Recording individual real yield in mozzarella cheese in the Italian Mediterranean buffalo population

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Abstract

The aim of this study was to develop a new protocol for recording real data on individual mozzarella yield to be included in breeding programs to increase mozzarella production in the buffalo population. Almost all the milk from the Italian Mediterranean buffalo is transformed into mozzarella cheese. Therefore, increasing yield in mozzarella cheese is the main goal of the breeding programs. Traditionally, yield in mozzarella cheese is estimated using milk, fat and protein by the well-known PKM formula. However, the yield in mozzarella not only depends on protein in the milk, but also on the type and on the proportion of the different protein variants. Moreover, the PKM is highly related to milk production. Therefore, selecting for the PKM might increase in the population the number of buffalo that produce more milk, and not necessarily more mozzarella cheese. The most accurate, and not expensive trait to be recorded for estimating the individual cheese yield is the Dry Matter Yield in Curd (DMYC). A total of 499 milk samples of 1 kg from 89 buffalo distributed in 8 farms from 2010 to 2015, were collected 3 to 6 times per lactation, at intervals of 40-45 days from DIM 30 to 270.

To obtain DMYC from each milk sample, the Real Yield in Curd (RYC) was first calculated with the micro-cheese technique according to the following protocol: 1 kg of milk sample was heated to 37 °C after adding 1 ml Kg^{-1} of liquid rennet, with a concentration of 160 IMCU mL^{-1}. The obtained curd was put in a plastic tray container, refrigerated at 4°C and weighted after 24 hours to getting the RYC after 24 hours (RYC24). From the RYC24, 50 g of curd were used to determine the percentage of dry matter in the curd by drying the RYC24 at 103°C. DMYC was then obtained by multiplying the weight of the curd from 1 kg of milk sample by the DM (%).

To evaluate the effectiveness of using the DMYC as estimator of individual RYC, correlation analysis of DMYC with the RYC24, PKM and APKM was performed. In addition, correlations of the average DMYC overall DIM intervals and DMYC for each DIM interval were evaluated to detect the possibility of using only one sample from a DIM interval per lactation. DMYC resulted largely correlated to RYC24; while it was lower correlated to PKM and APKM. Thus, DMYC might be used as estimator of the individual RYC. Moreover, DMYC estimated at DIM interval of 181-210 was highly correlated to DMYC overall DIM intervals.

Thus, collecting only one milk sample at DIM interval 181-210, might allow to estimate accurately the individual DMYC in the whole lactation. DMYC at DIM 180-210 is a novel, simple and not expenses trait to be recorded for the genetic selection of buffalo to increasing in the population the number of high yielding buffalo that will produce more mozzarella cheese than more milk.

Keywords: Buffalo mozzarella cheese, yield in curd.

Introduction

The increasing economic relevance of the Italian buffalo breed is due to the high market demand for the buffalo mozzarella cheese, resulting in a price for buffalo's milk that is more than three times higher than the price of cow's milk. The higher price, however, does not depend only on the higher yield of buffalo milk but also on the better flavour and, therefore, on the greater satisfaction of the consumer for the better tasty of the product. Due to its high dry matter content, buffalo milk is very suitable for processing, with a yield in cheese higher than that of cow's milk (Zicarelli, L., 2004). To produce 1 kg of mozzarella cheese are required 8 kg of cow's milk, but only 4 kg of buffalo's milk (Zicarelli, L., 2004). Therefore, in Italy, buffalo milk is primarily paid by its yield in mozzarella cheese and by its unique flavour. Moreover, the breeding schemes are aimed to achieve genetic improvement of yield in mozzarella cheese. Traditionally, the production of mozzarella cheese (PKM, kg) is estimated from the observation of milk, fats and proteins, from the formula of Altiero *et al.* (1989) (Rosati A. and D.L. Van Vleck, 2002).

This formula takes into account the amount of milk production and the percentage of protein and fat. However, the yield of mozzarella cheese does not only depend on the percentage of protein in the milk, but also on the type and on the proportion of the different protein variants (Zicarelli L. *et al.*, 2020). However, selection of the percentage of proteins in the milk does not guarantee the selection for a higher yield in mozzarella cheese.

Therefore, by selecting through the PKM, one risk is to increase the number of animals that will produce more milk, and not more mozzarella cheese. In a recent work, Parlato E., and Zicarelli L. (2015) proposed an adjusted PKM (APKM), obtained by multiplying the PKM by the ratio of its estimated yield and the mean estimated yield of the year that the lactation refers to. The APKM is lower correlated to the milk yield than the PKM and tended to increase ranking of the sire with positive EBVs for protein and fat percentage (Parlato E., and Zicarelli L., 2015).

The objective of this study was to set up a new protocol to recording individual yield in curd in the buffalo population to be used in selection program for increasing the number of high-yielding buffalo that will produce more mozzarella cheese than more milk.

Material and methods

Data

A total of 499 milk samples of 1 kg, from 89 buffalo distributed in 8 Italian farms, from year 2005 to year 2010, were collected. Buffalo were fed on a diet with the same chemical composition (15,5% of CP, 0,9 MFU/kg of DM., 130g of Ca; 76 g of P, >32% Fiber/ kg of DM., <240 gr / kg of DM). Milk samples were collected from 3 to 6 times during a single lactation, at intervals of about 40- 45 days from 30 to 270 days in milk (DIM). The day of calving was set equal to 0. From the same samples an addition of 500 ml of milk was collected for the analysis of Percentage of Crude Protein (PP) and Percentage of Fat (FP) by CombiFoss™ 7 using the dilution method.

Protocol to obtain individual Dry Matter Yield in Curd

To obtain the Dry Matter Yield in Curd (DMYC) from each milk sample, the Real Yield in Curd (RYC) was first calculated by the micro-cheese making technique according to the following protocol (Zicarelli *et al.,* 2001; Zicarelli *et al.* 2020): Liquid rennet (80% Chymosin) with a concentration of 160 IMCU mL^{-1} (International Milk-Clotting Units, mL^{-1}) was added to the milk sample (1 mL Kg^{1}) and heated to 37 °C. Since coagulation was performed with the maximum amount of rennet, the curdling and the curd formation were faster than that observed in the cheese factories. To facilitate the complete syneresis, the coagulum was cut first into a large piece then into small pieces, and then pressed to remove the residual whey. The curd was put in plastic tray containers, refrigerated (4°C) and weighted after 24 hours. The measured weight represented the yield of the curd per kg of milk after 24 hours (RYC24). After 24 hours at 4°C, 50 g of curd were used to determine the percentage of dry matter by drying the yield in curd at 103°C; Dry Matter Yield in Curd (DMYC) was obtained by multiplying the weight of the coagulum from 1 kg of milk sample by the DM.

$$DMYC = RYC24 * DM*0.01$$

PKM and adjusted PKM (APKM) were calculated for each individual milk sample by the following formula (Parlato E. and L. Zicarelli, 2015).

$$APKM = milk\ yield,\ kg * [3.5*(PP)+1.23*(FP)-0.88] / 100$$

where: C = EY / MEY; EY = [3.5*(PP)+1.23*(FP)-0.88] and MEY is the average milk yield of the year the lactation refers to.

Statistical analysis

To evaluate the effectiveness of using the DMYC as estimator of the individual RYC, correlation analysis among DMYC, RYC24, PKM, and APKM was performed by PROC CORR procedure of SAS (2005). Moreover, to detect the possibility of using only one sample per animal, as representative of the whole lactation, correlation analysis of the average DMYC per lactation with the DMYC per each DIM interval was also evaluated.

Results and discussion

Means and standard deviations of DMYC, RYC24, PKM and APKM are shown in Table 1. DMYC (113.75 g) showed the smaller mean weight compared to RYC24 (260.19 g), PKM (263.98 g), and APKM (264.33 g). The coefficients of correlation for DMYC, RYC24, PKM, and APKM are shown in Table 2. Correlation coefficients ranged between 0.52 (PKM *vs* DMYC) and 0.90 (PKM *vs* APKM). All the correlations were highly statistically significant. PKM *vs* APKM showed a large correlation because APKM is derived from the PKM. Also, DMYC *vs* RYC24 had a large correlation because DMYC is derived from the RYC24. Whereas correlations of PKM and APKM with RYC24 and DMYC were low. These results showed that PKM and APKM might not be good estimators of the RYC24 and consequently of the DMYC. The weight of the dry matter (DMYC) of the coagulum would give results more accurate than the RYC24, avoiding any bias due to the process by which the RYC24 is obtained.

Coefficient of correlations of the overall average DMYC per lactation, and the DMYC at each DIM intervals, are shown in Table 3. Correlations were all highly statistically significant. The larger (0.79) correlation was found at the DIM interval of 181-210 days. At this stage of the lactation, buffalo have reached the energetic balance, therefore, they can express completely their mammary synthesis capability. Whereas, the smaller (0.59) correlation was found at the DIM interval of 151-180 days. Since there was a large correlation between the overall average DMYC and the DMYC at DIM interval

of 181-210 days, DMYC might be evaluated per animal, per lactation, only one time at DIM interval of 181-210 days.

Conclusion

DMYC at DIM 180-210 is a novel, simple and not expenses trait to be recorded for the genetic selection of buffalo to increasing in the population the number of high yielding buffalo that will produce more mozzarella cheese than more milk. Moreover, selection for DMYC will help to keep the characteristic flavour of the buffalo milk. Animals with larger yield in mozzarella cheese but less milk production are desirable to avoid flavour dilution in the milk (Zicarelli, 2020). Yield in mozzarella cheese and flavour are the most important traits for improving the profit of the buffalo farm.

Table 1. Overall unadjusted means and standard deviations of weights for Real Yield in Curd after 24 hours (RYC24), PKM; adjusted PKM (APKM) and Dry Matter Yield in Curd (DMYC), in grams, of 499 individual milk samples at different DIM of 89 animals.

Trait	Mean	Std.Dv
DMYC	113.75	14.85
RYC24	260.19	29.32
PKM	263.98	22.15
APKM	264.33	32.33

Table 2. Coefficients of correlation (above and below the diagonal) among DMYC, RYC24, PKM and APKM.*

	DMYC	RYC24	PKM	APKM
DMYC	1.00	0.85	0.52	0.65
RYC24	0.85	1.00	0.56	0.58
PKM	0.52	0.59	1.00	0.90
APKM	0.65	0.56	0.90	1.00

*: $P \leq 0.0001$

Table 3. Coefficients of correlation, r for the unadjusted mean of DMYC overall DIM intervals and DMYC at each DIM interval of 89 buffalo.*

DIM	r
30 -60	0.71
61-90	0.68
91-120	0.70
121-150	0.65
151-180	0.59
181-210	0.79
211-270	0.72

*: $P \leq 0.0001$

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