Journal of Dairy Research (2015) **82** 485–490. © *Proprietors of Journal of Dairy Research 2015*
doi:10.1017/S0022029915000540

Variation of milk components in the Italian Brown cattle

Erika Frigo[1]†, Antonia B Samorè[1]†, Liliana Reghenzani[1], Nicola Bergomi[1], Maria G Strillacci[1], Fausta Schiavini[1], Raphaelle TMM Prinsen[1], Maria C Cozzi[1], Marco Serra[2], Attilio Rossoni[3] and Alessandro Bagnato[1]*

[1] Dipartimento di Scienze Veterinarie per la Salute, la Produzione Animale e la Sicurezza Alimentare (VESPA), Università degli Studi di Milano, Via Celoria 10, 20133 Milano, Italia
[2] ARAL (Associazione Regionale Allevatori della Lombardia), Crema, Italy
[3] ANARB (Associazione Nazionale Allevatori Razza Bruna Italiana), Bussolengo, Italy

Received 24 February 2015; accepted for publication 14 August 2015

The aim of this study was to evaluate the variations of protein, casein, saturated (SFA), unsaturated (UFA), monounsaturated (MUFA), polyunsaturated (PUFA) fatty acids contents and cheese yield in the milk of two groups of Italian Brown cows conventionally reared in indoor period of housing or consuming pasture during the summer months in 2008 and 2013. Milk components were obtained from samples collected during the national routine (conventionally reared) and 'extraordinary' (pasture period) milk recording scheme in herds located near Sondrio (Lombardia, Italy). Milk samples were processed with the MilkoScanTM FT6000 for the identification of milk casein, SFA, UFA, MUFA and PUFA composition. The groups were analysed separately per year and the environmental factors affecting milk protein, casein, and fatty acids contents (pasture/indoor, parity, data of sampling, days in milk, days from collection to analysis) were included in the MIXED procedure of SAS 9.3. A total of 778 milk samples were available, including 234 records from indoor and 544 observations from pasture feeding. Pasture intake affected the content of casein (%) and the proportion of fat in milk (g/100 g), enhancing milk casein levels (from 2·90 to 3) and reducing the concentration of milk SFA in milk from grazing cows (from 2·29 to 1·92). Additionally, the cheese yield was calculated as 'kg of cheese per 100 kg of milk' and resulted to be 10·4 and 12 in 2008 from milk of cows reared indoor and with pasture based diet, respectively. The dairy industry should take advantage of the milk production during grazing periods from which high quality products may be obtained.

Keywords: Casein, fatty acids, cheese yield, pasture, Italian Browns Swiss cattle.

In the last years, the interest in foods with specific health benefits for humans (commonly identified as 'functional foods') has significantly enlarged and the development of products with particular features for the food market has been stimulated. Recent studies have also explored the possibility to revise the selection indexes for the Italian Holstein Friesian and the Italian Brown cattle breeds with specific emphasis to milk casein and fatty acids contents (Samorè et al. 2012; Tullo et al. 2014). Moreover, the niche markets that today are requesting milk with specific nutritional properties, may suggest to the farmers the improvement of particular milk productions where the analyses on casein or fatty acids content may assure an added value.

Milk has an exceptional nutrient profile, providing important amounts of high-quality proteins, minerals, vitamins as well as several other essential nutrients. Casein and fat milk contents are the major factors in determining cheese yield, cheese composition, and coagulating properties, influencing the physical nutritional and flavour properties of milk (Artegoitia et al. 2012).

In detail, the milk protein composition is important because of its effect on the manufacturing properties of milk (cheese yield, milk coagulation time, and curd firmness) (Auldist et al. 2004; Wedholm et al. 2006). In numerous countries, a great proportion of raw milk is used for cheese production and the improvement of milk protein composition for dairy processing may increase the economic outcome for the dairy industry. Regarding milk fat content, usually, it contains 66% saturated fatty acids (SFA), 30% monounsaturated fatty acids (MUFA), and 4%

†First two authors contributed equally.
*For correspondence; e-mail: alessandro.bagnato@unimi.it

polyunsaturated fatty acids (PUFA) (Lindmark Månsson, 2008). Among milk fatty acids, SFA are recognised unsafe for human health, since they are involved in the development of cardiovascular disease and obesity (Haug et al. 2007). Contrariwise, MUFA and PUFA have a blood cholesterol depressing effect in humans (Livingstone et al. 2012).

The variation of dairy cows milk components is influenced by environmental (e.g., feeding, stage of lactation, season, milking interval and health status of the animal) and genetic factors (Chen et al. 2014; Tullo et al. 2014). Among the environmental factors, grazed pasture plays an important role, being a major low cost source of nutrients for dairy cattle (Akbaridoust et al. 2014). In Europe, most of the farms provide seasonal grazing, with pasture access in summer and indoor housing for the other 5–7 months (EFSA, 2009a). Various studies have shown that pasture access has given benefits for cow welfare, improved health (including reductions in mortality, mastitis, metritis, teat trampling, dystocia, retained placenta and ketosis), and for milk quality (EFSA, 2009a, b). Also, it is generally recognised that the cost of milk production is reduced as the proportion of grazed pasture in the diet of the cow increases (Dillon et al. 2008).

Feeding strategies can affect milk fatty acid composition, enhancing the concentration of conjugated linoleic acid (CLA) in cow's milk (White et al. 2001; Akbaridoust et al. 2014); also, the proportion of the casein fractions of milk changes at times associated with periods of pasture (Chen et al. 2014). Nevertheless, using pasture as the only source of food is insufficient for high milk producing cows and the lower intake of dry matter and energy may be the main origin of suboptimal production (Reis & Combs, 2000; Bargo et al. 2002).

Among the dairy cattle breeds, the Italian Brown usually exploits the mountain pasture resources in the summer months. In Italy, more than the 75% of milk is used for cheese making and the Italian Brown cattle stands out for the quality and the quantity of its milk. Its main trait is being particularly appropriate for cheese making: in fact, the allele A of the milk K-casein of this breed, having negative effect on curd formation, has lower frequency in respect to other breeds (http://www.anarb.it). In order to support the specific attitude of the Italian Brown breed milk to be processed for cheese making, the National Association of Brown Swiss Breeders (ANARB) promoted the 'disolabruna®' registered brand used for the commercialisation of typical cheeses produced with only milk coming from the Italian Brown cows in order to exploit the uniqueness of the breed.

Since the milk sampling does not occur while cows are at pasture, knowledge of how the comprehensive protein and fat composition vary at pasture in the Italian Brown breed is still limited.

The aim of this study was to evaluate the variations of casein, fatty acid contents and yield in the milk of two groups if Italian Brown cattle consuming pasture or conventionally reared.

Materials and methods

Group A consisted of 40 Italian Brown cows from one herd (located in Valchiavenna, Lombardia, Italy) and the data collection spanned from May 2008 to September 2008. Group B comprised 81 Italian Brown cows from four herds (located in Lanzada and Caspoggio, Lombardia, Italy) and the data collection spanned from June 2013 to September 2013.

The cows were maintained indoors on a total mixed ration during the months of May and June (group A), June (group B) and in the last 15 d of September (both groups A and B), while they spent the summer months on grass (both groups A and B). Milk components were obtained from samples collected in the course of the national routine milk recording during the indoor period of housing, while they were collected with 'extraordinary' milk recording during the mountain pasture period.

Milk samples were processed at the Regional Breeders Association of Lombardia (ARAL) by Fourier transform infrared spectroscopy with the MilkoScanTM FT6000 (Foss Electric, Hillerød, Denmark) for the identification of milk casein and fatty acids contents. For group A the sample analysis with the MilkoScan instrument were performed three times, thus providing results for the same cow at different time intervals of sampling, in order to test the degradation of milk components after one, 2 and 3 d after the milk recording.

Analysis for group A

Production traits considered for group A were casein content (C%), fat content (F%), protein content (P%), lactose % (L%), urea content (mg/dl) (U%) and somatic cell count (SCC).

The fixed effects of the place of collection data (2 levels: indoor or pasture), month of collection (place of collection) (5 levels: May, June, July, August, September), days-interval between the data collection and the analysis (3 levels: 1, 2 or 3 d) were included in the MIXED procedure of SAS 9.3 (SAS Institute Inc., Cary, NC). The effect of the animal was considered as random. Additionally, as milk was transformed in cheese, the cheese yield was calculated as 'kg of cheese per 100 kg of milk'.

Analysis for group B

Production traits considered for group B were SFA, UFA, MUFA and PUFA. The fixed effects of DIM (30 d classes, resulting in 13 levels), place of collection data (2 levels: indoor or pasture), month of collection (place of collection) (4 levels: June, July, August and September) and parity classified in 3 classes (class 1: lactation = 1, class 2: from lactation 2 to 3, class 3: lactation $\geqslant$3) were included in the MIXED procedure of SAS 9.3 (SAS Institute Inc., Cary, NC). The effects of animal and herd were considered as random; milk production, protein and fat contents were considered as covariates.

https://doi.org/10.1017/S0022029915000540 Published online by Cambridge University Press

Table 1. Means and standard deviations (SD) of milk productive traits and fatty acids in Italian Brown cows (Groups A and B)

	Group A				Group B			
	Indoor feeding		Pasture		Indoor feeding		Pasture	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Milk (kg/d)	11·93	1·61	8·07	1·20	10·86	3·57	9·95	3·12
Fat (%)	4·06	0·82	4·32	0·75	3·60	1·18	3·39	1·20
Protein (%)	3·80	0·51	3·86	0·40	3·59	0·45	3·65	0·40
Casein (%)	2·91	0·40	2·99	0·34	2·78	0·33	2·80	0·29
Urea (mg/dl)	31·14	7·59	35·60	6·69	20·73	6·93	24·05	7·82
SCC (×1·000)	809·60	1444·36	924·29	750·55	385·33	613·02	530·07	892·89
UFA (%)					1·14	0·42	1·15	0·45
MUFA (%)					0·89	0·39	0·87	0·42
PUFA (%)					0·17	0·05	0·17	0·07
SFA (%)					2·32	0·75	1·88	0·87

Table 2. Summary of the significance levels for model terms for the productive traits (Group A)

Model terms	Productive traits					
	Casein (%)	Protein (%)	Fat (%)	SCC (×1000)	SCS	Urea (mg/dl)
Place of data collection (indoor/pasture)	***	ns	**	ns	*	***
Days-interval (data collection-analysis)	ns	ns	ns	ns	ns	ns
Month of collection	***	***	***	***	***	***

*$0·001 < P < 0·005$.
**$0·001 < P < 0·0001$.
***$P < 0·0001$.

Results and discussion

A total number of 510 samples was available for group A, including 105 and 405 ones from indoor and pasture feeding respectively, while the total number of milk samples for group B was 268, including 129 and 139 records from indoor and pasture feeding, respectively. The descriptive statistics of the productive traits for both the groups are reported in Table 1.

The values for the productive traits are in agreement with the average yields of the cows registered in the national Herd Books and reported in the AIA Bulletins (http://bollettino.aia.it/bollettino/bollettino.htm). A decrease in milk production was observed for cows which diet consisted of pasture only. This is somehow expected and due to the sudden transition from the total mixed diet to pasture, which can induce a stress state for the cows.

The SCC is the main indicator for the inflammation of the udder and for the milk quality and varies due to many factors such as parity, stage of lactation, including also seasonal and management effects (Lamarche et al. 2000). Moreover, SCC is one of the traits used as an indirect measure of mastitis resistance/susceptibility in breeding programs in cattle (Strillacci et al. 2014). In this study, higher SCC values were found in milk produced during the pasture period in both the two groups, confirming the seasonal variation in milk SCC, and its increasing during the summer months (Lambertz et al. 2014).

Protein, casein and urea milk contents resulted higher during the grazing season compared with the indoor period for both the groups, confirming that the proportion of protein fractions of milk are altered at specific times of the years (Barber et al. 2005). The main period of seasonal variation for protein milk content (especially its casein fraction) is seen in the summer-autumn months, suggesting that casein composition is under the influence of nutritional changes in animals and may be manipulated through nutrition to improve the processing efficiency and functionality of dairy products.

Group A

The Table 2 reported the summary of the significance levels for the fixed effects in the model for the productive traits. As expected the 'month of collection' had significant effects on all the productive traits. The place of data collection (indoor or pasture) had significant effects on casein and urea milk contents, and the date of collection data within pasture had significant effects on all the productive traits. The value of the least square means of casein content values in milk for the fixed effect 'place of collection data', brought evidence of higher contents of casein in milk from pastures based diet cows, confirming data reported in Table 1. The casein fraction of milk protein is one of the principal factors affecting curd firmness, moisture retention and cheese quality (Mona et al. 2011). Also, the role of casein

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Table 3. Cheese yield and cheese amount obtained from the milk of Italian Brown cows in the period May–September 2008 (Group A)

Period	Cheese type	Cheese yield
May	Semi-mature/semi-hard	10·4
June	Similar 'Bitto' manufacturing	10·3
July	'Bitto'	10·9
August	'Bitto'	11·4
September	'Bitto'	12

in influencing the amount of cheese produced is well recognised (Samorè et al. 2007) and the quality/quantity of cheese obtained are relevant for the profitability of the dairy industry.

The Table 3 reported the cheese yield (expressed as 'kg of cheese per 100 kg of milk'), and the cheese type obtained from the milk of Italian Brown cows in the period May–September 2008.

In May the milk was used to produce the 'latteria cheese', a semi-mature, semi-hard cheese with a mild delicate flavour, made from whole or semi-skimmed milk. During the months of June, July, August and September, the milk was used to produce the 'Bitto' cheese and a 'similar Bitto' manufacturing cheese. The Bitto cheese is a traditional dairy product with Protected Designation of Origin (PDO), produced in the Valtellina area of region Lombardia from whole cows' milk with a small portion of goat's milk (10–20%). This cheese can be produced only in the summer, high up in the mountain pastures, as its organoleptic characteristics depend on the quality of grass eaten by the cows, which varies from slope to slope.

Cheese yield is one of the keys to improve the economy of cheese production and it is affected by several factors, including milk composition, milk quality, amount of genetic variants of casein, SCC in milk, milk pasteurisation, coagulant type, and manufacturing parameters (Mona et al. 2011). In this study cheese yield resulted higher in milk from pastured cows, providing evidence that the grazing system may be an efficient milk production strategy.

Group B

The fatty acids profiles were similar to those reported in other studies (De Marchi et al. 2011; Tullo et al. 2014) and SFA, UFA, MUFA and PUFA represented approximately the 68, 32, 25 and 7% of the total fat. These values are in line with those reported by Grummer (1991).

The differences of the values of UFA and PUFA in the milk of grazing cows were very little, in comparison to milk from indoor feeding system. The values of SFA composition in milk were lower in the grazing period and the minimum value of SFA was measured in the month of August. When grazing pasture, the UFA present in the diet or originating from the mobilisation of body reserves exert a potent inhibitor effect on the de novo synthesis at the mammary gland, thus reducing the concentration of milk SFA (Slots et al. 2009). Moreover, the difference in terms of milk SFA from pasture and indoor feeding systems lie in the fact that diets rich in concentrates (used in indoor feeding systems) favor the production of SFA, which instead decrease with a pasture-based diet (Mucchetti & Neviani, 2006).

The model terms of place of collection and month of collection data (place of collection), had significant effects on all the categories of fatty acids ($P < 0{\cdot}0001$) and the Figs. 1 & 2 reported the least square means of UFA, MUFA, PUFA and SFA for these effects.

Dairy producers are considering new ways to optimise bovine milk composition for human health and to improve physical and functional properties of milk. Some attempts have been made in France with the Bleu-Blanc-Coeur (http://www.bleu-blanc-coeur.org/), commercialising higher-value milk with improved nutritional characteristics through a specific food chain production with particular nutritional claims. Production and efficacious marketing of goods and services that are highly valued by consumers promote the maintenance of minor breeds. For example, in Italy, the population of the Reggiana cattle increased in the last decades because of the development of the branded Parmigiano Reggiano cheese, made exclusively from milk obtained from Reggiana cows, thus providing economic revenues for farmers for the conservation and use of a breed that may otherwise be lost (De Roest & Menghi, 2000; Gandini et al. 2007).

Pasture intake may affect the proportions of fat and casein fractions in milk through their direct effect on energy and protein intake, thus meeting feed demands with feed supply. This study has confirmed in a field study, conducted in different locations and times, that in a low input grazing system the total production exhibits a higher true casein content and a minor amount of SFA.

Nutritional changes and productive strategies can be used to develop naturally added value dairy products especially from Brown Swiss cows that, even if selected for milk production in recent years, are able to maintain their rusticity, adapting themselves to highly varied agricultural and climatic conditions.

The dairy industry may take benefit of the better milk production during grazing periods from which high quality products may be obtained, avoiding food waste and giving a renewed and healthier look to the dairy products. Nevertheless, the management of a profitable grazing system needs different management skills when compared with indoor systems. In fact the frequently change of the quality and quantity of pasture during every grazing season and the lack of control of the feeding programs compared to an indoor feeding system, is still a major challenge in obtaining high and consistent feed intake for each day.

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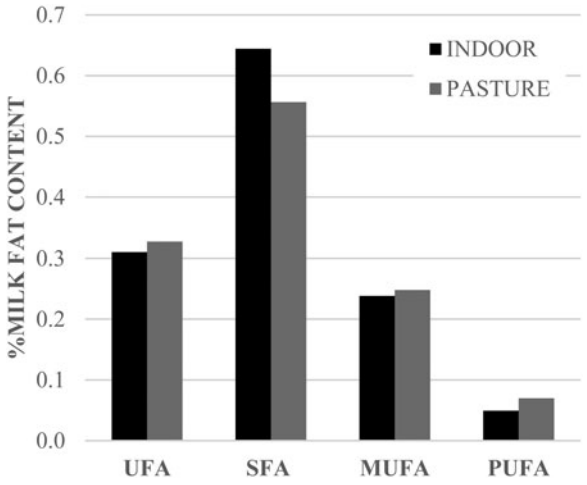

Fig. 1. Least square means of unsaturated (UFA), monounsaturated (MUFA), polyunsaturated (PUFA) and saturated fatty acids (SFA) for the fixed effect of place of collection data (Group B).

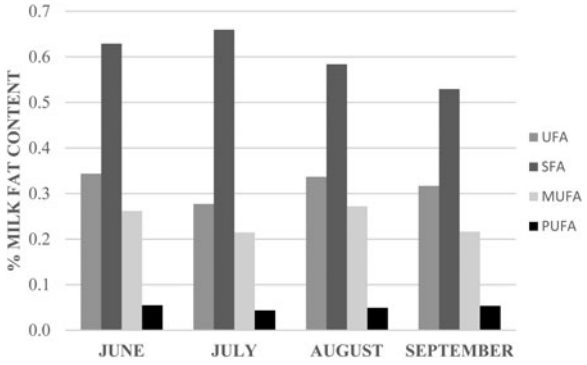

Fig. 2. Least square means of unsaturated (UFA), monounsaturated (MUFA), polyunsaturated (PUFA) and saturated fatty acids (SFA) for the fixed effect of month of collection data (place of collection) (Group B).

As 'Bitto' cheese is produced only in summer and the consortium 'disolabruna' guarantees its milk from the Italian Brown breed, the chance to certify the nutritional properties of the milk used in the cheese making process is of interest for ANARB. Taking into consideration that in summer the routine milk recording is not done, the results of this study are a first effort to provide such information and to offer possible framework for pasture milk recording with the final goal of providing the best accessible information for the dairy producers. If this would occur routinely, farmers and 'Bitto', 'Similar Bitto', and 'Latteria' cheeses producers may release to consumer the nutritional properties of pasture milk to raise awareness of the quality of marketed productions.

We would like to thank the Regional Association of Breeders of Lombardia (ARAL) for collecting and providing the data. This study was funded by Regione Lombardia projects n. 705 (BruCa) and n. 1328 (LattOmega).

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