for 10 minutes. These conditions gave several advantages including better utilization of milk protein and fat, higher yield and higher biological value of cheese.

Material and Method

Milk treated at 87ºC for 10 minutes was used. These conditions induced chemical interaction between casein and serum proteins (coaggregates formation). Coagulation of milk was performed with rennet at 35ºC for 20 minutes. The curd was processed according to modified traditional Dutch semi-hard cheese procedure. Drying temperature was modified. The curd particles were dried at 42ºC and 45ºC for 60 minutes and formed two types of curd, named curd A and curd B. We registered the effect of drying temperatures on curd chemical composition.

Each experiment was performed in 12 replicates (n=12)

The following analyses were performed:
-Determination of total solids by standard drying method at 102±2ºC (AOAC 16.032:1990)
-Determination of milk fat by standard method according to Gerber (IDF Standard 105:1981)
-Determination of total nitrogen matter with Kjeltec system by Kjeldahl method (IDF Standard 20B:1993)
- Lactose content (IDF Standard 28A:1974)
-Ash content (AOAC 16.035 :1990)
-Titratable acidity determination according to Soxlet-Henkel (Carić et al, 2000)
-Determination of pH with pH-meter Sentron 1001
-For density determination lactodensimeter was used (Carić et al., 2000)

The curd composition was determined by the following methods:
-Determination of total solids by standard drying method at 102±2ºC (IDF Standard 4A: 1982)
-Determination of milk fat according to van Gulik method (Carić et al., 2000)
-Determination of total nitrogen matter with Kjeltec system by Kjeldahl method (IDF Standard 20B:1993)
- Lactose content (IDF Standard 28A:1974)
-Titratable acidity according to Thörner (Pejić and Djordjević, 1963)
- Determination of ash according to standard method (Carić et al, 2000)
-Determination of pH with pH-meter Sentron 1001
-Determination of salt according to Mohr-u (Pejić and Djordjević, 1963).

Statistical analysis was performed. All data for the investigated parameters are shown as mean values. Also, analyses of variance for all data were performed (standard deviation and coefficient of variation).

Results and Discussion

The most important quality parameters of milk treated at 87ºC for 10 minutes are presented in table 1.

T a b. 1. - Quality parametars of milk heat treated at 87°C/10 minutes

Investigated parametars	Calculated parametars				
	min.	max.	x (n=12)	Sd	Cv (%)
Total solids (%)	11.45	12.41	11.82	0.3047	2.58
Moisture(%)	87.59	88.55	88.18	0.3047	0.34
Milk fat (%)	3.20	3.30	3.25	0.0522	1.61
TSNF* (%)	8.25	9.21	8.57	0.3159	3.68
Total nitrogen (%)	0.4470	0.5044	0.4834	0.0200	4.14
Proteins (%)	2.85	3.22	3.08	0.1278	4.14
P/F* (%)	0.86	1.00	0.95	0.0463	4.88
Lactose (%)	4.60	4.65	4.63	0.0186	0.40
Ash (%)	0.69	0.79	0.75	0.0360	4.78
Acidity (°SH)	6.14	8.09	6.99	0.8354	11.94
pH	6.40	6.66	6.52	0.1102	1.69
Density	1.0292	1.0328	1.0309	0.0011	0.11

Legend:
*TSNF- total solids non fat
*P/F- protein/fat

According to these parameters, total solids were 11.45%-12.41%; the average value was 11.82%. Total solids in non- fat matter were 8.25%-9.21% (the average value 8.57%). Due to the standardization performed before heating, milk fat content was lower relative to the raw milk. The average milk fat content was 3.25%. Nitrogen content was 0.4470%-0.5044% (the average value 0.4834%), while protein content was 2.85%-3.22%.

The average content of lactose and ash was 4.63% and 0.75%, respectively. Titratable acidity was 6.99^0SH and pH value was 6.52.

The effect of drying temperature on curd composition

The important stage of curd processing is drying of curd particles. During this stage the whey separation (syneresis) is completed. In contrast, Green and Grandison (1993) suggested that syneresis had occurred through the earlier phase of rennin process. The purpose of the drying treatment is to obtain desirable level of total solids and optimal acidity of curd particles. Optimal acidity is an important regulation factor for biochemical processes occurring through molding, pressing, salting and, especially ripening. Drying stage caused a suitable structure of curd particles incorporated in cheese. Thus, this treatment is important for their microstructure (Green and Grandison,1993; Pejić, 1956; Scott, 1986; Walstra, 1993; Walstra et al.,1993).

Two drying methods were used for these experiments, heat treatment at 42ºC and 45ºC for 60 minutes. These values are higher relative to the temperatures used for the traditional semi-hard cheese making method (Pejić, 1956; Walstra et al., 1993). This could be explaind by slower whey separation (syneresis), which occurs in soft curd made by coagulation of milk in which coaggregates were formed (Jovanović et al., 1996, Maćej, 1989, Maćej, 1992, Maćej, 1994, Maćej et al., 1999, Pudja, 1992, Pudja et al., 1995).

The composition of curd (t=42ºC) A and curd B (t=45ºC), depending on drying temperatures is reported in table 2.

T a b. 2. - Major composition parametars of curd A and curd B depending on drying temperature

Investigated parametars	Curd A				
	Calculated parametars				
	min.	max.	x (n=12)	Sd	Cv (%)
Total solids (%)	46.50	50.89	49.09	1.2658	2.58
Moisture (%)	49.11	53.50	50.91	1.2658	2.49
Milk fat (%)	24.00	28.00	25.94	1.5155	5.84
Fat in total solids (%)	48.63	58.52	52.90	4.0459	7.65
MFFB* (%)	65.26	72.44	68.78	2.7851	4.05
Total nitrogen (%)	3.1200	3.7469	3.4852	0.2023	5.80
Total nitrogen in total solids (%)	6.49	7.46	7.10	0.3109	4.38
Proteins (%)	19.90	23.90	22.23	1.2908	5.80
Proteins in total solids (%)	41.39	47.62	45.27	1.9834	4.38
Lactose (%)	1.02	1.92	1.55	0.3977	25.60
Ash (%)	1.81	2.26	1.98	0.1431	7.24
Ash in total solids(%)	3.71	4.44	4.02	0.2299	5.69
Acidity (^oT)	64.97	81.11	71.70	6.4164	8.95
pH	5.98	6.44	6.22	0.1996	3.21
Investigated parametars	Curd B				
	Calculated parametars				
	min.	max.	x (n=12)	Sd	Cv (%)
Total solids (%)	47.46	51.18	49.40	1.1530	2.33
Moisture (%)	48.82	52.54	50.60	1.1530	2.28
Milk fat (%)	24.00	29.75	26.14	1.9349	7.40
Fat in total solids (%)	47.38	60.84	53.00	4.7492	8.96
MFFB* (%)	64.45	72.74	68.58	3.0128	4.39
Total nitrogen (%)	3.1900	3.8267	3.5647	0.2238	6.28
Total nitrogen in total solids (%)	6.59	7.59	7.21	0.3344	4.64
Proteins (%)	20.35	24.41	22.74	1.4280	6.28
Proteins in total solids (%)	42.02	48.44	46.01	2.1334	4.64
Lactose (%)	1.12	2.01	1.47	0.3919	26.66
Ash (%)	1.85	2.12	1.94	0.0783	4.03
Ash in total solids(%)	3.65	4.27	3.94	0.1537	3.90
Acidity (^oT)	74.11	78.03	75.92	1.6793	2.21
pH	6.00	6.16	6.07	0.0722	1.19

Legend:

CURD A-drying at 42ºC CURD B- drying at 45ºC *MFFB- moisture in fat free basis

According to our results, different temperatures have no significant influence on chemical composition of curds. The curd B had only 0.31 % higher total solids. Total solids of curd A and B were 46.50%-50.89% (average 49.09%) and 47.46%-51.18% (average 49.40%), respectively. Coefficients of variations were low (2.58% for curd A and 2.33% for curd B). These values indicate that both data series were homogenous. Also, it can be seen that total solids data were similar to those obtained according to the traditional method for semi-hard cheese production (Pejić, 1956; Walstra et al, 1993). Milk fat content of curd A was 24.00%-28.00% (average value 25.94%) and represented 48.63%- 58.52% of total solids.

Simultaneously, fat content of curd B was 24.00%-29.75% and represented 47.38%-60.84% of total solids. The total solid contents as well as fat contents indicate that cheeses prepared from curd A and B could be classified as full fat cheeses. The protein content of both curds was high. The average protein content of curd A and B was 22.23% and 22.74%, respectively. Total protein represented 45.27% (curd A) and 46.01% (curd B) of total solids. According to these results, the decrease of fat content in milk (for example to achieve the level of 45% in total solids in the cheese) will result in a protein ratio increase. Furthermore, comparing our results those obtained by traditional method, it can be concluded that we obtained higher degree of protein utilization.

The average lactose content of curd A was 1.55%. Curd B had lower lactose content (1.47%). The same effect was registered for ash content. These values were 1.98% and 1.94%, respectively.

According to the aforementioned, it can be concluded that the different drying temperatures without removing part of the whey had no significant influence on chemical composition of the curd.

Conclusion

According to the results of these investigations, it can be concluded that:

Heat treatments at 42°C and 45°C had no significant influence on curd composition;

Total solids content of curd A and B was 46.50%-50.89%, 47.46%-51.18%, respectively;

Moisture in fat- free basis (MFFB) of curd A and Curd B was 68.78% and 68.58%, respectively. This moisture in fat-free basis content by applying other treatments (pressing, salting and ripening), will no doubt provide conditions for classifying these cheeses as semi-hard Dutch-type cheeses.

Fat content in total solids of curd A was 52.90%, protein content 22.23%, lactose content 1.55% and ash content 1.98%. These values for curd B were 53.00%, 22.74%, 1.47%, 1.94%, respectively. The titratable acidity of curd A was 71.70ºT, and pH 6.22. The same parameters for curd B were 75.92ºT and pH 6.07.

According to aforementioned, it can be concluded that by processing of curd made of milk in which coaggregates were formed (cutting, scalding, drying and pressing), moisture in fat- free basis content characteristic of semi-hard cheeses made traditionally can be achieved.

REFERENCES

1. Association of official analytical chemists (AOAC) (1990): Official methods of analysis. 15th ed., Arlington, Virginia, U.S.A.
2. Carić, M., Milovanović, S. and Vucelja, D. (2000): Standardne metode analiza mleka i mlečnih proizvoda, Novi Sad.
3. Cogan, T.M. and Jordan, K.N. (1990): Flavour production by starter cultures in cheese and butter. 2nd Cheese symposium. Ed. by Cogan, T.M., Moorepark, 11-18.
4. Cogan, T.M. and Hill, C. (1993): Cheese starter cultures in Cheese: Chemistry, physics and microbiology. Volume 1. General aspects. Second edition. Chapter 6, 193-255. Ed. by Fox, P.F., Chapman &Hall, London and New York.
5. Engels, W.J.M., Dekker, R., de Jong, C., Neeter, R. and Visser, S. (1997): A comparative study of volatile compounds in the water-soluble fraction of various types of ripened cheese. Int. Dairy J. 7 (4), 255-263.
6. Fox, P.F. and Cogan, T. M. (1990): Production and metabolism of lactate during cheese manufacture and ripening. 2nd Cheese symposium. Ed. by Cogan, T.M., Moorepark, 63-70.
7. Green, M.L. and Grandison, A.S. (1993): Secondary (non-enzymatic) phase of rennet coagulation and post-coagulation phenomena in Cheese: chemistry, physics and microbiology. Volume 1, Chapter 4, 101-140.Second edition. Ed. by Fox, P.F., Chapman & Hall, London.
8. International Dairy Federation (IDF) (1974): Determination of lactose content of milk. IDF Standard 28A.
9. International Dairy Federation (IDF) (1981): Milk. Determination of fat content. Gerber butyrometers. IDF Standard 105.
10. International Dairy Federation (IDF) (1982): Cheese and processed cheese. Determination of the total solids content. IDF Standard 4A.
11. International Dairy Federation (IDF) (1993): Milk. Determination of nitrogen content (Kjeldahl method) and calculation of crude protein content. IDF Standard 20B.
12. Jovanović, S., Maćej, O. and Mikuljanac, A. (1996): Primjena koagregata proteina mlijeka u proizvodnji mekih, polutvrdih i tvrdih sireva. Zbornik radova V medjunarodnog simpozijuma "Savremeni trendovi u proizvodnji mleka". Ur. Obrenović, S., Kopaonik, 94-100.
13. Jovanović, S., Maćej, O. and Denin Djurdjević, J. (2002): Uticaj različitih faktora na sinerezis i reološke karakteristike sireva. Preh. ind. Mleko i mlečni proizvodi, Vol. 13 (1-2), 35-43
14. Kalab, M. (1995): Practical aspects of electron microskopy in cheese research. Chemistry of structure-function relationship in cheese, 247-276. Ed. by Malin, E.L. and Tunick, M.H., Plenum Press, New York.
15. Konings, W.N., Kok, J., Kuipers, O.P. and Poolman, B. (2000): Lactic acid bacteria: the bugs of the new millennium. Review article. Current Opinion in Microbiolog. 3, 276-282.
16. Maćej, O. (1989): Proučavanje mogućnosti izrade mekih sireva na bazi koagregata belančevina mleka. Doktorska disertacija, Univerzitet u Beogradu.

17. Maćej, O. (1992): Proizvodnja mekih sireva na bazi koagregata proteina mleka. Zbornik radova I medjunarodni simpozijum Savremeni trendovi u mlekarstvu. Ur. Maćej, O., Kopaonik, 54-59.
18. Maćej, O. (1994): Proizvodnja kamambera na bazi koagregata proteina mleka. Zbornik radova III medjunarodni simpozijum Savremeni trendovi u mlekarstvu. Ur. Krunić, M. i Žurić, M., Kopaonik, 47-51.
19. Maćej, O. and Jovanović, S. (1998): Uticaj različitih režima termičke obrade na iskorišćenje suve materije mleka. Prehramb. Ind. Mleko i mlečni proizvodi 9 (3-4), 46-50.
20. Maćej, O. and Jovanović, S. (1999): The application of high heat treatment of milk in white brine cheese production. Book of abstracts 2nd Slovenian Congresse "Milk and dairy products", Portorož, 45.
21. Milanović, S. and Carić, M. (2000): Primena biotehnologije u industriji mleka. Arh. poljopr. nauke 61, 211 (1-2), 281-293.
22. Pearse, M.J., Linklater, P.M., Hall, R.J. and Mackinlay, A.G. (1985): Effect of heat induced interaction between β-lactoglobulin and κ-casein on syneresis. J. Dairy Res. 52 (1), 159-165.
23. Pearse, M.J., Linklater, P.M., Hall, R.J. and Mackinlay, A.G. (1986): Effect of casein micelle composition and casein dephosphorylation on coagulation and syneresis. J. Dairy Res. 53 (3), 381-390.
24. Pearse, M. J. and Mackinlay, A.G. (1989): Biochemical aspects of syneresis: a review. J. Dairy Sci. 72 (6), 1401-1407.
25. Pejić, O. (1956): Mlekarstvo II deo. Tehnologija mlečnih proizvoda. Naučna knjiga, Beograd.
26. Pejić, O. and Djordjević, J. (1963): Mlekarski praktikum. Drugo, izmenjeno izdanje. Naučna knjiga, Beograd.
27. Pudja, P. (1992): Karakteristike tvrdih sireva izradjenih od mleka koncentrovanog ultrafiltracijom u zavisnosti od termičke obrade mleka. Doktorska disertacija, Univerzitet u Beogradu.
28. Pudja, P. and Obradović, D. (1994): Uzajamna povezanost tehnoloških i mikrobioloških faktora u proizvodnji sireva. Zbornik radova III medjunarodnog simpozijuma "Savremeni trendovi u mlekarstvu". Ur. Krunić, M. i Žurić, M. Kopaonik, 57-60.
29. Pudja, P., Maćej, O., Jovanović, S., Milčić, M. and Mikuljanac, A. (1995): Iskorišćenje proteina mlečnog seruma u proizvodnji sireva primenom visokih temperatura. Monografija "Osnovna istraživanja u prehrambenoj tehnologiji", Ur: Radovanović, R. M. Beograd, 192-215.
30. Scott, R. (1986): Cheesemaking practice. Second edition. Elsevier Applied Science Publishers Ltd, London and New York.
31. Walstra, P. (1993): The syneresis of curd in Cheese: chemistry, physics and microbiology. Volume 1, Chapter 5, 141-191. Second edition. Ed. by Fox, P.F., Chapman & Hall, London.
32. Walstra, P., Noomen, A. and Geurts, T. J. (1993): Dutch-Type varieties in Cheese: Chemistry, physics and microbiology. Volume 2. Major cheese groups. Second edition. Chapter 2, 39-82. Ed. by Fox, P.F., Chapman &Hall, London and New York.

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UTICAJ RAZLIČITIH TEMPERATURA SUŠENJA SIRNOG ZRNA NA SASTAV SIRNE GRUDE DOBIJENE OD MLEKA U KOME SU OBRAZOVANI KOAGREGATI

Snežana Jovanović,[1] O. Maćej[1] i M. Barać[1]

R e z i m e

U radu je ispitivan uticaj različitih temperatura sušenja sirnog zrna sa ciljem dobijanja sirnog zrna koje je po sastavu karakteristično za polutvrde sireve holandskog tipa. U ogledima je korišćeno mleko kod kojeg je prethodnom termičkom obradom na 87^0C u toku 10 minuta, obrazovan hemijski kompleks izmedju kazeina i serum proteina, poznatih u literaturi kao koagregati proteina mleka.

Sušenje sirnog zrna izvršeno je na temperaturi od 42^0C, i nakon toga obrazovana sirna gruda A, i na temperaturi od 45^0C (sirna gruda B) u vremenu od 60 minuta. Rezultati istraživanja su pokazali da primenjene temperature sušenja nisu imale značajnijeg uticaja na hemijski sastav dobijene sirne grude. Prosečan sadržaj suve materije kod sirne grude A iznosio je 49.09%, sadržaj vode u bezmasnoj materiji sira (VBMS) 68.78%, proteina 22.23%, laktoze 1.55%, pepela 1.98%, titraciona kiselost 71.70^0T i pH 6.22. Prosečan sadržaj suve materije kod sirne grude B iznosio je 49.40%, vode u bezmasnoj materiji sira 68.58%, proteina 22.74%, laktoze 1.47%, pepela 1.94%, titraciona kiselost 75.92^0T i pH 6.07.

Primenom različitih temperatura sušenja sirnog zrna (42ºC i 45ºC), kao i daljim tehnološkim operacijama (presovanje, soljenje i zrenje) obezbedjeni su uslovi za dobijanje sira koji po hemijskom sastavu odgovara polutvrdim sirevima holandskog tipa, proizvedenim na tradicionalan način.

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[1] Dr Snežana Jovanović, docent, dr Ognjen Maćej, redovni profesor, dr Miroljub Barać, docent, Poljoprivredni fakultet, 11081 Beograd-Zemun, Nemanjina 6, Srbija i Crna Gora

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