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Original Article

Raw milk composition of Malian Zebu cows (*Bos indicus*) raised under traditional system

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Abstract

Milk from Malian Zebu cows was analysed during the dry and hot season (March–June) in order to assess its composition and the components variation according to the presence of subclinical mastitis and supplementary feeding. The Zebu cow milk ($n = 30$) was composed of 8 g/kg ash, 43 g/kg fat, 48 g/kg lactosemonohydrate, 37 g/kg proteins and 134 g/kg total solids. One-third of the cows tested positive to subclinical mastitis (white blood cell count $>350{,}000$/mL). Milk components were significantly affected by the somatic cell count (decrease of lactosemonohydrate, increase of fat and total solids $P<0.01$). Supplementation of the diet of Zebu cows with low quantity of pasture straw significantly and positively affected milk composition. The fatty acids were composed of a high proportion of polyunsaturated, long-chain fatty acids (oleic acid). This indicates that Zebu cows at this period of the year mobilize body fat for milk production because of the energy deficit in their diet. Lack of supplementary feeding of the Zebu cows and subclinical mastitis appeared to be main constraints in the extensive livestock system in Mali.

Keywords: Zebu; Milk; Composition; Subclinical mastitis; Supplementary feeding; Mali

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1. Introduction

Agriculture and livestock contribute about 23% of the total export earnings and 40% of the gross domestic product in Mali (Anonymous, 1999). Despite its estimated livestock population of 6.9 million cattle, 15.4 million small ruminants and 236,000 camels, Mali cannot meet its domestic demand for dairy products. Local production is still very low and the average consumption is estimated to be 12 kg/person/year of which 60% is met by imported milk products (Debrah et al., 1995).

In Mali, stock breeders concentrate mainly on the development of breeds that are well-adapted to diverse climatic and environmental conditions. The breeds which are found are mainly N'dama, Zebu, crossbreed N'dama × Zebu and local breed × exotic breeds such as Montbéliard, Rouge des steppes and Holstein. The Zebu represents up to 90% of the cattle population in suburban Bamako on which dairy development relies (Sall, 2003). The Zebus are raised under an extensive system and hardly achieve their milk production potential because of unfurnished pasture and high costs of supplementary feeding (cotton seeds) for the farmers (Debrah et al., 1995). The cheapest supplementary feeding in the extensive system remains pasture straw (63% of extensive farms) and rice or millet bran (60%). Milk production is low and seasonal and it fluctuates according to pasture accessibility, feed quality and the proportion of lactating cows (Debrah et al., 1995; Sall, 2003).

In Mali there are three milk production systems. In the "traditional system", local breeds (N'dama and Zebu) are used on suburban pasture where there are scarce food supplements (pasture straw or rice bran). Milk production is fairly low (1–2 L/cow/day). The "modern" production system is practised on farms owned by civil servants and business traders. It consists of mixed farming (livestock, orchard, cereals) with a high input of feed supplements (cotton cake, rice bran and salt). Milk production is relatively high (5–12 L/cow/day) with the crossbreed. The "semi-modern system", is established mainly on private farms, which raise local and crossbreeds of cattle on natural pasture. The level of feed supplement is low and so is milk production (2–5 L/cow/day) (Debrah et al., 1995).

The quality assessment of milk produced and sold in Bamako showed that 30% of market milk samples were positive to Abortus Bang Ring Test (Bonfoh et al., 2002a), high and diversified microbiological contamination of 10^7 colony forming units per mL (CFU/mL) and high subclinical mastitis prevalence (72%) (Bonfoh et al., 2002b, 2003). A part of the milk (21%) was adulterated with water (Bonfoh et al., 2002b) and 6% of raw milk contained antibiotic residues (Bonfoh et al., 2002c). Such milk conditions may have an effect on public health and affect the nutritional value and the technological processes used for the treatment of milk and milk products.

While cow productivity and the bacteriological quality of the milk are relatively well established, there is only little information available on the contribution of local milk to nutritional status in humans, Zebu cow milk composition, physiological variation of milk content and trends of milk components with regard to both udder health and local feed supplementation. The aim of the present study was to establish, for the first time, the full Zebu cows' raw milk composition and assess the effect of subclinical mastitis and supplementary feeding as two main factors potentially influencing milk nutritional quality at the farmer's gate.

2. Materials and methods

2.1. Zebu cows selection

The study was conducted in April 2002 during the hot and dry season in suburban Bamako (rainfall 700–1300 mm with average high temperatures ranging from 35°C to 39.5°C). In this study, the farm selection was based on the traditional livestock system, on the absence of crossbreed (exotic × local) in the flock and on the willingness of livestock owners and herdsmen to participate. The crossbreed Wolosso (Zebu × N'dama) as well as N'dama (*Bos taurus*) were excluded from the study. The Zebu (*Bos indicus*) consisted of a mixture from the Maure, Peul, Azawak and Goudali sub breed. Cows were grazed on mixed natural pasture from 9.00 to 16.00 h and had access to drinking water from the river Niger once a day. Depending on the management practice of the farmer, lactating cows were sporadically supplemented as a group with straw (0.5–1 kg/day/cow) or rice bran (0.25–0.3 kg/day/cow) collected at the beginning of the dry season (September–October 2001).

Out of 118 cows in 5 herds meeting the breed selection criteria and available for sampling, all lactating Zebu cows (30) were selected to collect milk samples. Out of 30 lactating cows, 14 were supplemented either with rice bran ($n = 2$) or pasture straw ($n = 12$). The rest of cows ($n = 16$) did not receive any supplementary feeding. The milk yield was assessed.

2.2. Milking and milk samples

Traditionally, the herdsman lets the calf suckle for 1–2 min, after which individual cows were hand milked directly into sterile screw-topped bottles (500 mL). Samples were taken in the middle and at the end of the milking procedure from early morning and late evening. The aliquots of the 4 udder quarters were mixed during sampling. The morning and evening milk samples were considered as similar in the analysis. Bronopol was used to stabilize samples for chemical analysis. At the time of leaving the farm, the fat was already dispersed by the high ambient temperature (39°C).

All samples were kept in an ice-cooled box and sent to the Swiss Federal Dairy Research Station (Berne, Switzerland) where they arrived the following day at the temperature ranging from 8°C to 10°C with the ice elements still frozen.

In the laboratory, milk samples were warmed to 40°C in a water bath and thoroughly mixed to disperse milk fat homogeneously, without damaging the globule membrane. Replicates from each sample were obtained by splitting the samples into 250 mL sterile bottles.

2.3. Somatic cells counts

Somatic cell counts (SCC) were assessed for both milk samples stabilized and non stabilized with Bronopol. These did not differ significantly. The bacteriological smear of strains from blood agar was performed to assess mastitis aetiology. The SCC was evaluated according to the procedures and guidelines of the International Dairy Federation. The threshold of SCC had been fixed at 350,000 cells/mL (IDF, 1990).

2.4. Milk composition analysis

The compositional analyses of all milk samples collected were carried out using methods listed in Table 1. The total solids was determined by summing ash, fat (Röse-Gottlieb), lactosemonohydrate, and total protein (total nitrogen $\times$ 6.38). The total solids obtained this way matched the results from the direct analyses.

2.5. Statistical analysis

For the data analyses, a random effects model was used in PROC MIXED (SAS™, V 8.02). Cattle herds were specified as random effect (0, δ_{herd}). SCC was transformed as ln(SCC+1). Classes were made for normal milk (SCC$\leqslant$350,000/mL) and subclinical mastitis milk (SCC$>$350,000/mL). The type of supplementation (none, pasture straw or rice bran) was specified as a fixed effect and compared by linear contrasts. The PROC MIXED procedure was chosen to obtain the population base estimates (intercept) in dairy cows

$$\begin{aligned}\gamma_{\text{Milk component}} = {} & \alpha + \beta_1(\text{supplement}) \\ & + \beta_2(\text{subclinical mastitis}) \\ & + \mu(0; \delta_{\text{herd}}) + \varepsilon(0, \delta_\varepsilon),\end{aligned}$$

where α is the intercept (population mean), β_1 the partial slope (supplement), β_2 the partial slope (subclinical mastitis), $\mu(0; \delta_{\text{herd}})$ the random effect of herd, and $\varepsilon(0, \delta_\varepsilon)$ the error.

The PROC GLM procedure was used to compare the two methods of fat evaluation (butyrometric and Röse-Gottlieb). The model was forced through the origin

Table 1
Analytical methods and number of samples used for the quantification of nitrogen compounds, lipids, lactosemonohydrate, total solids, ash and somatic cells in Zebu cow milk

Parameters analysed	Number of samples	Methods (Reference)
Nitrogen compounds		
Total protein	30	(IDF, 1993a)
Non-protein nitrogen	30	(IDF, 1993b)
Lipids		
Fat (butyrometric method)	27	(IDF, 1976)
Fat (Röse-Gottlieb method)	30	(IDF, 1987b)
Fatty acid composition	30	(Collomb and Bühler, 2000, FAM[a])
Others		
Lactosemonohydrate	30	(Werner et al., 1970)
Total solids	30	(IDF, 1987c)
Ash	30	(IDF, 1987a)
Somatic cells counts	30	(IDF, 1990)

[a] FAM Swiss federal dairy research station.

(no intercept)

$$\gamma_{\text{fat}} = ax + \varepsilon(0, \delta_\varepsilon),$$

where a is the slope.

3. Results and discussion

3.1. Somatic cell counts (SCC)

The average SCC in the milk was 645,000 ± 1,246,000 cells/mL (min: 9000; max: 5,578,000). *Staphylococcus aureus* was present in 20% and *Corynebacterium bovis* in 10% of the samples. The other species identified (other *Staphylococcus* spp. and *Streptococcus* spp.) are not potentially responsible for mastitis. Thirty percent of the milk samples contained more than 350,000 cells/mL (Table 2), showing a high prevalence of subclinical mastitis in the extensive milk production in suburban Bamako as described by Bonfoh et al. (2002b).

3.2. Variation of Zebu milk composition

Due to the dry season (shortage of feed) and to the end of lactation period, the milk yield ranges 0.5–1 L/day/cow (morning and evening milking). This milk yield is lower than the daily production described by Sall (2003) in suburban Bamako (1.6 L/cow/day).

The Zebu cow milk composition showed higher protein and fat content (Table 3) than what has been described with *Bos taurus* by Belitz and Grosch (1992). The relatively higher fat content of Malian Zebu milk could be related to low milk production. Ash and lactosemonohydrate did not vary significantly within herds and cows. Protein content may be influenced by the breed, the lactation period, the season and the feeding status while the fat content reflects supplementary feeding, the effects of subclinical mastitis, the breed, the age and the lactation period.

Table 2
Somatic cell counts and percentage of bacterial strains isolated from the Zebu cow milk

Parameters	Somatic cell count (× 1000/mL)	
Threshold	< 350	> 350
N	21	9
Frequency	70%	30%
Average	71	1 296
Standard deviation	75	1 741
Minimum	9	410
Maximum	257	5 578
Bacteria isolated from milk		
Staphylococcus aureus	14%	33%
Corynebacterium bovis	0%	33%

Table 3
Arithmetic means and population based estimates (intercept) of Zebu cow milk composition (ash, fat, lactosemonohydrate, proteins and total solids)

Components/parameters	Arithmetic means (g/L)	Intercept (g/L)	95% LCL (g/L)	95% UCL (g/L)
Ash	7.9	7.8	7.5	8.2
Fat (Röse-Gottlieb method)	42.7	35.7	20.9	50.6
Fat (butyrometric method)	37.7	34.5	23.3	45.6
Lactosemonohydrate	48.5	49.9	48.2	51.7
Proteins	36.8	35.1	33.1	37.0
Total solids	134.5	127.7	112.7	142.7

Table 4
Least squares means (g/L) variation of Zebu milk component according to subclinical mastitis and supplementary feeding

Zebu milk component	Subclinical mastitis			Supplementary feeding		
	Negative	Positive	Significance	None	Straw	Significance
Ash	7.8	8.2	*	8.2	7.8	ns
Fat (Röse-Gottlieb method)	40.4	56.5	**	35.9	61.0	***
Fat (butyrometric method)	37.4	46.1	ns	35.6	47.9	*
Lactosemonohydrate	49.8	44.7	***	48.1	46.4	ns
Proteins	34.9	40.9	**	37.7	38.2	ns
Total solids	131.9	147.5	*	129.0	150.4	***

SSC as an indicator of subclinical mastitis affected significantly all the milk components. The lactosemonohydrate content decreased with high SCC (partial slope -1.4; $-2.0 < x < -0.8$; 95% IC), which is in line with Lindmark-Mansson et al. (2003). Fat, protein and total solids contents significantly increased with high SCC. The interactions between udder health and changes in milk composition have been described by Kitchen (1981). Most of the milk parameters show strong mastitis-related changes. The author concluded that the ultimate impact is the reduction of cow milk yield.

Within the 30 cows, the fat content of milk from cows receiving diet supplemented with pasture straw was higher (Table 4). There is a significant effect of feed supplement on fat and total solids composition (Table 4). The pasture straw (0.5–1 kg) increased the milk fat by 12 g/L. Hamann and Krömker (1997) have indicated that changes in the biochemical milk profile and the metabolic status of the cow are related to an energy imbalance. Furthermore, they demonstrated a significant correlation between energy supply and fat/protein quotient. From this finding, the milk components are found to be indicators of the health and metabolic status of Zebu cows. Beside genetics (breed), stage of lactation and seasonal effects (Lindmark-Mansson et al., 2003) our study revealed that mastitis and feeding factors affect the Zebu cow milk composition.

The results of the determination of fat content revealed differences in the two analytical methods used, the butyrometric and the Röse-Gottlieb methods (Fig. 1). Fat content greater

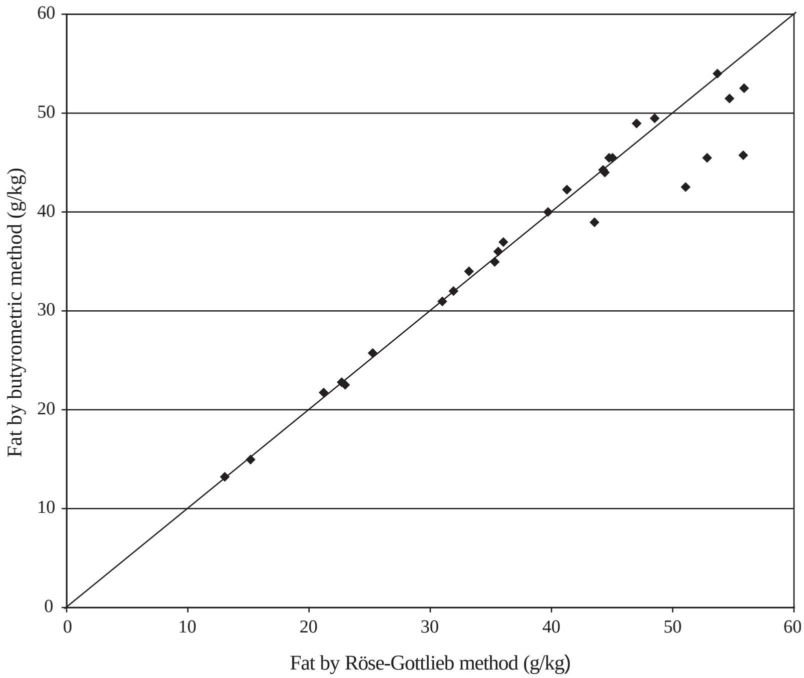

Fig. 1. Comparison of fat content using the butyrometric and Röse-Gottlieb method.

than 40 g/kg was more accurately detected by the Röse-Gottlieb method ($y = 0.96x$). The butyrometric method may be limited in Sahelian conditions where milk fat increases with low milk production.

3.3. Fatty acid composition

The quantities of the fatty acids in Zebu milk fat varied (Table 5). The short-chain fatty acid levels were low because of less butyric (C4), caprylic (C8), capric (C10) and caproleic (10:1) acid contents (Table 5). The higher level of long-chain, unsaturated, monounsaturated, n-3 and n-6 fatty acids was due to the increase of stearic, oleic, linoleic and linolenic fatty acids in Zebu milk fat. These fatty acids indicate high body fat mobilization due to energy deficit. This result is in line with Precht et al. (1985).

The level of these fatty acids may be attributed to metabolic process of the cow, including fermentation in the rumen. In addition, many substances, specific to the kind of fodder may be transferred in their original or modified form in small quantities from the digestive tract to the milk (Lindmark-Mansson et al., 2003). This contributes to a decrease in saturated fatty acids in the milk fat up to C16 from the mammary gland.

Energy deficit has a significant effect on the decrease of C4, C6, C8, C10, C12, and C14 on one hand, and on the increase of C18, C18:1, C18:2 on the other hand. There is no effect on C16. Zebu cows fed with the rice bran as a supplement show high content of linoleic acid (0.9 g/kg).

Table 5
Fatty acid content of Zebu cow milk expressed as g/100 g of total fat

Fatty acid	Average	Standard deviation	Minimum	Maximum
Short chain[a]	4.93	1.13	2.85	6.87
Intermediate chain	36.35	1.79	32.79	39.55
Long chain[b]	52.23	3.51	44.86	58.98
Saturated	56.18	2.33	51.91	59.18
C12, C14 & C16 saturated	31.82	1.76	28.54	34.67
C18:1	30.88	2.84	25.73	36.37
C18:2	3.49	0.48	2.51	4.68
Unsaturated[c]	37.28	3.04	32.08	43.05
Monounsaturated[d]	33.15	2.96	28.19	38.74
Polyunsaturated	4.10	0.66	2.79	5.41
C18:1t	3.51	0.81	2.14	5.19
C18:2t with CLA	1.38	0.26	1.01	2.04
CLA	0.82	0.23	0.49	1.33
C18:2t without CLA t	0.58	0.10	0.40	0.78
Trans total without CLA Trans	4.24	0.88	2.65	6.13
Total with CLA	5.05	1.04	3.28	7.09
Omega 3[e]	0.47	0.27	0.26	1.45
Omega 6[f]	3.22	0.57	2.20	4.32

[a] C4 to C10:1.
[b] C17 to C22:6t.
[c] C10:1, C14:1 ct, C16:1 ct, C17:1 t, C18:1 t4 to c14 + t16, C18:2 ttNMID to C18:2 c9c15, C20:1 t to C20:2 cc, C20:3 (n-6) to C22:6 (n-3).
[d] C10:1, C14:1 ct, C16:1 ct, C17:1 ct, C18:1 t4 to c14 + 16, C20:1 t to C20:1 c11.
[e] C18:2-t11c15 + c9c15, C18:3 c9c12c15, C20:3 n-3, C20:5, C22:5 and C22:6.
[f] C18:1-t12 + -c12, C18:2-t9t12 + c9t12 + -c9c12, C18:3 c6c9c12, C20:2 cc, C20:3 n-6 and C20:4 n-6.

The high level of unsaturated fatty acids, oleic acid in particular, in the Zebu cows milk gives a soft consistency to its fat. The composition of the fat influences the fat properties and the technological processes in dairy plants.

The long-chain fatty acids have a desirable effect on human health (Collomb et al., 2000). The analysis of fatty acid composition of Fulani ‘‘butter oil’ (made from cow’s milk) by Glew et al. (1999) showed that the content of polyunsaturated fatty acids may ultimately have implications for the general nutritional status of populations for whom milk products are the main dietary components.

4. Conclusions

These results provide first information on Malian Zebu cow milk composition and show the evidence that subclinical mastitis affects the content of Zebu milk. This study also demonstrated that the current diet provided by farmers is inadequately balanced to have standardized Zebu milk composition. Furthermore, the supplementation to the diet of Zebu cows with low quantity of pasture straw significantly affects milk composition and the improvement of milk yield may result from that trend. The current information will help to demonstrate livestock owners the importance of supplement feeding for Zebu cows to improve milk nutritional quality.

Further research is needed to assess the potential to increase milk production by locally available and affordable supplementation with Zebu and crossbred dairy cows.

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