POLISH JOURNAL OF FOOD AND NUTRITION SCIENCES
Pol. J. Food Nutr. Sci. 2006, Vol. 15/56, SI 1, pp. 61–64

COMPARISON OF SOME PHYSICOCHEMICAL PROPERTIES OF MILK FROM HOLSTEIN-FRIESIAN AND JERSEY COWS

Maria Czerniewicz, Katarzyna Kiełczewska, Antoni Kruk

Chair of Dairy Science and Quality Management, University of Warmia and Mazury, Olsztyn

Key words: milk from Holstein-Friesian cows, milk from Jersey cows, hygienic quality, chemical composition, physicochemical properties

The hygienic quality and physicochemical properties of raw milk from Holstein-Friesian and Jersey cows were determined in the study. It was found that the total bacterial count and the somatic cell count in milk samples were within the threshold limit values specified by relevant legal regulations. Milk from Jersey cows contained much higher levels of dry matter, which resulted primarily from higher concentrations of protein compounds (by approx. 19%), both casein and whey proteins, as well as fat (by approx. 50%), as compared with milk from Holstein-Friesians. The levels of all analysed calcium forms (total, colloidal, soluble, ionic) were higher in milk from Jersey cows than in milk from Holstein-Friesian cows. The characteristics of the dispersion state of fat globules showed that their average diameters were greater (by approx. 24%) in milk from Jersey cows, in comparison with milk from Holstein-Friesians. The levels of lactose and milk properties, *i.e*. acidity, density, conductivity and freezing temperature, were similar in both cow breeds.

INTRODUCTION

The quality of raw milk is a term with a very broad meaning. It encompasses such milk characteristics as chemical composition, physical properties, microbiological and cytological quality, sensory properties, technological suitability and nutritive value. It is very difficult to assure high quality and desirable physicochemical properties of raw milk designed for processing, since this is dependent upon numerous factors, including genetic ones (*e.g.* breed). A number of authors have demonstrated that differences in the chemical composition and physicochemical properties of milk from cows of various breeds are determined genetically [Boland, 2003; Nickerson, 1999]. Selection in terms of milk composition is directed towards increasing protein concentration and the protein:fat ratio. Jersey cows outclass other dairy breeds as regards the levels of milk protein, milk fat, calcium and vitamins [Frąckowiak, 2004; Antkowiak *et al.*, 2004], but the value of the protein:fat ratio is lower in their milk than in milk from cows of other dairy breeds [Boland, 2003].

The aim of the present study was to compare the hygienic quality, chemical composition and physicochemical properties of milk from Holstein-Friesian and Jersey cows.

MATERIALS AND METHODS

The experimental materials comprised milk samples collected from 123 Holstein-Friesian (HF) cows and 36 Jersey (Je) cows at the Research Station of the University of Warmia and Mazury in Olsztyn in the fall, winter and spring (from November to April). The samples were taken 20 times. Chilled (temp. +4°C) and preserved (1 mL of a 2% NaN_3 solution per 1 L milk) milk samples were transported in thermal bags to the laboratory. The hygienic quality of milk was determined based on the total bacterial count (TBC), estimated with the Bactoscan 8000S apparatus, and the somatic cell count (SCC), estimated with the Fossomatic 5000 apparatus. The physicochemical characteristics of milk included the determination of the chemical composition, *i.e.* the concentrations of non-fat solids, fat and lactose – using the Milkoscan 4000 apparatus, and total protein, casein and whey proteins [Budsławski, 1973]. The levels of total and soluble calcium (in the supernatant obtained by ultracentrifugation of milk at 35°C and centrifugal acceleration of 68 000 g for 35 min using a centrifuge, model MLW UP 65, as described by Thompson *et al.* [1969]) were determined by the complexometric method proposed by Satia & Raadsveld [1969]. Ionic calcium was determined using an ionometer, model WTW inoLab pH/ION Level 2. Milk properties measured in the experiment included: active acidity – with a pH-meter, type WTW inoLab pH Level 1; potential acidity [Budsławski, 1973]; conductivity – with a conductometer, type WTW inoLab Cond Level 1; freezing temperature – with a cryoscope, type 800cl (Trident Med); and density – by the aerometric method [Budsławski, 1973]. The size of milk fat globules was estimated by the microscopic method in samples prepared according to the Polish Standard PN-A-86059:1975. Microscopic observations permitted to determine the size distribution of milk fat globules in the samples, and to calculate their volume-surface average diameters (d_{vs}), the sur-

Author's address for correspondence: Katarzyna Kiełczewska, Chair of Dairy Science and Quality Management, University of Warmia and Mazury in Olsztyn, ul. Heweliusza 1, 10-957 Olsztyn, Poland; tel.: (48 89) 523 32 11; fax: (48 89) 523 34 02; e-mail: kaka@uwm.edu.pl

face area of 1 mL fat and the surface area of fat globules in 1 mL milk.

RESULTS AND DISCUSSION

The results of the study showed that milk obtained from Holstein-Friesian and Jersey was characterised by good microbiological quality (TBC 8.4×10^4 cfu/mL and 7.6×10^4 cfu/mL, respectively) and cytological quality (SCC 122×10^3/mL and 138×10^3/mL, respectively), corresponding to the relevant standards established for raw milk, specified in the Regulation by the Minister of Agriculture and Rural Development of May 18, 2005 (Dz. U. nr 96, poz. 819).

An analysis of the chemical composition of milk indicated that milk from Jersey cows contained much higher levels of dry matter, which resulted primarily from higher concentrations of protein compounds (by approx. 19%), both casein (by approx. 21%) and whey proteins (by approx. 13%), as well as fat (by approx. 50%), as compared with milk from Holstein-Friesians (Table 1). According to literature data [Boland, 2003; Nickerson, 1999; Frąckowiak, 2004; Skrzypek, 2001], the percentages of dry matter components, especially fat and protein, are higher in milk from Jersey cows than in milk from Holstein-Friesian cows. In our experiment the dry matter content of milk, including the levels of protein compounds (both casein and whey proteins), and especially fat, was found to be significantly higher than reported previously [Boland, 2003; Nickerson, 1999]. According to Skrzypek [2001] and Frąckowiak [2004], milk from Jersey cows contains by 20 to 50% more protein and fat. These authors stressed the fact that the production of milk protein and milk fat per head is the same in Jersey and Holstein-Friesian herds although Jersey cows have lower body weights and milk yields, compared with Holstein-Friesians.

Breed affects genetically determined polymorphism of major milk proteins, and composition of milk fat [Boland, 2003]. Milk from Jersey cows is distinguished by specific frequency of genetic variants of proteins, mainly β-casein B%and κ-casein B [Boland 2003]. Dalgleish [1995] demonstrated that the B variant of κ-casein is observed in milk with an increased casein content, elevated levels of the κ fraction and smaller micelles. Anema & Creamer [1993] also pointed to the higher κ-casein content and smaller size of casein micelles, as well as the higher degree of their hydration in the case of the variant B of κ-casein in cow's milk. The increase in the κ-casein B content of milk contributes to the reduction in the size of casein micelles, and enhances their hydration. This may affect the key technological properties of milk [Dalgleish, 1995]. Milk containing κ-casein B is more suitable for cheese production than milk containing κ-casein A [Devold *et al.*, 1995].

The results concerning the calcium content of milk show that the concentrations of all forms of this element were higher in Jersey cows (total Ca – by approx. 36%, colloidal Ca – by approx. 46%, soluble Ca – by approx. 19% and ionic Ca – by approx. 16%) than in Holstein-Friesian cows. It was also found that the proportions of colloidal Ca and soluble Ca were similar in milk samples from cows of both breeds. Frąckowiak [2004] reported that the calcium content of milk from Jersey cows was by 15% higher, compared with milk from cows of other breeds. Both the higher concentration of proteins, especially casein, and protein polymorphism characteristic of milk from Jersey cows, as well as the high calcium content, confirm the suitability of this raw material for cheese production.

The characteristics of milk fat dispersion in the samples analysed, based upon the results of microscopic observations and calculations, show that the fat contained in milk from Jersey cows has the form of bigger globules that the fat found in milk from Holstein-Friesians. In milk from Holstein-Friesian cows about 23% of fat globules are $1<x\leq2\,\mu$m in diameter, whereas in milk from Jersey cows approx. 20% of fat globules are $3<x\leq4\,\mu$m in diameter (Figure 1). The values of arithmetic means and volume-surface average diameters of fat globules were by approx. 24% higher in milk from Jersey cows that in milk from Holstein-Friesians. The surface area of 1 mL milk fat was also smaller in the former (Table 2). Cow breed affects not only the fat content of milk and the size of fat globules, but also the composition of fatty acids [Boland, 2003]. The size of milk fat globules increases along with an increase in the fat content of milk [Wiking *et al.*, 2004]. In addition, this factor affects the physicochemical properties of fat, including the composition of fatty acids [Michalski, 2004]. The differences in the composition of milk fat of Jersey and Holstein-Friesian

TABLE 1. Chemical composition of milk from Holstein-Friesian and Jersey cows. Mean values (n=20).

Parameter	Milk from					
	Holstein-Friesian cows			Jersey cows		
	$\bar{X}$	δ	v (%)	$\bar{X}$	δ	V (%)
Water (%)	86.07	0.65	0.8	83.12	1.25	1.5
Dry mater (%)	13.94	0.40	2.9	16.88	1.24	7.3
Non-fat solids (%)	9.25	0.17	1.8	9.86	0.34	3.4
Fat (%)	4.69	0.57	12.2	7.02	1.08	15.4
Lactose (%)	4.82	0.14	2.9	4.70	0.16	3.4
Total protein (%)	3.62	0.15	4.1	4.32	0.16	3.7
Casein (%)	2.72	0.12	4.4	3.30	0.27	8.2
Whey proteins (%)	0.68	0.09	13.2	0.77	0.06	7.8
Total calcium (mg·%)	120.57	4.23	3.5	163.97	7.40	4.5
Colloidal calcium (mg·%)	77.10	4.90	6.4	112.26	7.80	6.9
Soluble calcium (mg·%)	43.47	7.47	17.2	51.71	4.39	8.5
Ionic calcium (mg·%)	7.03	1.10	15.6	8.18	1.15	14.1

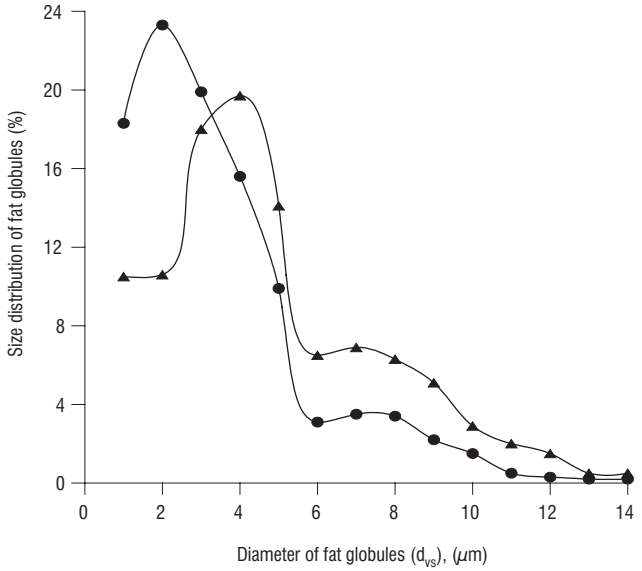

FIGURE 1. Size distribution of fat globules in milk from Holstein-Friesian ● and Jersey cows ▲.

TABLE 2. Characteristics of milk fat dispersion in Holstein-Friesian and Jersey cows. Mean values (n=20).

Milk from	Diameter of fat globules d_{vs} (μm)	Surface area of fat globules (m^2/mL milk)	Surface area of fat globules (m^2/mL fat)
Holstein-Friesian cows	6.19	0.12	2.39
Jersey cows	7.68	0.14	1.81

cows influence the properties of finished products. For instance, they are responsible for specific rheological properties of butter [Boland, 2003].

It was found that the values of selected physicochemical properties of milk from cows of both breeds were similar (Table 3). The results concerning active acidity, potential acidity and electrical conductivity were typical of fresh cow's milk in both breeds. The slight differences recorded in conductivity of milk samples were caused by their different chemical composition, *i.e.* concentrations of fat, hydrogen ions and mineral salts in soluble form. Mabrook & Petty [2003], who studied the effect of milk composition on its electrical conductance, found that mineral salts dissociated in the aqueous phase of milk played the dominant role in controlling this property. These authors also proved that conductance is affected by milk fat.

The results regarding the density and freezing temperature of milk samples confirmed that these properties corresponded to the relevant standards specified in the Regulation by the Minister of Agriculture and Rural Development of May 18, 2005. There were no significant differences between the density of milk from Jersey and Holstein-Friesian cows, because despite a high fat content, milk from Jersey cows has high levels of solids non-fat. The freezing temperature of milk from Jersey cows was somewhat lower, compared with milk from Holstein-Friesians, which was caused by various concentrations of milk components in the aqueous phase.

The results of the present studies on some physicochemical characteristics of milk from Jersey and Holstein-Friesian cows showed certain differences between them, which may affect the technological suitability of milk, thus enabling to modify technological process parameters and the properties of the ready-made products.

CONCLUSIONS

1. Milk obtained from Holstein-Friesian and Jersey was characterised by high microbiological and cytological quality, which indicated good sanitary and husbandry conditions on the cattle farm.

2. Milk from Jersey cows had higher concentrations of protein compounds, including casein, and (to a lower degree) whey proteins, as well as calcium salts, in comparison with milk from Holstein-Friesians.

3. Milk from Jersey cows contained more fat, which had the form of bigger globules, compared with milk from Holstein-Friesian cows.

4. The properties of milk from cows of both breeds, analysed in the experiment, *i.e.* density and freezing temperature, showed typical values, consistent with the relevant requirement specified in legal regulations.

REFERENCES

1. Anema S.G., Creamer L.K., Effect of the A and B variants of both α_{s1}- and κ-casein on bovine casein micelle solvatation and κ casein content. J. Dairy Res., 1993, 60, 505-–516.
2. Antkowiak I., Pytlewski J., Stanisławski D., Effect of selected factors of Jersey cows breeding on their performance and milk composition. Zesz. Nauk. Prz. Hod., 2004, 72, 101–111 (in Polish; English abstract).
3. Boland M., Influences on raw milk quality. 2003, *in*: Dairy Processing. Improving Quality (ed. G. Smith). C.H.I.P.S, Weimar, USA, pp. 42–67.
4. Budsławski J., Badanie mleka i jego przetworów. 1973, PWRiL Warszawa (in Polish).
5. Dalgleish D.G., Technological properties of milk protein variants. Bull. IDF, 1995, 304, 10.

TABLE 3. Characteristics of some physicochemical properties of milk from Holstein-Friesian and Jersey cows. Mean values (n=20).

Parameter	Milk from					
	Holstein-Friesian cows			Jersey cows		
	$\bar{X}$	δ	v (%)	$\bar{X}$	δ	V (%)
Active acidity pH	6.64	0.02	0.3	6.67	0.04	0.5
Potential acidity (°SH)	6.87	0.15	2.2	6.82	0.11	1.7
Conductivity (mS/cm)	4.55	0.21	4.7	4.44	0.15	3.4
Density (g/mL)	1.030	0.001	0.1	1.029	0.0014	0.13
Freezing temperature (°C)	-0.531	0.006	1.1	-0.541	0.013	2.4

6. Devold T.G., Vegarud G.E., Langsrud T., Micellar size and protein composition related to genetic variants of milk proteins. Bull. IDF, 1995, 304, 10–11.
7. Frąckowiak H., Cattle from the Jersey Island – history and significance. Medycyna Wet., 2004, 60, 666–667 (in Polish).
8. Mabrook M.F., Petty M.C., Effect of composition on the electrical conductance of milk. J. Food Engin., 2003, 60, 321–325.
9. Michalski M.C., Milk fat globules: physicochemical properties as a function of size. Bull. IDF, 2004, 389, 104–107.
10. Nickerson S.C., Milk production: Facors affecting milk composition. 1999, *in*: Milk Quality (ed. F. Hardling). An Aspen Publ. Gaithersburg, Maryland, pp. 3–24.
11. PN-A-86059:1975. Milk, sweet cream and cream. Determination of homogenization efficiency. (in Polish).
12. Regulation by the Minister of Agriculture and Rural Development of May 18, 2005 altering the regulation on veterinary requirements for milk and dairy products. Dz. U. Nr 96, poz. 819. 2005 (in Polish).
13. Satia H.S., Raadsveld C.W., The quality of gouda cheese, made from milk enriched with calcium and phosphate. Neth. Milk Dairy J., 1969, 23, 276–287.
14. Skrzypek R., Characteristics of functional traits in cattle of Jersey breed. Przegl. Hod., 2001, 10, 7–10 (in Polish).
15. Thompson M.P., Boswell R.T., Martin V., Jennes R., Kiddy C.A., Casein-pellet-solvation and heat stability of individual cow's milk. J. Dairy Sci., 1969, 52, 796–798.
16. Wiking L., Stagsted J., Björck L., Nielsen J.H., Milk fat globule size is affected by fat production in dairy cows. Int. Dairy J., 2004, 14, 909–913.

PORÓWNANIE WYBRANYCH CECH FIZYKOCHEMICZNYCH MLEKA KRÓW RASY JERSEY I HOLSZTYŃSKO-FRYZYJSKIEJ

Maria Czerniewicz, Katarzyna Kiełczewska, Antoni Kruk

Katedra Mleczarstwa i Zarządzania Jakością,Uniwersytet Warmińsko-Mazurski, Olsztyn

W pracy przeprowadzono ocenę jakości higienicznej i podstawową charakterystykę fizykochemiczną mleka surowego pochodzącego od krów rasy holsztyńsko-fryzyjskiej i jersey. Analiza wyników wykazała, że badane próbki cechowały się wartościami ogólnej liczby drobnoustrojów i liczby komórek somatycznych, zgodnymi z wymogami zawartymi w obowiązujących przepisach prawnych. Mleko krów rasy jersey charakteryzowało się znacznie wyższą zawartością suchej substancji, wynikającą głównie z większego poziomu związków białkowych (o ok. 19 %), zarówno kazeiny jak i białek serwatkowych, oraz tłuszczu (o ok. 50 %) w porównaniu z mlekiem krów rasy holsztyńsko-fryzyjskiej (tab. 1). Stwierdzono wyższy poziom wszystkich analizowanych form wapnia (ogółem, koloidalny, rozpuszczalny, jonowy) w mleku krów rasy jersey aniżeli u krów rasy holsztyńsko-fryzyjskiej (tab. 1). Charakterystyka stanu dyspersji tłuszczu mlekowego wykazała, że mleko krów rasy jersey zawierało kuleczki tłuszczowe o średnicy większej (o ok. 24%) w porównaniu z mlekiem krów rasy holsztyńsko-fryzyjskiej (rys. 1, tab. 2). Poziom laktozy oraz wartości badanych właściwości tj. kwasowość, gęstość, konduktywność oraz temperatura zamarzania mleka krów obu ras kształtowały się na zbliżonym poziomie (tab. 1, 3).