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Original Research Article

Physicochemical Properties of Fresh Cow's Milk Produced in the North-West Region, Cameroon (Central Africa)

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Abstract

The aim of this study was to evaluate the physicochemical properties of raw cow's milk produced in the locality of Sabga (North-West Region, Cameroon). Seventy-four cows were randomly selected. These animals were grouped into 8 different genetic groups of cows as followed: White Fulani (WF), Red Fulani (RF), Gudali (G), Holstein (H), HxWF (Holstein crossed White Fulani) WFxG (White Fulani crossed Gudali, RFxWF (Red Fulani crossed White Fulani), GxBr (Gudali crossed Brahman). Each sample was collected in triplicates making 222 samples of fresh milk. Fat, titratable acidity, energy, dry matter, proteins, lactose, added water, ash contents and pH were different milk the properties evaluated. Fat, lactose, energy, pH, titratable acidity and protein contents were found to increase with the lactation length with the highest values recorded between 120 days (4 months) and 270 days (9 months) after the beginning of lactation. The results revealed a positive correlation between added water and fat as well as added water and protein. Thus, the highest titratable acidity (8.00±3.23%), protein (3.40±0.01%), lactose (5.10±0.01%), ash (0.76±0.00%) as well as dry matter (9.18±0.01%) were registered with WF genetic groups of cows, whereas the highest (5.12±1.15%) fat and energy (75.69±9.81%) content were obtained with WFxG genetic groups of cows. The highest pH (6.88±0.09CU) and added water (5.96±0.85%) were recorded with HxWF genetic groups whereas WF once more registered one of lowest added water (0.00±0.00%) value. Based on these results, fresh milk collected from WF genetic groups of cows could be recommended for the production cheese whereas in the case of butter production, the milk from the genetic group WFxG would be the best indicated considering its fat content.

Keywords: Physicochemical properties, Raw milk, Genetic groups, Cameroon

INTRODUCTION

Milk is a fluid secreted by the mammary glands of females for the nourishment of their young. The cow has now become the main dairy animal associated with the term “milk” being almost synonymous with cow milk in most people’s minds. However, milk from a range of other breeds and crossing is also consumed [1]. The demand for milk in developing countries is expected to increase by 25% by 2025 [2]. Small-scale livestock holders supply the vast majority of this milk, and dairy animals provide household food security and a means of fast returns for them. About 180–200 million people belong to pastoral societies that raise livestock using natural rangelands as the main forage [1]. These rangelands are in deserts, mountains and steppes- land that cannot be cultivated or used for agricultural purposes and cover almost 25% of the world’s land surface [3]. Pastoralists traditionally keep more than one breed of cattle in order to make the most of the rangelands, as some breeds are mainly grazers. Diversifying in this manner also reduces risk from disease or extreme environmental conditions [4]. The composition of milk may change due to differences in relative rates of synthesis and secretion of milk components by the mammary gland. Variations are due to differences among breeds, between individuals within a strain, and between conditions affecting an individual. Conditions affecting the cows may include the weather or seasons and the stage of lactation [5,6]. In Cameroon, milk production has been characterized by the traditional system using local zebu cows (Gudali, white Fulani, Red Fulani), however this production has been insufficient reaching only an average of 3 l/day per animal [4]. Milk production in Cameroon stands at 18400 tons yet the demand of milk product is far above production and 21% of natural consumption is imported [7]. Since then, improvement in milk production has been possible due to importations of high yielding breeds such as Holstein Friesian, Jersey and others. The introduction of

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improved European milk breeds (Bos taurus) such as Jersey and Holstein led to the existence of semi-intensive, intensive systems, crossing, and crossed breeds with agriculture being closely associated with dairying [8]. In developed country, analysis of cow milk from breed has already been made but in Sabga there is still no analysis. In addition, they are mostly using the local methods of rearing that will also interfere with the physicochemical parameter of cow milk. Therefore, the objective of this work was to evaluate the physicochemical properties of fresh cow's milk produced in Sabga.

MATERIALS AND METHODS

Description of study site

This study was carried out in Sabga village, Tubah Sub-division in Mezam in the North West region of Cameroon. The geoclimatic characteristics are shown in **Table 1.**

Table 1. Geoclimatic characteristics of Sabga.

Characteristics	**Values**
Altitude	1350 meters
Latitude	5°95' and 6°10'N,
Longitude	10°10' and 10°15'E
Soil	Argilo-ferralitic
Pluviometry	2310.9 ± 196.3 mm
Temperature	Dry season (November-mid-March) 15.50°C, rainy season (mid-March-October) 24.5°C
Humidity	52% for dry season, 70% for rainy season

Source: [9]

Population sample

A total of 74 cows were haphazardly selected. These animals were grouped into 8 different genetic groups of cows as followed: White Fulani (WF), Red Fulani (RF), Gudali (G), Holstein (H), HxWF (Holstein crossed White Fulani) WFxG (White Fulani crossed Gudali, RFxWF (Red Fulani crossed White Fulani), GxBr (Gudali crossed Brahman). Each sample was collected in triplicates making a total of 222 samples of fresh milk.

Research instrument

In order to carry out this study an interview was conducted on rears to enable us select farmers who have milking cow. Laboratory analysis was then carried out on fresh milk samples to bring out the proximate physicochemical parameters of milk.

Method of data collection

All milk samples were collected from different breeders within a period of 3 weeks irrespective of the date of given birth. Samples were transported to Bambui Regional Centre of the Institute of Agricultural Research for Development (IRAD) where the analyzes were conducted, in a flask with ice cubes in order to avoid rapid bacteria growth. Each sample was analyzed tries and the mean of three samples that constituted each breed was taken.

Physicochemical Analysis

Physicochemical analysis was done using two methods. The developed Lactoscan, and the titration.

Lactoscan

We used a Lactoscan apparatus of the mark Milk Analyzer, made in Bulgaria to evaluate fat, dry matter, proteins, lactose, added water, ash contents and pH. The milk samples were brought in the laboratory in 250ml bottles and were analyzed according to the technic described by Milkotronic [10].

Titration of acidity

The titration was expressed in lactic acid content. It was determined as follows:

- 10ml of sample was pipette into a beaker
- 3 to 4 drops of phenolphthalein were added into the sample
- The burette was gently filled with 0.1 m NaOH and pour into the beaker gently while shaking stirring the solution until it turns pink
- The volume of NaOH 0.1m was then recorded [11].

Data expression

Titrated acid (%) = V_{NaOH} x 0.09

Where V_{NaOH} = Volume of NaOH

Energy

Energy (kcal/100ml) was calculated for each milk sample according to the technic described by Bhupathiraju and Hu [12].

Data analysis

Data from the laboratory test were subjected to ANOVA analysis and means separated by Duncan standardized test using Statgraphic 11.0. Non-parametric data were analyzed and variations were weighted with Chi square. All at the confidence level of 5%. Figures were drawn using Excel 2010.

RESULTS

Physical variation

As pH content is concerned, no significance difference ($p>0.05$) was observed between the different genetic groups of cows involved in the present study **(Table 2).** The same (no significance difference was observed between the different genetic groups of cows) observation was obtained concerning the acid titration content.

Table 2. Physical properties and titratable acidity of the different genetic groups of cows**.**

Genetic groups	**N**	**pH (CU)**	**Titration (%)**
Gudali	12	6.84±0.02a	7.00±2.06a
GxBR	3	6.78±0.01a	7.55±0.65a
Holstein	9	6.81±0.01a	5.67±1.42a
HxWF	14	6.88±0.09a	7.11±1.06a
Red Fulani	12	6.84±0.02a	4.81±1.08a
RFxWF	6	6.72±0.03a	6.68±2.67a
White Fulani	6	6.85±0.01a	8.00±3.23a
WFxG	12	6.88±0.01a	5.63±1.49a
F (p)	74	0.98 (0.4556)	0.37(0.9150)

Values are expressed as Mean±SD. In the same column means followed by the same letter are not statistically significantly different (p>0.05); N: Number of observations; CU: Conventional units; RF: Red Fulani; H: Holstein; G: Gudali; WF: White Fulani; BR: Brahman

Although no significant difference ($p>0.05$) was observed between the lactation length as pH is concerned, the highest pH was recorded at 4 months, followed by 7 months and 10 months of lactation with an average value of 6.94±0.01, 6.89±0.06 and 6.85±0.01 CU respectively whereas for the lactation lengths of 6 months and 5 months with an average value of 6.77±0.07 and 6.78±0.01 CU respectively the pH was the lowest **(Table 3).**

Table 3. Physical properties and titratable acidity by lactation length (months).

Lactation length (months)	**N**	**pH (CU)**	**Titration (%)**
2	3	6.79±0.01a	5.15±0.09a
4	3	6.94±0.01a	9.85±0.09a
5	3	6.78±0.01a	7.55±0.37a
6	11	6.77±0.07a	5.86±1.40a
7	15	6.89±0.06a	4.79±0.99a
8	15	6.83±0.02a	6.98±1.21a
9	12	6.84±0.02a	7.06±1.04a
10	12	6.85±0.01a	6.10±1.41a
F(p)	74	0.92(0.4943)	0.81(0.5860)

Values are expressed as Mean±SD. In the same column means followed by the same letter are not statistically significantly different (p>0.05), N: Number of observations; CU: Conventional units

Acid titration lactation lengths having the highest titration content is the 4 months, followed by 5 months and 9 months with an average value of 9.85±0.09, 7.55±0.37 and 7.06±1.04 % respectively while the lactation lengths of 2 and 7 months with an average value of 5.15±0.09 and 4.79±0.99 % respectively had the least titration content though there was no significant difference ($p>0.05$) **(Table 3).**

Chemical variation

Energetic constituents (fat, protein, lactose and energy) of milk of the different genetic groups of cows were found to be significantly ($p<0.05$) affected by the genetic groups of cows considered. The genetic groups WFxG, RFxWF and Red Fulani recorded respectively the highest fat content which was significantly different ($p<0.05$) of the lowest average value recorded by the genetic groups GxBR and White Fulani. Concerning the protein content, genetic groups of cows White Fulani, GxBR and Holstein recorded respectively the highest average value whereas the lowest values were obtained with the genetic groups of cows HFxWF and WHxG respectively **(Table 4).** Once more, the highest lactose content was recorded with cows of genetic groups White Fulani, GxBR and Holstein with a mean value of 5.10±0.01, 4.82±0.01 and 4.68±0.03 % respectively while RFxWF and HxWF obtained the lowest average value respectively. Energy content expressed in kcal/100 ml of milk of the different genetic groups of cows taken in consideration in this study revealed that, the highest energy content was recorded with cows WFxG, RFxWF and Red Fulani respectively while Holstein and White Fulani obtained the lowest energy content **(Table 4).**

Table 4. Energetic constituents of milk of the different genetic groups of cows.

Genetic groups	N	Fat (%)	Protein (%)	Lactose (%)	Energy (kcal/100ml)
Gudali	12	3.65±0.27bc	3.00±0.01bc	4.51±0.01bc	62.87±2.40bcd
GxBR	3	1.67±0.03ab	3.22±0.00d	4.82±0.01b	47.21±0.23abc
Holstein	9	1.70±0.36ab	3.12±0.03cd	4.68±0.03bc	46.48±3.35ab
HxWF	14	3.36±0.12bc	2.84±0.03a	4.26±0.04a	58.63±0.95abcd
Red fulani	12	3.71±0.08bc	3.09±0.02bcd	4.64±0.03bcd	64.31±0.59cd
RFxWF	6	5.09±0.54c	2.86±0.04a	4.30±0.05a	74.41±4.48d
White fulani	6	1.21±0.05a	3.40±0.01e	5.10±0.01c	44.88±0.41a
WFxG	12	5.12±1.15c	2.96±0.08ab	4.44±0.12ab	75.69±9.81d
F (p)	74	5.36 (0.0001)	15.76(0.000)	16.09 (0.0000)	4.96 (0.0001)

Values are expressed as Mean±SD. In the same column means followed by the same letter are not statistically significantly different (p>0.05); N: Number of observations; RF: Red Fulani; H: Holstein; G: Gudali; WF: White Fulani; BR: Brahman

Ash, dry matter, and added water content of milk of the different genetic groups of cows varied significantly (p<0.05) among groups of cows. Therefore, the breeds and crossbreed having the highest ash content are White Fulani and GxBR respectively while RFxWF and HxWF respectively had the lowest ash content. The genetic group with the highest dry matter content is the White Fulani followed by GxBR and Holstein respectively while RFxWF and HxWF respectively had the lowest dry matter content. The genetic group of cows with the highest added water content is the HxWF followed by RFxWF and WFxG with an average value of 5.96±0.85, 3.07±0.68 and 2.69±0.82 % respectively whereas GxBR, White Fulani and Red Fulani obtained the lowest added water content respectively. The results revealed that, crossbreeds obtained high added water content (p<0.05) than pure breeds. Also, genetic crossed cows HxWF have high added water content than local crossed cows GxBR, RFxWF and WFxG **(Table 5).**

Table 5. Ash, dry matter, and added water content of milk of the different genetic groups of cows.

Genetic groups	N	Ash (%)	Dry Matter (%)	Added water (%)
Gudali	12	0.67±0.01ab	8.22±0.03bc	0.16±0.07a
GxBR	3	0.72±0.00b	8.77±0.01d	0.00±0.0a
Holstein	9	0.70±0.01ab	8.51±0.06cd	0.51±0.27a
HxWF	14	0.64±0.01a	7.75±0.07a	5.96±0.85c
Red fulani	12	0.70±0.01ab	8.46±0.05bcd	0.00±0.00a
RFxWF	6	0.65±0.01a	7.84±0.09a	3.07±0.68b
White fulani	6	0.76±0.00c	9.28±0.01e	0.00±0.00a
WFxG	12	0.67±0.02ab	8.10±0.21ab	2.69±0.82b
F (p)	74	14.38 (0.0000)	16.21 (0.0000)	14.67 (0.0000)

Values are expressed as Mean±SD. In the same column means followed by the same letter are not statistically significantly different (p>0.05); N: Number of observations; RF: Red Fulani; H: Holstein; G: Gudali; WF: White Fulani; BR: Brahman

The lactation length was found to have a significant (p<0.05) effect on the energetic constituents (fat, protein, lactose and energy) of the different genetic groups of cows taken is consideration in the present study. The highest fat content was recorded at 9 months, followed by 7 and 6 months with an average value of 5.75±0.99, 3.66±0.41 and 3.34±0.44 % respectively. This is followed by 8, 4, 5 and 2 months in that order **(Table 6).**

Table 6. Energetic Constituents with lactation lengths (months).

Lactation lengths (months)	N	Fat (%)	Protein (%)	Lactose (%)	Energy (kcal/100ml)
2	3	0.39±0.02a	3.06±0.01ab	4.58±0.02ab	34.14±0.12a
4	3	2.59±0.05ab	2.89±0.00a	4.35±0.00a	52.28±0.47ab
5	3	1.67±0.03ab	3.21±0.00b	4.82±0.01b	47.21±0.22ab
6	11	3.34±0.44c	2.90 ±0.01a	4.36±0.02a	59.14±4.03b
7	15	3.66±0.41cd	2.92±0.07a	4.39 ±0.08a	62.21±3.35b
8	15	3.33±0.13c	3.13±0.03b	4.69 ±0.05b	61.29±0.93b
9	12	5.75±0.99c	2.89±0.00a	4.35±0.08a	80.72 ±8.42c
10	12	2.51±0.39ab	3.22±0.05b	4.83±0.08b	54.87±3.03b
F(p)	74	5.51 (0.0001)	7.72 (0.000)	7.85 (0.000)	5.15 (0.000)

Values are expressed as Mean±SD. In the same column means followed by the same letter are not statistically significantly different (p>0.05); N: Number of observations

The lactation length was the highest protein content was recorded were 10 months followed by 5 and 8 months with an average value 3.22±0.05, 3.21±0.00 and 3.13±0.03 % respectively while at 4 months and 9 months of lactation, the lowest average value (2.89±0.00 and 2.89±0.00 %) were recorded respectively as protein content is concerned. The highest lactose content was recorded at 10 months of lactation followed by 5 and 8 months with an average value 4.83±0.08, 4.82±0.01 and 4.69 ±0.05 % respectively, while at 4 months and 9 months of the lactation the lowest lactose content were obtained. The results revealed that at 9 months, 7 and 8 months of lactation, the highest energy content was recorded (80.72 ±8.42, 62.21±3.35 and 61.29±0.93 kcal/100ml respectively) while at 2 months and 4 months of lactation the lowest average values (47.21±0.22 and 34.14±0.12 kcal/100ml respectively) were obtained **(Table 6).**

Correlation analysis between the physicochemical parameters of milk of the different genetic groups of cows.

The results for the interrelationship between physicochemical parameter are presented in **Table 7.** Significant correlation was found between lactose and added water, lactose and pH, added water and fat as well as added water and protein.

Table 7. Correlations between parameters.

Parameters	Added water	pH	Fat	Protein
Lactose	-0.8; (0.0000)	-0.8 (0.0000)		
Added water	1		0.3; (0.0141)	0.9; (0.0000)
Fat			1	
Protein				1

The correlation coefficient, r is followed by the probability p in bracket

This correlation was significant positive between fat and added water (r=0.3, p=0.0141) as well as added water and protein while a negative correlation between lactose and water (r= -0.8, p=0.0000) was recorded. In addition, a negative correlation between lactose and pH (r= -0.8, p=0.0000) was obtained.

DISCUSSION

This study was conducted to assess the physicochemical properties of fresh cow's milk produced in Sabga. Fresh cow milk has a pH value that ranges from 6.6 to 6.8 [13]. In the present study, the pH ranged from 6.77 to 6.85. This value was close to the pH value (6.76) of fresh raw cow milk reported by Ahmad [14] with Holstein in France. These pH values were within the normal range of milk pH. This result indicated that no major biochemical change went on from collection to analysis. The pH values obtained may also testify of a poor, if not absent, infection of the udder of the animal. Taking in consideration the lactation lengths (months), the pH value recorded with cows at their fourth month of lactation was higher than the recommended range. This could be due to the presence of mastitis on the udders as O'Connor, [13] reported that pH values higher than 6.8 indicates mastitis milk. Normal fresh milk has an apparent acidity of 0.14 to 0.16% as lactic acid [13]. The titratable acidity milk obtained from the different genetic groups of cows were above the recommended range. This high acidity of milk may be due to the high bacterial growth and multiplication during transportation of the milk from the collection sites to the laboratory where the different samples of milk were analyzed on one hand, and on the other hand to the longer storage of the milk before titration test. Similar results were obtained by Hossain [15]. In the current study, 100% of milk samples obtained from dairy farms had a titratable acidity value of greater than 0.16%. The effect of genetic group on milk composition, for example, fat and protein has been discussed widely [16-18]. Because of genetic background and traits, milk samples collected from different cattle genetic groups have diverse compositional profile. A similar trend was observed in the results of this study, where fat and protein content varied across different genetic groups over the period of study. The average fat values obtained with local cows (Gudali, Red Fulani) and their various genetic crossed (WFxG, HxWF and RFxWF) in the current study were higher than the 3.42 found by Sanzceballos [19] in milk of Holstein. Fat content in this study showed that fresh natural milk from local's cows is richer source of fat than Holstein exotic breed. Such values for local cows in the range of 3.25 to 6.5 % had been reported by Kra [20]. This indicated that, in the case of butter production, the milk from local cows mostly the genetic crossed groups WFxG would be the best indicated considering its fat content. The average protein content of raw milk obtained from the different genetic groups of cows and from the different lactation lengths were not different from the 3.30 % found by Mirzadeh [21] in Holstein cow milk of Bordegan region of Iran and Abd Elrahman [22] who reported a protein content of 3.48 % for milk produced in dairy farms. According to European Union quality standards for unprocessed whole milk, total protein content should be between 2% to 4 % [20]. Therefore, the average proteins content observed from the different samples were within the recommended standards. The protein content is an essential characteristic of its market value because higher protein content improves the performance of milk processing technology. Milk with high protein content is good for cheese production [23]. The high protein content of milk samples from White Fulani (WF) cows therefore represents a good raw material for the dairy industry particularly in the production of cheese. The average lactose content ranges from 4.30 to 5.10%. This value was higher value found by Sanzceballos [19] in Holstein breed. Lactose is the major carbohydrate fraction in milk. The average lactose content of milk varies between 3.6 to 5.5%. Therefore, the average lactose content observed from the various genetic groups of cows were within the recommended standards. Lactose levels are normally greater than 4.5% in early and mid-lactation. Values recorded during the fourth, sixth, seventh and ninth lactation months could be attributed to the degeneration of the alveoli of the mammary glands or to the presence of mastitis as mastitis reduces lactose secretion [24]. The ash contents ranged from 0.65 to 0.76% was similar to the 0.65% found by Sanzceballos [19] in Holstein breed in France but lower than 0.79 found by Bonfoh [25] in raw milk composition of local crossbreed cows found in south Africa. The ash content of cow milk remains relatively constant 0.7 to 0.8% and it is influenced by breed, stage of lactation and feed of the animal [13]. The higher the ash content the higher the density. As regards dry matter content, the values founded in this study varied between 7.75 to 9.82 %. These values were lower than 13.0% reported by Mapekula et al. [26] in milk from local crossbreed cows in South Africa. The results for dry matter content from this study show the highest dry matter value for White Fulani genetic group, compared to all the other genetic groups of cows. This may be attributed to genetic merit of the animal. Raw milk energy value was higher with WFxG genetic group of cows and tended to increase with the days of lactation. Similar to the current study, lower energy values in early and late lactation stages were reported by Janus and with Polish Holstein-Frisian and Montbeliarde cows Barlowska [27]. The authors found in their study that milk energy value was significantly influenced by breed. The lowest milk energy value obtained during the first 120 days of lactation could be probably due to lower fat content as it was the case in this research work. Similar findings were reported by Salamonczyk [28]. Results showed a variability in the added water content in milk samples depending on the genetic group. The highest content of added water was found in HxWF (Holstein crossed White Fulani) genetic group of cows as compared to local cows. This observation could be due to the management practices, particularly as feed and nutrition are concerned. In fact, high temperature negatively influences milk production through a reduction of voluntary food intake and digestibility coupled to an increase pulmonary evaporation [8]. Cattle with high milk potential are not adapted to tropical climatic conditions. Due to their important milk production, they produce large extra heat quantity, calorific production difficult to evacuate when hygrometric air degree is important. Temperature Sudano-guinean zone of Cameroon and in particular Sabga varied between 15.50°C and 24.5°C, respectively with temperature possible to go above 30°C. These genetic crossed cows (HxWF) although tropical animals do not really support high temperature [29]. Therefore, the lowest added water content registered with local genetic groups of cows in this study might be due to the better capacity and thus their crossed (GxBr) to adapt in difficult environment as in the tropics [30]. Correlations have also been reported between milk components. Thus, positive correlations between added water and fat on one hand and added water and protein on the other hand could be attributed to variations in management conditions. These results were different from the founding of Stojan [31] who reported that by adding 25 % water to milk, fat and protein concentration drops down for 25 %.

CONCLUSION

In the present study, preliminary investigations were carried out to assess the physicochemical properties of cow's milk produced in Sabga locality. The results show a relatively good quality of fresh milk with variation of physicochemical parameters according to the genetic groups of cows considered and the lactation length. Values registered for most of the different contents of the different samples were within the recommended standards. In addition, results of this study revealed that local genetic cows White Fulani and their genetic crossed had the best performances concerning the milk constituents analyzed. Values recorded with added water and fat as well as added water and protein were positively correlated. These findings can be used as a base for determination of the quality of milk used directly by population or be used in milk industry in the production of dairy products such as butter and cheese. Based on these results, fresh milk collected from White Fulani genetic groups of cows could be recommended for the production cheese whereas in the case of butter production, the milk from the genetic group WFxG would be the best indicated considering its fat content. Nevertheless, further investigation on the microbiological status should be carried out on the cow's milk produced in the locality of Sabga.

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CONFLICT OF INTEREST

Authors declare no conflict of interest in the realization and publication of this piece of work.

ETHICAL ISSUE

This study is accordance to ethical guidelines of the Institute of Agricultural Research for Development (IRAD), Cameroon.

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