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Study of the physicochemical and mineralogical parameters of milk from suckling cows raised in the Donga basin (Northern Benin)

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Abstract

Context: *The physicochemical and mineralogical composition of cow milk is variable according to the animals' diet, environmental conditions and the lactation period. Samples of raw cow milk collected locally by semi-sedentary agro-pastoralists and mobile pastoralists of North Benin were analyzed in order to evaluate their physicochemical and mineralogical characteristics and to highlight their dietary properties.*

Materials and methods: *The milk samples were collected in sterile glass bottles and transported at room temperature in the dark to the laboratory and then subjected to physicochemical and mineralogical analyses. Parameters such as pH, acidity, density, fat and dry matter content, lactose content and viscosity were determined. Minerals and trace elements were determined by an atomic adsorption spectrophotometer with air-acetylene flame of VARIANet type AA20.*

Results: *From the results obtained, it appears that all the samples of cow's milk analyzed have a pH (6.58 to 6.80) and titratable acidity that are in the range that characterizes a normal and stable milk and undiluted. The fat content varies from 29.2 g/l to 31.6 g/l and dry matter is between 127.8 and 132.7g/l. Lactose, the main sugar present in milk, substrate of lactic fermentation for lactic bacteria, is in the normal range for raw milk, i.e. 40-50 g/l. These cow milk samples are very rich in major mineral elements (Ca, Mg, Na, P and K) and trace elements such as Zn, Cu, Fe and Mn.*

Conclusion: *This study, although limited, allowed to gather analytical data on some physicochemical parameters and mineral composition of suckling cow milk raised in Northern Benin. This cow milk is a food very rich in minerals and trace elements. Its appearance and composition depend on their immediate environment, their diet and the sanitation of milking.*

Key words: *Raw milk, cow, physicochemical analyses, mineralogical composition*

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I. Introduction

Milk occupies a strategic place in the daily diet of humans, due to its balanced composition in basic nutrients (proteins, carbohydrates and lipids) and its richness in vitamins and minerals, particularly dietary calcium[1].

In Benin, milk is a by-product of the exploitation of cattle, which is primarily used for meat. Its importance in livestock statistics is considered minor[2].

In Benin, in the Donga basin (northern Benin), there are two production systems that provide the bulk of cattle production, with nearly 70% : semi-sedentary agro-pastoralists and mobile pastoralists[3]. The role of cow's milk in the diet and economy of this pastoral community is well established. It contributes more than 50% of the annual income of Fulani households[4,5]. This milk, given its perishability, is transformed into a fresh molded cheese called "wagaashi", made by the agro-pastoralists. It is estimated that more than two-thirds of this milk is used in the production of cheese. It is estimated that more than two-thirds of local milk production is used to make this cheese. The other third is either self-consumed or sold as raw milk or curd[6]. It is the main local dairy product consumed in Benin, but also in Northern Togo and Western Nigeria.

In this study, we are interested in the study of bovine milk collected locally by semi-sedentary and mobile pastoralists in northern Benin. The aim is to evaluate its physicochemical and mineralogical characteristics in order to highlight its dietary properties.

II. Materials and Methods

Sampling

The samples analyzed were raw milk collected after milking a few suckling cows from semi-sedentary agro-pastoralists and mobile pastoralists in Donga, mainly from Djougou.

For each type of farmer, three cows were randomly selected for milking. Milking was manual and took place in September 2021 at 6:00 a.m. every third day for two weeks. Samples 1 to 3 were taken from cows of semi-sedentary agro-pastoralists and samples 4 to 6 from cows of mobile pastoralists.

The milk was collected in sterile glass bottles and transported at room temperature in the dark to the laboratory.

Physicochemical analysis

Immediately after milking, the temperature of the milk was measured with an electronic probe thermometer.

As soon as the raw milk samples arrive at the laboratory, the pH is measured with a pH meter of the Hanna instruments type after calibration at pH 7.02 and 4.00 by soaking in a small volume of milk taken in a Becher [7-12].

The titratable acidity was measured by titration with 1 N NaOH in the presence of phenophthalein and was expressed as a percentage of lactic acid

Freezing temperature was determined using an incubator/freezer (BIO, Firlabo).

The density is measured with a thermo-lactodensimeter. It is brought back to 20°C by the following formula: corrected density = density read + 0.2 (milk temperature - 20°C)

The fat content is determined by the acid-butyrometric method of Gerber, which consists of an attack of milk by sulfuric acid and separation by centrifugation in the presence of isoamyl alcohol of the fat released.

The dry matter content is estimated by evaporation in a water bath at 70°C and then drying the sample (10 ml) for 3 hours in an oven at 103 ± 2°C to a constant weight.

The lactose content is determined by spectrophotometry. To 1 ml of milk is added 1 ml of phenol water and 5 ml of sulfuric acid.

The mixture is mechanically homogenized and boiled for five minutes. The absorbance is read at 490 nm against a control prepared with distilled water. A standard curve is made from a stock solution containing 1 g/l of lactose.

- The viscosity is a physical quantity measured with a cylinder viscometer, coaxial type (BROOKFIELD, DV - E Viscometer). It is expressed in centipoise (cp).
- The ash content was obtained after the incineration of the total dry matter of the sample at a temperature of 550°C for 6 hours.

Mineralogical analysis

The content of minerals and trace elements was determined by atomic adsorption spectrophotometer. The spectrophotometer used in this study is the atomic adsorption spectrophotometer with air-acetylene flame of brand VARIAN and type AA20[13].

Mineralization and preparation of sample solutions

A quantity of 10ml of sample is taken and introduced in a porcelain crucible then put in the furnace (PROLABO) at 650°C during 5 h. After cooling, 5ml of 1 mol nitric acid is added to the obtained ash and then evaporated on a sand bath. To the residue are added 5 ml of 0.1 mol hydrochloric acid. It is then put back into the oven at 400 °C for 30 min. The final residue is recovered with 10 ml of 1 mol hydrochloric acid and poured into a 50 ml flask. The crucible is rinsed twice with 10 ml of hydrochloric acid. The flask is completed to 50ml with hydrochloric acid. Under the same conditions, a blank test is performed.[14]

Statistical analysis

To compare the effect of the different factors studied on the milk samples used, the Student's t-test at 5% on Exel 2003 was used (p=0.05). All the analyses are done in duplicate for each sample and the values represented in the tables and curves are the averages of the results obtained for the 6 samples already described.

III. Results

Physicochemical analysis

The results of the physicochemical analysis are shown in Table 1. Temperatures measured immediately after milking ranged from 36.5 to 37.5°C (Table I). The pH ranged from 6.55 to 6.80 with an average of 6.68. The average titratable acidity value was 16.9%. The density measured at 20°C is between 1.028 and 1.033 with an average value of 1.030.

Table no 1: Physicochemical parameters of the cow's milk samples analyzed

	Parameters									
Samples	(°C)	pH	Acidity (%)	Freezing (°C)	Density	Fat matter (g/l)	Dry matter (g)	Lactose (g/l)	Ash content (g/l)	Viscosity cp
E_1	37,2	6,67	16,7	-0,48	1,032	31,0	130,4	51,2	8,1	3,6
E_2	36 ,5	6,64	17,5	-0,46	1,030	30,2	128,6	49,7	8,4	2,8
E_3	37,1	6,58	17,6	-0,50	1,029	29,2	131,9	48,9	9,4	3,3
E_4	37,5	6,65	17,3	-0,51	1,028	30,4	132,7	50,3	9,2	3,4
E_5	36,6	6,80	15,9	-0,48	1,031	31,6	129,7	50,1	8,6	4,1
E_6	36,8	6 ,76	16,4	-0 ,47	1,033	31,2	127,8	49,8	7,8	3,8
Moyenne	36,9	6,68	16,9	-0,48	1,030	30,6	130,1	50,0	8,58	3,5

The average fat content is 30.6 g/l. The average freezing temperature is -0.48°C. The dry matter is between 127.8 and 132.7 g with an average of 130.1 g. The average lactose concentration is 50.0 g/l.

Mineralogical analysis

The composition of major mineral elements and trace elements was determined by atomic absorption spectrometry and is shown in Table no 2.

Table no 2: Mineral content of analyzed cow milk samples

	Mineral elements (g/l)								
Samples	Ca	K	P	Mg	Na	Cu	Zn	Fe	Mn
E_1	1,26	1,46	0,78	0,115	0,46	0,00020	0,0053	0,00063	0,000058
E_2	1,22	1,57	0,65	0,120	0,37	0,00017	0,0049	0,00049	0,000069
E_3	1,25	1,48	0,70	0,122	0,43	0,00023	0,0037	0,00067	0,000057
E_4	1,28	1,40	0,72	0,121	0,39	0,00019	0,0044	0,00044	0,000054
E_5	1,31	1,53	0,68	0,116	0,38	0,00014	0,0052	0,00042	0,000062
E_6	1,22	1,41	0,75	0,125	0,43	0,00023	0,0048	0,00058	0,000048

IV. Discussion

The different pH measurements of the milk of cows in the samples studied have an average pH of 6.68. The pH values reported in this study are in the range of 6.6 and 6.8 which characterizes a normal and stable milk[15] and are close to those reported by some authors such as Remeuf et al.[16] with a pH equal to 6.7 and Le Jaouen et al.[17]. The pH as well as the taste of the milk may depend on the nature of the fodder, the genetic factor, the health status of the animal and the availability of water.

As for titratable acidity, the average values of titratable acidity of the milk studied are lower than those found by Mathieu[18] for ten samples of cow's milk and under traditional milking conditions. Variability is related to climate, stage of lactation, feed availability, water intake, health status of cows and milking conditions.

In our study, we found very close specific gravity values in the range of 1.028 to 1.033, indicating that the milk is in its normal state and not diluted. The density depends on the dry matter content, fat content, temperature increase and food availability.

At a shear rate of 100 rpm, the measurement of viscosity gives results that oscillate between 2.8 cp and 4.1 cp with an average of and 3.5 cp. This variability can be explained by the difference in fat and protein content.

The results obtained show that the fat content varies from 29.2 g/l to 31.6 g/l. The average content is in agreement with the range of 28.5 to 32.5 g/l given by the AFNOR[19]. In the literature, we find very similar values recorded by Jaubert[20], 33 g/l and Singh et al.[21]. Nevertheless, we also find very distant values like the one found by Darkova et al.[22] 56.1 g/l. The variability of fat content depends on factors such as climatic conditions, stage of lactation and feeding.

The dry matter value is within the range of standards (28.5 to 34.3%) reported in the Moroccan literature, and depends on climatic and feeding factors.

Regarding their dry matter content, the results obtained show that the content is between 127.8 and 132.7g/l. Nevertheless, despite this variability, these values are very similar to values found in previous works such as Larpent[23] 134 g/l.

The average ash content of the analyzed samples is equal to 8.58g/l. It is in the range of works reported by other authors, since it is between 8g/l [24] and 9.66 g/l [25].

The average lactose value of the cow milk samples analyzed is approximately equal to that of the milk studied by Mathieu[17] (49.00 versus 50.00 g/l). Lactose, the main sugar present in milk, a substrate for lactic acid fermentation for lactic acid bacteria, is in the normal range for raw milk, i.e. 40-50 g/l.

The cow's milk samples analyzed are very rich in major mineral elements (Ca, Mg, Na, P and K) as reported by other works [26,27] . But still show differences between the studies carried out27 regarding the concentration of these minerals and trace elements (Zn, Cu, Fe and Mn). The variations observed from one

sample to another in their mineralogical composition may be due to the nature of the farm, the feed, the stage of lactation as well as the analytical procedures[28,29]

V. Conclusion

This study, although limited, has allowed to collect analytical data on some physicochemical parameters and mineral composition of suckling cow milk raised in Northern Benin. This cow milk is a food very rich in minerals and trace elements. Its appearance and composition depend on their immediate environment, their diet and the safety of milking.

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