Annals of Warsaw University of Life Sciences – SGGW
Animal Science No 54 (1), 2015: 15–25
(Ann. Warsaw Univ. of Life Sci. – SGGW, Anim. Sci. 54 (1), 2015)

Changes in cow's milk composition and physical properties during the uninterrupted milking process

EDWARD DYMNICKI[1], MARCIN GOŁĘBIEWSKI[2], AGATA WÓJCIK[2], KAMILA PUPPEL[2], BEATA KUCZYŃSKA[2], EWA SOSIN-BZDUCHA[4], TADEUSZ SZULC[3]

[1] Department of Animal Science, Institute of Genetics and Animal Breeding, Polish Academy of Science

[2] Department of Cattle Breeding, Warsaw University of Life Sciences – SGGW

[3] Department of Cattle Breeding and Milk Production, Wroclaw University of Environmental and Life Sciences

[4] Departament of Animal Genetic Resources Conservation, National Research Institute of Animal Production

Abstract: *Changes in cow's milk composition and physical properties during the uninterrupted milking process*. The chemical composition of milk determines the nutritional value and technological properties of milk and dairy products. Many studies have been performed on the chemical composition of milk, including fatty acid and protein profile, however a limited number of investigations have determined the changes in chemical composition of the milk during the milking process. Experiment were designed to study changes in milk chemical composition (i.e. fat, protein, casein, lactose, urea, citric acid, total solids – TS, solids-non-fat – SNF, free fatty acids – FFA, as well as acidity, density, freezing point and somatic cell score) during the uninterrupted milking. Fifty two cows (455 samples) of three different breeds; with daily production 5–12 kg; were sampled during interrupted milking process. Representative sample were collected from each kg of milked liquid. There were significant ($P \leq 0.01$) changes in fat, FFA, lactose, TS and density of milk during milking. The concentration of fat, FFA, and TS shown increasing tendency with the course of milking, however, lactose and density presented opposite trends. Therefore, obtaining the whole quantity of milk from udder during the milking process, beside shaping the health status, is an indispensable step to produce milk of the highest quality in terms of its nutritional and technological value.

Key words: milking process, milk composition, cow's milk, fat

INTRODUCTION

Raw milk and dairy products are very important components of human diet in many part of the world. The chemical composition of raw milk determines the nutritional value and technological properties of milk and dairy products. Therefore, the chemical milk composition is of great importance for dairy industry and there is a great need for changing the composition of raw milk. Numerous studies have been carried out to investigate the influence of different factors on cow's milk chemical composition (Glantz et al. 2009, Kuczyńska, 2011, Sakowski et al. 2012). The milk chemical composition strongly depends upon the season (Lindmark-Månsson et al. 2003, Lock and Garnsworthy 2003, Nałęcz-Tarwacka and Grodzki 2005), stage of lactation (Kuchtík et al. 2008, Puppel et al. 2012), feeding (Friggens et al. 2007, Kuczyńska et al. 2012), health status (Wielgosz-Groth and Groth 2003, Batavani et al. 2007) of the cow as well as and genetic factors (Fox and McSweeney 1998, Stoop et al. 2008a, Stoop et al. 2008b). Each milk compound can be affected by the same factors. When determining raw milk composition it is also important to realize the interaction between the feeding systems, management practices and breed (Heck et al. 2009).

Over the last years, many studies have been performed on the chemical composition of milk, including fatty acid and protein profile (Wedholm et al. 2006, Soyeurt and Gengler 2008) as well as its influence on human health (Roche et al. 2001). However a limited number of investigations have determined the changes in chemical composition of the milk during the milking. Mostly, the fat fraction of milk have been investigated (Whittlestone 1953, Kernohan et al. 1971, Ontsouka et al. 2003), and other milk compounds have been rarely analyzed (Dobicki et al. 1993, Lollivier et al. 2002, Vangroenweghe et al. 2002). Typically, changes in cow's milk constituents during the milking have been examined by analyzing certain fraction (e.g. beginning, middle and end of the milking) and not sampled during the whole milking process (Nielsen et al. 2005). Probably, the reason for that was the equipment limitation which not allowed to sample milk (e.g. representative sample of each liter of milk) during uninterrupted milking.

Therefore, the aim of the study was to investigate changes in milk chemical composition during the uninterrupted milking.

MATERIAL AND METHODS

Animals and treatment

Fifty two cows were used in the experiment of which 18 represented Polish Holstein-Friesian (PHF) breed; 17 to Polish Red (PR) and 17 to Polish Black and White (PBW) breed. The animals originated from two different farms: all PHF cows belonged to Institute of Technology and Life Sciences located in Falenty near Warsaw, PR and PBW belonged to Research Station of Organic Farming and Animal Breeding in Popielno. For the experiment purposed the chosen cows varied in terms of their productivity (5–12 kg of milk per milking). In both farms cows were housed in a tie stall system in accordance with standards of animal welfare developed by Polish Ministry of Agriculture and Rural Development. The lactation number as well as lactation stage differ within the group of studied cows; 2–4 lactation and 90–200 day in milk (DIM), respectively. Cows were milked twice a day. All cows were healthy and had continuous access to water. The cows were fed individually in accordance with their requirements, stage of lactation and physiological status. Feeding rations were balanced according to the INRA system (INRA 2009). The diet composition is presented in Table 1.

The procedures involving animals were approved by the Local Commission for Animals Ethics concerning animal experimentation and care of experimental animals.

TABLE 1. Diet and chemical composition of the cow' diet

Item	Treatment[a]	
	PHF cows	PR and PBW cows
Maize corn silage	24.0	–
Corn silage	3.50	–
Grass silage	–	30
Hay	–	6
Soybean meal (46% C.P.)	0.7	–
Pasture ground chalk	0.1	0.1
Premix[a]	0.14	0.05
Salt	0.05	0.02
Rapeseed meal	2.0	–
Ground triticale	–	1.5
Magnesium oxide	0.05	–
Chemical composition		
Dry matter (% of DM)	57.5	67.2
Ash (% of DM)	4.2	6.45
Crude protein (% of DM)	7.5	5.75
Acid detergent fiber (% of DM)	27.9	33.7
Neutral detergent fiber (% of DM)	33.7	41.6
Calcium (% of DM)	0.9	0.7
Phosphorus (% of DM)	0.5	0.6
Crude fiber (% of DM)	4.36	4.56
UFL (% of DM · kg of DM^{-1})	1.10	1.16

[a] Contained (on 1000 g): Ca – 150 g, P – 100 g, Na – 50 g, Mg – 40 g, Zn – 9000 mg, Mn – 7000 mg, Cu – 1000 mg, J – 100 mg, Se – 50 mg, vitamin A – 1,200,000 IU, vitamin D3 – 120,000 IU, vitamin E – 5 000 mg, vitamin K – 93 mg, vitamin B1 – 80 mg, vitamin B6 – 160 mg, vitamin B2 – 110 mg, vitamin B12 – 1000 μg.
C.P. – crude protein.

Sampling

Milk samples were collected between April and June of 2012 once from each of studied cow. All samples were collected from evening milking. Before collecting standard procedures of cow and udder preparing were maintained. The teats were cleaned with the cloth and the first squirt of milk was discarded. Before attaching milking tubes to udder milking cluster was connected to De Laval (Milkocsope MK II-KG-Scale) milk sampler. During the interrupted milking representative sample (50 ml) of milk from each kg of milked liquid was pooled out. As the milk yield of studied cows varied from 5 to 22 kg five to twenty samples were collected from each cow. The milk samples were placed in the sterile bottles containing milk preserver – Microtabs II (Bentley). Immediately after milking, samples were delivered to the laboratory of Institute of Genetics and Animal Breeding for chemical examination. Totally, 455 samples were collected.

Chemical analysis

The concentration of standard chemical compounds of the milk, i.e. fat, protein, casein, lactose, urea, citric acid, total solids (TS), solids-non-fat (SNF), free fatty acids (FFA), as well as acidity, density, freezing point and somatic cell score were determined by automated infrared analysis with a Milkoscan 6000 instrument (FossElectric). MilkoScan employs the FTIR measuring principle, in compliance with IDF and AOAC standards.

Evaluation of somatic cell count (SCC) of the milk was proceeded on Fossomatic 5000 (Bentley). Than SCC was transformed to somatic cell score (SCS) by natural logarithm.

Statistic analysis

The data were performed to multi-factor analysis of variance (least square means) by IBM SPSS Statistics 19.0 software. The level of significance was set at $P \leq 0.05$ or $P \leq 0.01$. The model used to analyze influence of collecting number and milk yield on milk compounds was as follows:

$$Y_{ijk} = \mu + A_i + B_j + (A_i \times B_j) + e_{ijk}$$

where:

Y_{ijk} – dependent variable;
μ – general mean;
A_i – effect of collecting (i = 1 – collected from 1st kg of milk, …, 12th and beyond 12th kg of milk);
B_j – effect of yield (1–5 kg milking yield, …, 10 and beyond 14 kg milking yield);
$(A_i \times B_j)$ – fixed interaction effect between collecting and yield;
e_{ijk} – random error.

To present the tendency in changes of milk components the exponential tendency line has been drown.

Only chemical compounds of milk which were significantly affected by collecting and milking yield were the subject of further investigation. No effect of consequent sampling and milking yield on protein, casein, urea, citric acid, freezing point, acidity and somatic cell score was observed.

RESULTS AND DISCUSSION

The average production and milk composition of the cows is presented in Table 2.

The fat concentration in raw milk of cows tend to change during the milking process (Fig. 1). The lowest level of fat was observed in milk at the beginning of milking, however the lowest value was noted in second collecting (from the 2nd kg of milk). The difference between the lowest and the highest level of milk fat was over 30 $g \cdot kg^{-1}$. The average increasing rate of raw milk fat fluctuated at 23 $g \cdot kg^{-1}$ per collecting. Whittlestone (1953), noted that fat content in fore milk was much lower than obtain in our study and was established at 16 $g \cdot kg^{-1}$ and in stripping milk was 89 $g \cdot kg^{-1}$. The author suggested that the trends towards increasing fat content during milking may be explained by the clustering of the fat globules as the consequence of the partial filtration of the globule clusters as the milk flows from the glands.

There was significant ($P \leq 0.01$) influence of the milk production on fat concentration in raw milk (Fig. 2), however the tendency was unclear. It is well known that there is the negative correlation between the fat concentration and

TABLE 2. The mean values for analyzed traits

Trait	N	Mean	SD	Min	Max
Milk (kg)	455	10.19	4.21	5.00	22.00
Fat (g·kg^{-1})	438	41.2	15.9	5.0	113.9
Protein (g·kg^{-1})	438	32.0	4.7	22.5	43.6
Casein (g·kg^{-1})	284	23.5	2.9	13.1	31.3
Lactose (g·kg^{-1})	438	47.9	2.8	3.5	53.9
Total solids, TS (g·kg^{-1})	438	128.7	16.2	91.7	189.6
Solids-non-fat, SNF (g·kg^{-1})	284	89.3	4.0	76.3	98.9
Urea (mg·1^{-1})	438	217.97	73.12	63.00	478.00
Citric acid (g·kg^{-1})	284	1.91	0.49	0.01	2.90
Freezing point (m°C)	284	584.35	20.70	545.00	702.00
Fry fatty acids (mmol·100 g^{-1})	284	0.93	0.79	0.01	4.91
Density (g·cm^{-3})	284	1.026	0.002	1.017	1.034
Acidity (°SH)	284	19.95	5.02	12.00	38.00
Somatic cell score (ln SCC·10^{-3})	154	4.97	1.15	2.40	8.65

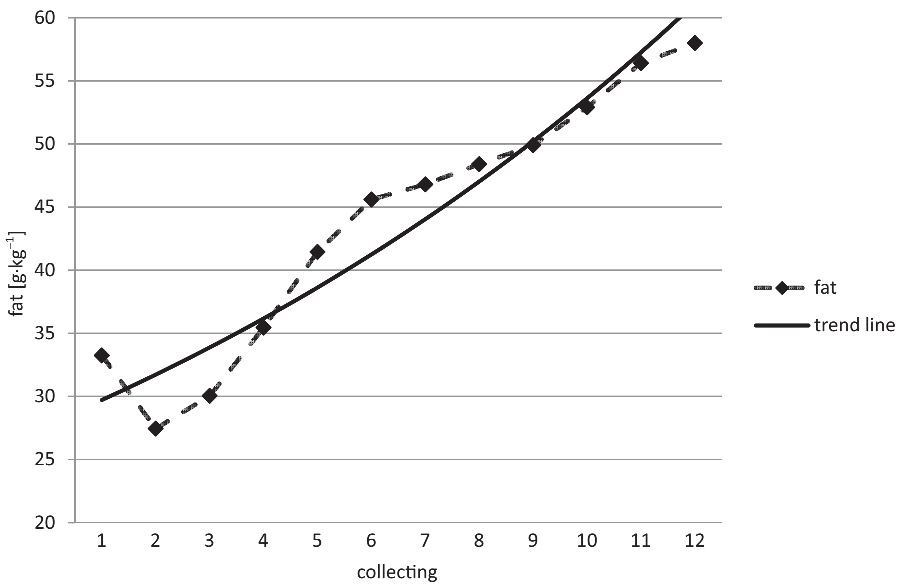

FIGURE 1. Changes in fat concentration during milking

milk production (Gaydarska et al. 2001), however some authors have found opposite relation (Chaunan and Hayes 1991). The highest level of milk fat was observed in milk of cows producing 7 kg of milk a milking and the lowest in milk of high yielding cows (above 14 kg of milk per milking). The difference between the highest and the lowest level was over 10 g·kg^{-1}.

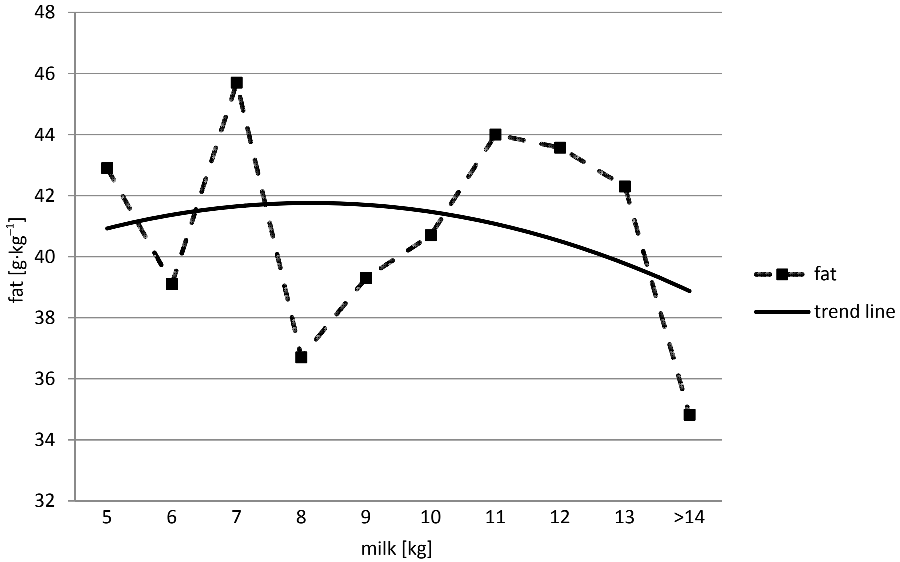

FIGURE 2. Influence of the milking yield on fat concentration in cow's milk

Whittlestone (1953), confirmed that the rise in fat percentage is the greatest in cows producing a large amount of milk, or milking with long intervals. Moreover, he stated that the increase in fat content results mainly from the increased number of milk fat globules. Results obtained by Dobicki et al. (1993), shown that fat content was 2.88 and 5.79% at the milk yield of 6 kg and 1.92 and 6.71% at the milk yield 12 kg (in the single milking – the first and the last liter of milk, respectively). According to Lollivier et al. (2002), the concentration of milk fat increases with the course of milking; milk removed at the beginning of a milking, corresponding to the cisternal milk, is less rich in milk fat than milk removed at the end of milking, corresponding to the alveolar milk. The explanation of the phenomenon revealed Guinard-Flament et al. (2001), who stated, that milk fat globules are transferred from the alveoli to the cistern during machine milking as a result of oxytocin-mediated milk ejection.

An interesting results reported Froberg et al. (2007) who observed low fat content in milk of suckler cows after isolation or weaning of their calves. Dymnicki and Sosin-Bzducha (2012), reported that milk of PR cows milked mechanically after 12 hours of their calves isolation characterized by a very low fat content (0.55–0.87%) depending on the lactation stage. Similar results obtained Combellas and Tesorero (2003), and Marin et al. (2007).

Similar to fat concentration tendencies of free fatty acids changes in milk during milking were stated (Fig. 3). The increasing rate was equal to 0.04 mmol·100 g^{-1} of fat. However, the higher than in fat content variation in the concentration of FFA was observed. The pick of the FFA concentration was reported at the 11^{th} collection and its lowest level at 2^{nd} collecting (79% between extremes).

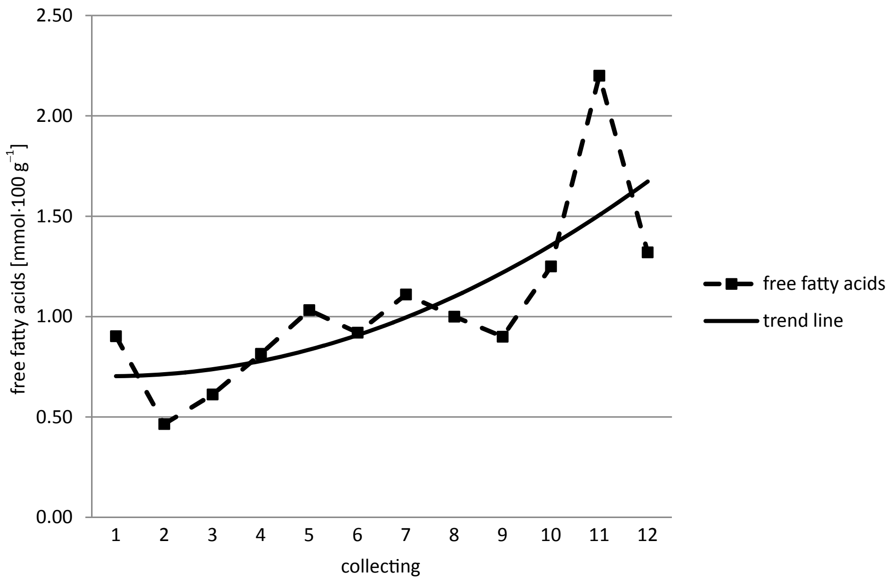

FIGURE 3. Changes in free fatty acids concentration during milking

The level of lactose in milk of studied cows was strongly affected by collecting number (Fig. 4). The changes in lactose concentration during milking can be compared to shape of the standard lactation curve and the tendency line was opposite to that observed in fat. The highest level of lactose was observed in 2nd kg of milk (2nd collection) and the lowest at 12th collection. Difference

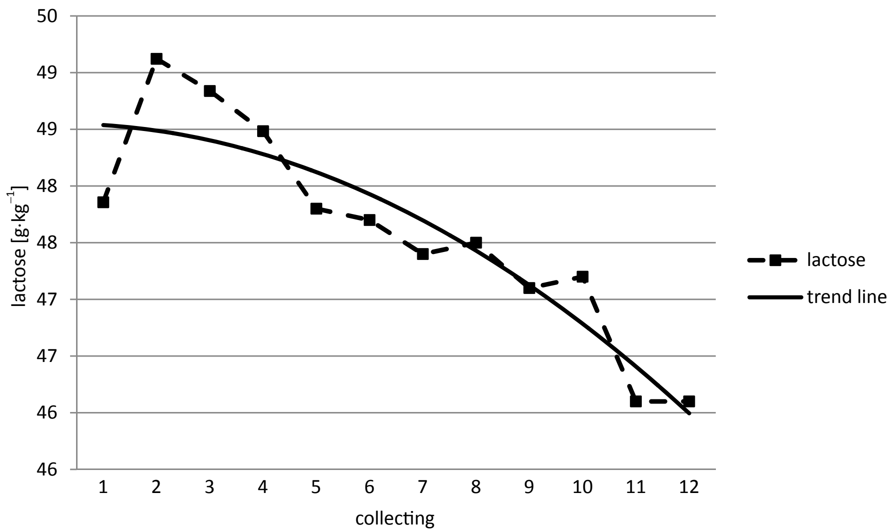

FIGURE 4. Changes in lactose concentration during milking

between extremes was fluctuated at 3.0 $g \cdot kg^{-1}$. With the course of milking lactose level in raw milk dropt with the rate of 0.2 $g \cdot kg^{-1}$ per collecting.

The results of other authors differed significantly. According to Dobicki et al. (1993) and Bruckmaier et al. (2004) there were no differences in percentage of protein and lactose between the first and the last squirts of milk during the milking. However Vangroenweghe et al. (2002) observed that the lactose and protein content in raw milk was lower in post-striping compared to fore milk. Moreover, lactose concentration also strongly depends upon the health status of mammary gland and is synthesized exclusively by udder epithelial cells. In case of mastitis lactose partially leaks into blood circulation through the damaged blood vessels and its concentration in milk decreases (Bruckmaier et al. 2004).

Total solids concentration in milk during milking was changed ($P \leq 0.01$) with following collection (Fig. 5). The highest level was observed at 11th sample and the lowest at the 2nd with the difference between ambivalent values equal to 29.8 $g \cdot kg^{-1}$. Clear increasing tendency for TS content during milking was noted (increasing rate – 0.2 $g \cdot kg^{-1}$).

The highest density was observed at the beginning of milking and the its lowest value at the end of the process (Fig. 6). However, the difference between the highest and the lowest values were small and equal to 1.06 $g \cdot cm^{-3}$. The tendency of raw milk density changes were similar to those observed in lactose concentration. Decreasing rate was equal to 0.21 $g \cdot cm^{-3}$ per collecting.

The results of the research shown linear relationship between consequent sample of milk and concentration of milk components. Fat, free fatty acids, total

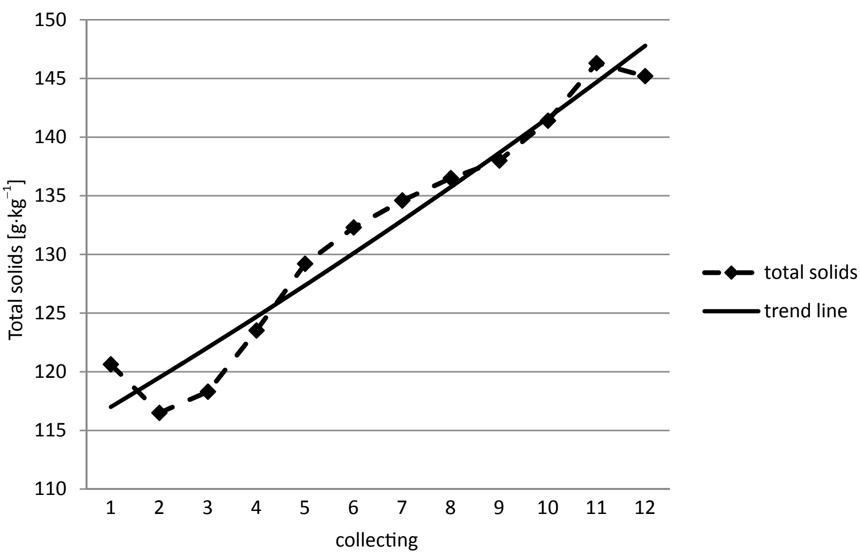

FIGURE 5. Changes in dry matter total solids concentration during milking

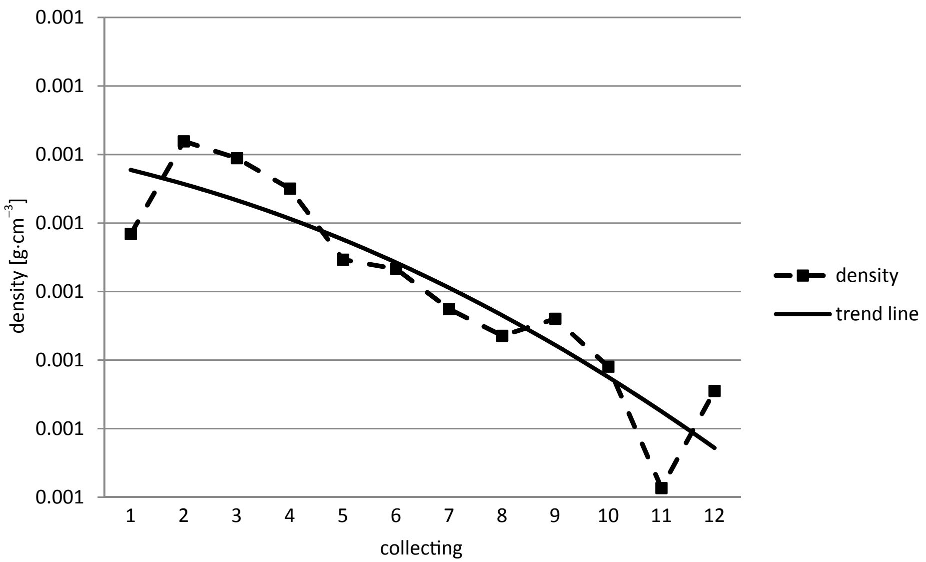

FIGURE 6. Changes in milk density during milking

solids contents were increasing, lactose decreasing and protein content shown no changes. From physical properties of milk only density was changing during milking process. Therefore, obtaining the whole quantity of milk from udder during the milking process, beside shaping the health status, is an indispensable step to produce milk of the highest quality in terms of its nutritional and technological value.

REFERENCES

BATAVANI R.A., ASRI S., NAEBZADEH H., 2007: The effect of subclinical mastitis on milk composition in dairy cows. Iranian J. Vet. Res. 8: 205–2011.

BRUCKMAIER R.M., ONTSOUKA C.E., BLUM J.W., 2004: Fractionized milk composition in dairy cows with subclinical mastitis. Vet. Medicine – Czech 49: 283–290.

CHAUNAN V.P.S., HAYES J.F., 1991: Genetic Parameters for First Lactation Production and Composition Traits for Holsteins Using Multivariate Restricted Maximum Likelihood. J. Dairy Sci. 74 (2): 603–610.

COMBELLAS J., TESORERO M., 2003: Cow – calf relationship during milking and its effect on milk yield and calf live weight gain. Livestock Res. Rural Development 15 (3): 1–10.

DOBICKI A., ASUQUO I.B., ADAMSKI M., 1993: Zmienność składu mleka krów w kolejnych porcjach udojonego mleka. Przegląd Hodowlany 4: 11–14.

DYMNICKI E., SOSIN-BZDUCHA E., 2012: Effects of calves separation and injection of oxytocin on milk composition of the Polish Red cows. Proceedings of the LXXVII Zjazd Naukowy Polskiego Towarzystwa Zootechnicznego, September 10–12, Wroclaw. Book of Abstracts: 32.

FOX P.F., McSWEENEY P.L.H., 1998: Dairy Chemistry and Biochemistry. Blackie Academic and Professional, London.

FRIGGENS N.C., RIDDER C., LØVENDAHL P., 2007: On the Use of Milk Composition Measures to Predict the Energy Balance of Dairy Cows. J. Dairy Sci. 90: 5453–5467.

GAYDARSKA V., KRUSTEV K., SIMEONOVA S., IVANOV M., 2001: Influence of environmental and genetic factors on the milk yield and phenotypic and genotypic parameters of milk production in Black-and-White dairy cows in Bulgaria. Biotechnology in Animal Husbandry 17: 11–15.

GLANTZ M., LINDMARK M., STÅLHAMMAR H., BÅRSTRÖM L., FRÖJELIN M., KNUTSSON A., TELUK C., PAULSSON M., 2009: Effects of animal selection on milk composition and processability. J. Dairy Sci. 92: 4589–4603.

GUINARD-FLAMENT J., MICHALSKI M.C., RULQUIN H., 2001: Evolution of milk fat content and fat globule diameter according to milking time in dairy cows. Renc. Res. Rum Paris, France.

HECK J.M.L., Van VALENBERG H.J.F., DIJKSTRA J., Van HOOIJDONK A.C.M., 2009: Seasonal variation in the Dutch bovine raw milk composition. J. Dairy Sci. 92: 4745–4755.

KERNOHAN E.A., WADSWORTH J.C., LASCELLESA A.K., 1971: Changes in the composition of bovine milk fat during milking. J. Dairy Res. 38: 65–68.

KUCHTÍK J., ŠUSTOVÁ K., URBAN T., ZAPLETAL D., 2008: Effect of the stage of lactation on milk composition, its properties and the quality of rennet curdling in East Friesian ewes. Czech J. Animal Sci. 53: 55–63.

KUCZYŃSKA B., 2011: Bioactive components and technological parameters of milk produced at ecological and conventional farms. Warsaw University of Life Sciences Press, Warsaw.

KUCZYŃSKA B., PUPPEL K., GOŁĘBIEWSKI M., KORDYASZ M., GRODZKI H., BRZOZOWSKI P., 2012: Comparison of fat and protein fractions of milk constituents in Montbeliarde and Polish Holstein-Friesian cows from one farm in Poland. Acta Vet. Brno 81: 139–144.

LINDMARK-MÅNSSON H., FONDÉN R., PETTERSSON H.E., 2003: Composition of Swedish dairy milk. Inter. Dairy J. 13: 409–425.

LOCK A.L., GARNSWORTHY P.C., 2003: Seasonal variation in milk conjugated linoleic acid and delta(9)-desaturase activity in dairy cows. Liv. Production Sci. 79: 47–59.

LOLLIVIER V., GUINARD-FLAMENT J., OLLIVIER-BOUSQUET M., MARNET P., 2002: Oxytocin and milk removal: Two important sources of variation in milk production and milk quality during and between milkings. Reproduction Nutrition Development 42: 173–186.

MARIN B., BERG C., HERNÁNDEZ C., GALINA C.S., LIDFORS L., SVENNERSTEN-SJAUNJA K., 2007: Effect of restricted suckling on milk yield, milk composition and udder health in cows and behavior and weight gain in calves, in dual-purpose cattle in the tropics. Tropical Animal Health and Production 39: 71–81.

NAŁĘCZ-TARWACKA T., GRODZKI H., 2005: Influence of early spring feeding on fatty acid levels of cow's milk. Polish J. Food Nutrition Sci. 1: 67–70.

NIELSEN N.I., LARSEN T., BJERRING M., INGVARTSEN K.L., 2005: Quarter health, milking interval, and sampling time during milking affect the concentration of milk constituents. J. Dairy Sci. 88: 3186–3200.

ONTSOUKA C.E., BRUCKMAIER R.M., BLUM J.W., 2003: Fractionized milk composition during removal of colostrum and mature milk. J. Dairy Sci. 86: 2005–2011.

PUPPEL K., NAŁĘCZ-TARWACKA T., KUCZYŃSKA B., GOŁĘBIEWSKI M., GRODZKI H., 2012: Influence of combined supplementation of cow's diet with linseed and fish oil on thrombogenic and atherogenic indicators of milk fat. Animal Sci. Papers and Reports 30 (4): 317–328.

ROCHE H.M., NOONE E., NUGENT A., GIBNEY M.J., 2001: Conjugated linoleic acid: A novel therapeutic nutrient? Nutrition Research Reviews 14: 173–187.

SAKOWSKI T., KUCZYŃSKA B., PUPPEL K., METERA E., SŁONIEWSKI K., BARSZCZEWSKI J., 2012: Relationships between physiological indicators in blood, and their yield, as well as chemical composition of milk obtained from organic dairy cows. J. Sci. Food Agric. 92 (14): 2905–2912.

SOYEURT H., GENGLER N., 2008: Genetic variability of fatty acids in bovine milk. Biotechnology, Agronomy, Society and Environment 12: 203–210.

STOOP W.M., BOVENHUIS H., Van ARENDONK J.A.M., 2008a: Genetic parameters for milk urea nitrogen in relation to milk production traits. J. Dairy Sci. 90: 1981–1986.

STOOP W.M., Van ARENDONK J.A.M., HECK J.M.L., Van VALENBERG H.J.F., BOVENHUIS H., 2008b: Genetic parameters for major milk fatty acids and milk production traits of Dutch Holstein friesians. J. Dairy Sci. 91: 385–394.

VANGROENWEGHE F., DOSOGNE H., BURVENICH C., 2002: Composition and milk cell characteristics in quarter milk fractions of dairy cows with low cell count. Vet. Journal 164: 254–260.

WEDHOLM A., HALLÉN E., LARSEN L.B., LINDMARK MÅNSSON H., KARLSSON A.H., ALLMERE T., 2006: Comparison of milk protein composition in a Swedish and a Danish dairy herd using reversed phase HPLC. Acta Agric. Scandinavica, Sect A 56: 8–15.

WHITTLESTONE W.G., 1953: Variation in the fat content of milk throught the milking process. J. Dairy Sci. 20: 146–153.

WIELGOSZ-GROTH Z., GROTH I., 2003: Effect of the udder health on the composition and quality of quarter milk from black and white cows. Electronic J. Polish Agric. University 6 (2): 2–5.

Streszczenie: *Zmiany w składzie mleka krowiego podczas nieprzerwanego doju.* Skład chemiczny mleka określa wartość odżywczą i właściwości technologiczne mleka i produktów mlecznych. Przeprowadzono wiele badań dotyczących składu chemicznego mleka, profilu kwasów tłuszczowych i zawartości białek. Jednak istnieje mało badań, które dotyczyłyby zmian w składzie chemicznym mleka w trakcie procesu dojenia. Celem badań było określenie zmian w składzie chemicznym mleka (czyli tłuszcz, białko, kazeina, laktoza, mocznik, kwas cytrynowy, sucha masa – s.m., sucha masa beztłuszczowa – s.m.b., wolnych kwasów tłuszczowych – FFA oraz kwasowość, gęstość, punkt krzepnięcia i liczba komórek somatycznych) podczas nieprzerwanego doju. Badania przeprowadzono na 52 krowach (3 różnych ras) o średniej dziennej produkcji mleka wynoszącej 5–12 kg. Ogółem pobrano 455 próbek mleka. Reprezentatywne próbki pobierano z każdego kolejnego udojonego kilograma mleka. Stwierdzono istotne ($P \leq 0{,}01$) zmiany w zawartości tłuszczu, FFA, laktozy, TS i gęstości mleka podczas dojenia. Koncentracja tłuszczu, FFA i TS wykazały tendencję wzrostową w trakcie dojenia, jednak laktoza i gęstość wykazały trend odwrotny. Pozyskanie całej ilości mleka z wymion podczas procesu dojenia, obok kształtowania stanu zdrowia, jest więc niezbędnym krokiem w kierunku produkcji mleka najwyższej jakości pod względem jego wartości odżywczej i technologicznej.

MS received May 2015

Authors' address:
Marcin Gołębiewski
Zakład Hodowli Bydła
Katedra Szczegółowej Hodowli Zwierząt
Wydział Nauk o Zwierzętach SGGW
02-786 Warszawa, ul. Ciszewskiego 8, Poland
e-mail: marcin_golebiewski@sggw.pl