**EFFECT OF BREED AND AGRO-ECOLOGY DIVERSITY OF THE SAVANNAHS OF NORTHERN CAMEROON ON PHYSICOCHEMICAL PROPERTIES AND ANTIOXIDANT ACTIVITY OF COW’S RAW MILK**

**Abstract**

While the mechanisms of antioxidant activity have been well identified and described for plant products, this is less true for dairy products. Their antioxidant potential has never been highlighted, making it particularly interesting to focus on them. It is in this dynamic that the present study was initiated with the aim of assessing the effect of agro-ecological diversity on the physicochemical and antioxidant parameters of raw milk in northern Cameroon. 81 samples of raw milk from four cattle breeds (Holstein, Montbeliarde, Goudali and Red Fulani) were collected from three production basins (Vina, Diamaré, Logone et Chari) to assess some physicochemical and antioxidant activity parameters. The physicochemical parameters vary significantly according to the sites: pH (6.2±0.08 to 6.6±0.01); TA (18.01±0.7 to 19.29±0.05°D); glucose concentration (43.93±0.52 to 52.59±0.21 g/l); lactose (45.85±1.08 to 47.68±0.05 g/l); reducing sugar (23.88±2.63 to 32.29±0.42 gEqGalactose/l); protein (3.80±0.7 to 4.85±0.29%); and amino acid (21.31±0.06 to 30.16±0.25 gEqAlanine/L). The antioxidant activity of milk, DPPH (56.79±0.93 to 74.25±0.17%), ABTS (54.16±2.27 to 69.71±4.93%), FRAP (53.14±1.59 to 65.57±0.54 Eq Trolox/l), vitamin C (12.81±0.11 to 17.35±0.42 mg Eq Ascorbic Acid/l) and vitamin A (6,39±0,21 à 9,4±0,7 µg/L) varies significantly (p <0.05) between basins production. Overall, agroecological diversity significantly influences (p <0.05) the measured parameters.

**Keywords**: raw milk, antioxidant activity, agroecology, quality.

**1. Introduction**

Milk is a prized food with an average worldwide consumption of 20.2 Kg/inhabitant/year (OECD and FAO, 2017) and 6 Kg/inhabitant/year in Cameroon. It is a complete food in terms of its physico-chemical composition. The protective power of food is the complex result of the synergistic action of all its components, which may have anti-inflammatory, anti-carcinogenic, antioxidant, hypoglycemic, probiotic properties, etc. (INRA, 2017). While the mechanisms have been well identified and described for plant products this is less true for animal products, and dairy products in particular (Abduljalil *et al*., 2023). The antioxidant power of a food is its ability to help the consumer's body neutralize the free radicals that can contribute to the aging of the body and the onset of various chronic diseases such as cancer, cardiovascular disorders, diabetes etc. (Tadesse *et al*., 2024). To date, no study has assessed the antioxidant potential of dairy products from the northern savannahs of northern Cameroon, compared with that of other foods. Yet the scientific literature clearly shows that dairy products are a significant source of antioxidants, notably due to their protein fraction, and have an antioxidant capacity of the same order of magnitude as that of cereals, legumes and fruit juices (Yilmaz-Ersan *et al.*, 2018; Pauletto *et al.,* 2020). The physico-chemical of raw milk is closely linked to sanitary quality, and is dependent on the associated technical practices. Studying the antioxidant activity of raw milk in order to understand its beneficial properties is of vital importance to public health.

**2. Materials and methods**

**2.1- Study areas**

The study was carried out in two agro-ecological zones of Cameroon, the Sudano-Sahelian zone and the Guinean high savannah zone, which are showcases for cattle breeding, constituting one of the major activities of these zones. Breeders make livestock a prestigious asset that they voluntarily and proudly hoard, even when essential family needs are not met (DSCN, 20012).

**2.2- Milk sampling**

Sampling was carried out at 9 milk collection sites per production basin. At each site, after morning milking, 20 ml of blended milk per dairy breed were collected in sterile, coded bottles, then placed in an adiabatic cooler containing ice pellets and transported to the laboratory to limit microbial proliferation.

**2.3- Physicochemical Analyses**

Milk pH was determined using a Cherker Hanna pH meter, in accordance with the method described by AOAC (2005). DM content was determined by dehydrating milk samples at 105°C in an oven. Ash content was determined by calcining the milk in a muffle furnace at 550°C for 6 hours. Dornic acidity was measured in the presence of sodium hydroxide solution (0.1N) and phenolphthalein as a color indicator, and expressed in Dornic degrees (°D) according to the method described by Ranganna (1979). Determination of total carbohydrate content was carried out in hot acid medium using the spectrophotometric method described by Dubois *et al*. (1956). Lactose was determined by reduction in a ferric sulfate solution using the method of Miller (1972). Milk lipids were extracted using hexane for 24 hours, according to the method developed by AOAC (2005). Total protein content was determined using the Kjeldhal method (AFNOR, 1984). The crude protein value was obtained by multiplying the nitrogen content by the conversion factor specific to dairy products, i.e. 6.38. Soluble amino acid content was assessed using the method described by Michel (1968). Vitamin C was determined using the method described by Zanini *et al*. (2018), while Vitamin A was determined using the method described by Bassey *et al*. (1946).

**2.4- Analysis of the antioxidant capacity of milk.**

The antioxidant capacity of milk was assessed by determining ABTS, FRAP and DPPH. The ABTS test was evaluated using the method described by Re *et al*. (1999). The principle of this method consists in the reduction of the ABTS+ radical in the presence of potassium persulfate. This causes the mixture to decolorize, absorbing at 734 nm. The FRAP test was carried out using the method described by Benzie and Strain (1996). The principle of this method is based on the ability of an antioxidant to reduce the Fe(III)-2,4,6-Tri(2)-pyridyl-s-triazine (TPTZ) complex to a blue Fe(II)-TPTZ complex that exhibits an absorption maximum at 593 nm. The intensity of coloration depends on the reducing power of the molecule tested. DPPH radical scavenging activity was determined using the method described by Sun et al. (2005). The principle is that, in the presence of an antioxidant, the free DPPH radical is scavenged following the antioxidant's hydrogen transfer reaction, leading to the formation of the non-radical DPPH-H. In the course of the reaction, a loss of violet color ensues, which can be easily monitored with a spectrophotometer at a wavelength of 517 nm. The speed of color loss is directly proportional to the antioxidant activity of the hydrogen donor.

**2.5. Data exploitation**

All measurements were performed in triplicate and results expressed as mean ± standard deviation. Analysis of variance (ANOVA) of means was used to assess the effect of different factors, and Duncan's test to classify means significantly different at the p<0.05 probability level. Statgraphics 5.0 software was used for this purpose.

**3- Results**

**3.1- General Physicochemical Properties of Raw Milk**

The pH of the milk collected differed significantly (p<0.05) between agro-ecological zones and cow breeds (Table 1). The pH of local breed ranged from 6.2±0.08 to 6.6±0.01 and 6.5±0.01 in Vina, Diamaré and Logone-et-Chari respectively. As for Montbeliarde pH, it followed the same trend of 6.2±0.01 and 6.7±0.02 in Vina and Diamaré respectively, while showing a profile comparable to the effects observed for Holstein pH (6.5±0.07 (Vina) and 6.9±0.4 (Diamaré). TA varied significantly (p<0.05) between cow breeds and production basins (Table 1). The TA of local breed showed the following profile: 18.96±0.54 °D (Vina), 18.48±0.03 °D (Diamaré) and 19.29±0.05 °D (Logone-et-Chari). The TA of Montbeliarde cows in Vina (18.46±0.51°D) and Diamaré (18.49±0.30°D) follows the same trend. Whereas the Holstein breed shows a TA profile of 18.69±0.14 °D in Vina and 18.01±0.7 °D in Diamaré. Milk density, DM, ash and water content did not vary significantly (p >0.05) between cows of the same breed and in the different agro-ecological zones (Table 1). The lowest milk density was observed in the Mbororo breed in Logone-et-Chari (1.12±0.01), while the highest value was observed in the Holstein breed in Diamaré (1.27±0.09). DM content remained variable across breeds, with Montbeliarde in Vina (13.28±0.45%), and Holstein in Diamaré (14.82±1.01%). Ash content varies according to breed, with Montbeliarde in Diamaré (0.83±0.03%) and Mbororo breed in Logone-et-Chari (0.94±0.02%). Moisture content also follows the same trend as the other parameters assessed, 85.18±1.01% for the Holstein breed in Diamaré and 86.71±0.45% for the Montbeliarde breed in Vina.

**Table 1:** Variation in pH, TA, density, dry matter, ash, and WC of raw milk

|  |  |  |
| --- | --- | --- |
| Parameters | Breed | Average value per production basin |
|  |  | Vina | Diamaré | Logone-and-Chari |
| pH | Local | 6.2±0.0 | 6.6±0.01 | 6.5±0.01 |
|  | Montbeliarde | 6.2±0.01 | 6.7±0.02 | - |
|  | Holstein | 6.5±0.07 | 6.9±0.4 | - |
| Milk | Local | 18.96±0.54 | 18.48±0.03 | 19.29±0.05 |
|  | Montbeliarde | 18.46±0.51 | 18.49±0.30 | - |
|  | Holstein | 18.69±0.14 | 18.01±0.7 | - |
| Density | Local | 1.026±0.07 | 1.016±0.01 | 1.012±0.01 |
|  | Montbeliarde | 1.022±0.01 | 1.015±0.02 | - |
|  | Holstein | 1.023±0.01 | 1.027±0.09 | - |
| Dry | Local | 13.67±0.22 | 13.87±0.04 | 13.55±0.15 |
|  | Montbeliarde | 13.28±0.45 | 13.56±0.31 | - |
|  | Holstein | 13.87±0.47 | 14.82±1.01 | - |
| Ash (%) | Local | 0.91±0.01 | 0.87±0.02 | 0.94±0.02 |
|  | Montbeliarde | 0.92±0.05 | 0.83±0.03 | - |
|  | Holstein | 0.92±0.03 | 0.85±0.11 | - |
| Water content | Local | 86.33±0.22 | 86.12±0.04 | 86.45±0.15 |
|  | Montbeliarde | 86.71±0.45 | 86.43±0.29 | - |
|  | Holstein | 86.13±0.46 | 85.18±1.01 | - |

NB: Values ​​with the same letters do not differ significantly at the probability threshold (p < 0.05).

Local\*: local refers to the Goudali breed in the Vina and Red Fulan in the Diamaré and Logon-et-Chari.

**3.2-Nutritional Parameters**

The parameters glucose, reducing sugar, lactose, protein, amino acids and lipids in the milk analyzed showed significantly different values (p<0.05) between the agro-ecological zones of production. Glucose concentration in raw milk varied between local breed: 45.20±0.85; 52.48±0.32 and 52.59±0.21 g/l for Vina, Diamaré and Logone-et-Chari respectively. Glucose levels in Vina Montbeliardes (52.59±0.21 g/l) were comparable to those in Diamaré Montbeliardes (51.13±0.82 g/l). The milk with the lowest glucose concentration was observed in Holsteins from Vina (43.93±0.52 g/l). The reducing sugar content of local breed showed different profiles between agro-ecological zones: 25.83±0.69; 32.29±0.42 and 28.33±0.62 gEqGalactose/l, respectively for Vina, Diamaré and Logone-et-Chari. Reducing sugar for Montbeliardes was 26.35±1.8 gEqGalactose/l (Vina) and 31.77±0.8 gEqGalactose/l (Diamaré), while Holsteins recorded the lowest values at 23.88±2.63 gEqGalactose/l (Vina) and 31.04±0.76 gEqGalactose/l (Diamaré).

Milk lactose levels were highest for Red Fulani in Logone-et-Chari (47.68±0.05 g/l) and lowest for Holsteins in Diamaré (45.85±1.08 g/l). Lactose levels remain comparable for Montbeliardes, Vina (46.31±0.12 g/l) and Diamaré (46.05±0.14 g/l). The total protein content of local breed milk showed no significant difference between agro-ecological zones. Milk with the highest protein content (4.85±0.29%) was found in the Montbeliarde breed from Diamaré, and the lowest in the Holstein breed from Diamaré (3.80±0.7%). Local breed amino acid levels varied between agro-ecological zones, at 30.16±0.25; 21.31±0.06 and 28.22±0.53 gEqAlanine/L, respectively for Vina, Diamaré and Logone-et-Chari. This trend can also be observed in Montbeliarde cows, 28.68±0.54 (Vina) and 21.31±0.68 (Diamaré) gEqAlanine/L. The effects observed previously follow the same logic in Holsteins, 29.54±1.17 and 26.07±2.11 gEqAlanine/L, respectively for Vina and Diamaré. The fat content of local breed showed a similar trend to the previous parameters, with (4.39±0.36%) in Vina, (3.57±0.11) in Diamaré and (4.41±0.03) in Logone-et-Chari respectively. The fat content of Montbeliarde cows was not significant in Vina (4.40±0.29%) and Diamaré (4.40±0.03%), and the same trend was observed for Holstein cows in Vina (4.39±0.86%) and Diamaré (4.24±2.68%).

**Table 2:** Variation of nutritional parameters of raw milk

|  |  |  |
| --- | --- | --- |
| Parameters | Breed | Average value per production basin |
|  |  | Vina | Diamaré | Logone-and-Chari |
| Glucose ( | Local | 45.20±0.85 | 52.48±0.32 | 52.59±0.21 |
|  | Montbeliarde | 45.85±1.28 | 51.13±0.82 | - |
|  | Holstein | 43.93±0.52 | 50.64±2.18 | - |
| Reducing | Local | 25.83±0.69 | 32.29±0.42 | 28.33±0.62 |
|  | Montbeliarde | 26.35±1.8 | 31.77±0.8 | - |
|  | Holstein | 23.88±2.63 | 31.04±0.76 | - |
| Lactose (g/l) | Local | 46.14±0.18 | 46.29±0.03 | 47.68±0.05 |
|  | Montbeliarde | 46.31±0.12 | 46.05±0.14 | - |
|  | Holstein | 46.13±0.11 | 45.85±1.08 | - |
| Proteins | Local | 3.89±0.54 | 3.84±0.03 | 3.93±0.05 |
|  | Montbeliarde | 3.84±0.51 | 4.85±0.29 | - |
|  | Holstein | 3.86±0.14 | 3.80±0.7 | - |
| Amino | Local | 30.16±0.25 | 21.31±0.06 | 28.22±0.53 |
|  | Montbeliarde | 28.68±0.54 | 21.31±0.68 | - |
|  | Holstein | 29.54±1.17 | 26.07±2.11 | - |
| Lipid | Local | 4.39±0.36 | 3.57±0.11 | 4.41±0.03 |
|  | Montbeliarde | 4.40±0.29 | 4.40±0.03 | - |
|  | Holstein | 4.39±0.86 | 4.24±2.68 | - |

NB: Values ​​with the same letters do not differ significantly at the probability threshold (p < 0.05).

Local\*: local refers to the Goudali breed in the Vina and Red Fulan in the Diamaré and Logon-et-Chari.

The vitamin profile varies significantly (p <0.05) across production basins, as shown in Figure 1 for vitamin C in Holsteins (13.09±0.46 and 17.53±0.21 mgEqAscorbic Acid/L, respectively for Vina and Diamaré). Local breed Vit C showed the same significant trend, at 12.81±0.11; 13.79±0.29; 16.88±0.45 mgEqAscorbic Acid/L, for Vina, Logone-et-Chari and Diamaré respectively, while Montbeliardes from Diamaré (17.35±0.42) and Vina (15.61±2.36) showed divergent profiles. The vitamin A profile (Figure 1) is significant for the different production basins, with Montbeliardes at 6.39±0.21 and 8.64±0.19 µg/L for Diamaré and Vina respectively. Holsteins follow the same trend, with 6.55±0.16 in Maroua and 8.84±0.31 µg/L in Vina. Local breed follows the same pattern, with 8.53±0.30, 6.67±0.21 and 9.04±0.07 µg/L in Logone-et-Chari, Diamaré and Vina respectively.

**Figure 1:** Vitamin profiles (C and A)

**3.3- Antioxidant activities of raw cow milk**

The antioxidant activity of raw milk through the determination of DPPH, ABTS and FRAP enabled us to evaluate the antioxidant power of milk from different production basins (Table 4). It was found that the rearing site had a significant impact (p <0.05) on the various parameters analyzed. The highest DPPH was observed in the Diamaré Red Fulani (74.25±0.17%). The DPPH of Logone-et-Chari Red Fulani (56.79±0.93%) was comparable to that of Vina Goudali (57.87±1.79%). The DPPH of the Montbeliarde (72.43±0.39%) and Holstein (70.85±9.63%) breeds from Diamaré is higher than that of the Montbeliarde (59.41±0.55%) and Holstein breeds from Vina (57.92±0.72%). ABTS ranged from 54.16±2.27% (Vina Gougali) to 69.71±4.93% (Diamaré Holstein). Both ABTS and DPPH varied significantly (p<0.05) across production basins, with noticeable variations within breeds. Montbeliardes (66.49±0.38%) and Holsteins (69.71±4.93%) from Diamaré have higher ABTS than Montbeliardes (55.96±0.22%) and Holsteins (54.52±0.53%) from Vina.

Antioxidant activity through FRAP shows significantly (p<0.05) different values in the production basins, with loose variations between breeds, with 53.14±1.59 g Eq Trolox/l for Holsteins from Vina and 65.57±0.54 g Eq Trolox/l for Holsteins from Diamaré. The FRAP values for Montbeliarde from Vina (58.43±0.35 g Eq Trolox/l) differ from those for Diamaré (63.14±0.55 g Eq Trolox/l). For the local breed, FRAP follows this trend with 54,37±1,21 g Eq Trolox/l in Vina, 62,45±0,23g Eq Trolox/l in Diamaré and 65,04±0,07 g Eq Trolox/l in Logone-et-Chari.

**Table 3:** Variation in the antioxidant activity of raw cow's milk

|  |  |  |
| --- | --- | --- |
| Parameters | Breed | Average value per production basin |
|  |  | Vina | Diamare | Logone-and-Chari |
| DPPH (inhibition %) | Local | 57.87±1.79 | 74.25±0.17 | 56.79±0.93 |
|  | Montbeliarde | 59.41±0.55 | 72.43±0.39 | - |
|  | Holstein | 57.92±0.72 | 70.85±9.63 | - |
| ABTS (inhibition %) | Local | 54.16±2.27 | 68.22±0.17 | 65.15±0.49 |
|  | Montbeliarde | 55.96±0.22 | 66.49±0.38 | - |
|  | Holstein | 54.52±0.53 | 69.71±4.93 | - |
| FRAP (g | Local | 54.37±1.21 | 62.45±0.23 | 65.04±0.07 |
|  | Montbeliarde | 58.43±0.35 | 63.14±0.55 | - |
|  | Holstein | 53.14±1.59 | 65.57±0.54 | - |

NB: Values ​​with the same letters do not differ significantly at the probability threshold (p < 0.05).

Local\*: local refers to the Goudali breed in the Vina and Red Fulan in the Diamaré and Logon-et-Chari.

**4- Discussion**

The pH of the milks show values in a range compatible with those commonly observed in cattle, and are similar to the pH (6.6 to 6.8) of normal, stable raw milk obtained by Stobiecka *et al*. (2022), but contrasts, with the results (7.67±0.04) of Maïworé *et al*. (2018) on raw milk from cows in the town of Maroua in Cameroon. The differences observed between these results could be linked to the health status of the cows, so mastitis contamination would induce alkaline pH according to Maïworé *et al*. (2018). The titratable acidity of the milks studied ranged from 18.51±0.24 to 19.29±0.5°D, remaining in a range slightly above the AFNOR standard (16 to 18°D). This may have a causal link with the drop in milk pH, certainly due to the implementation of approximate hygienic methods during milking. Titratable acidity is one of the indicators of milk quality, and at high values may reflect bacterial activity of the lactic flora. The water content of the milk analyzed complies with the AFNOR standard for undiluted milk. Milk dry matter content remains closely linked to cow breeds, and is therefore within the genomic range for Holstein (14.82±1.01%), Montbeliarde (13.56±0.31%), Red Fulani (13,87±0,04%) and Goudali (13.67±0.22%) as well as for the Holstein (13.94%), Jersey (12.23%) and Simmental (12.79%) breeds reported by Tadesse *et al*. (2024). All these values fall within the range of 12.51% to 22.83% observed by Gondimo *et al.* (2024) and Dandare *et al.* (2014). The ash values obtained are similar to those recommended by FAO (2020).

The milk lactose values obtained (45.85±1.08-47.68±0.05 g/l) fall within the recommended limits (37.08 to 57.85 g/l) of the AFNOR standard, but contrast slightly with those of Otmane *et al.* (2022) (40.2±1.35 g/l) and Tesfay *et al*. (2015) (48.0±1.15 g/l). It is also a parameter that is correlated with cow breed according to the work of Tadesse *et al*. (2024) on raw cow milk, which justifies the variability observed within the three breeds studied. The fat content of the raw milks analyzed, ranging from 3.57±0.11 to 4.41±0.03%, remains lower than those obtained by Tesfay *et al*. (2015) (3.86% to 7.80%) and Dandare *et al*. (2014) (5.96 to 6.80%), but is slightly higher than the 3% recommended by the FAO (2020). This could be justified by a diet richer in cotton seed cake. The protein contents (3.84±0.51 to 4.85±0.29) obtained are similar to those obtained by Khan *et al.* (2017) (3.34±0.72%), and by Abduljalil *et al*. (2023) (3.63%). This could be justified by similar food formulations in African savannahs, but these contents remain within the minimum limit of 3% recommended by FAO (2020), but are lower than the 6.46% of Khan *et al.* (2019) and 6.89% of Gondimo *et al.* (2024). Protein and lipid variations in raw cow milk are correlated with genetic diversity, diet and stage of lactation (Wafa, 2018).

The presence of vitamins C and A in the milks analyzed testifies to their antioxidant power, which helps the consumer's body neutralize the free radicals that can damage cells and contribute to the onset of various diseases. In fact, vitamin C neutralizes lipidic free radicals produced from unsaturated acids during oxidative stress, thereby protecting cells against oxidative damage. In the same vision, beta carotene, which is a precursor of vitamin A possesses antioxidant properties that can help protect the body against oxidative stress (Karadag et al. 2019).

The antioxidant activity of raw cow's milk was apprehended on the basis of the assessment of anti-free radical activity with DDPH, anti-free radical activity with ABTS and antioxidant activity with FRAP. The choice of this diversity of methods is linked on the one hand to the mechanism of action, which differs from one antioxidant to another, and on the other hand to the lack of a single standard quantitative technique to explain all antioxidant activities, as reported by Karadag *et al.* (2019).

The DPPH free radical scavenging activity of the milks analyzed varies significantly (p ˂0.05) between production basins and raw milk from cows and the Diamaré production basin comes in pole position with a DPPH value of 73.30±0.97% and consequently the antioxidant activity of this milk appears more preeminent. This corroborates the findings of Khan *et al.* (2019), for whom the higher the DPPH value, the greater the antioxidant function. The DPPH of the analyzed milks is comparable to the results of Khan *et al*. (2019) of 77.12±3.01%. The reasoned choice of raw material and the conditions of implementation of the different feed formulations and breeding may be at the origin of the differentiation of DPPH values. Milk from the Diamaré production basin follows the same trend for antioxidant activity with ABTS of (69.71±4.93%) and comparable to the ABTS of 69.27% obtained by Yilmaz-Ersan *et al*. (2018), but remains above that of Otmane *et al.* (2022) of 30.27±9.25%. Antioxidant activity indicators (DPPH, ABTS, FRAP) follow the same trend in the different production basins, reflecting the pronounced antioxidant activity of the milks analyzed. Antioxidant activity by FRAP appears comparable in two basins, with 65.57±0.54 g Trolox Eq/l in Diamaré and 65.04±0.07 g Trolox Eq/l in Logone-et Chari, but remains contrasted in Vina (58.43±0.35g Trolox Eq/l). These values are considerably higher than those (44.71 g Eq Trolox/l - 52.71 g Eq Trolox/) obtained by Pauletto *et al*. (2020).

Overall, the different levels of antioxidant activity obtained seem to suggest a high level of antioxidant activity of the milks analyzed, although variability exists between production basins and breeds, which may be linked to food formulations and environmental factors. This perception is in line with the work of Abduljalil *et al* (2023) on the comparative study of the antioxidant activity of milk from Holstein, Red Bororo, Sokoto Gudali and White Fulani dairy cows in Nigeria. The results of analyses by DPPH, ABTS, FRAP and Vit C and A showed that milk is endowed with antioxidant activity, and consequently its consumption can help neutralize free radicals.

**Conclusion**

The aim of this study was to assess the antioxidant potential of raw milks from different production basins (Vina, Diamaré, Logone-et-Chari), which has not attracted much scientific and technical interest. This study highlighted the antioxidant activity of milks from the northern savannahs of North Cameroon through integrated analysis of vitamin profiles (C and A), DPPH, ABTS and FRAP. These results are comparable to those obtained in Africa savannah’s by others authors and these results suggest that milk consumption may help reduce oxidative stress and protect against chronic diseases such as obesity, metabolic syndrome, type 2 diabetes and cardiovascular disease.

**References**

1. Abduljalil M., Umar F., Nnamdi A., Haruna H., Ibrahim A., and

Shamsudeen U., 2023. Comparative analysis of the antioxydeant capacity of milk from different breeds of cow in Nigeria. Int. J. Biol. Chem. Sci. 17(2). http://www.ifgdg.org.

2. AFNOR, 1984. Food Products: General Guidelines for the Determination of Nitrogen with Mineralization According to the Kjeldahl Method. In Godon and Pineau. Practical Guide to Cereals. Apria France 4: 263-266.

3. AOAC, 2005. Official Methods of Analysis of AOAC International. (18th ed.). Gaithersburg, MD: AOAC International. In W. Horwitz and G. Latimer (Eds.).

4. Bassey O. A., Lowry O. H., Brock M. J., Lopez J. A., 1946. The determination of vitamin A and carotene in small quantities of blood serum. J. Biochem., 234(166): 177-188. 5. Benzie I., Strain J., 1996. Ferric Reducing Ability of Plasma (FRAP), a Measure of Antioxidant Power: The FRAP Assay. Analytical Biochemistry 239:70-76.

6. Burtin H., Cheruel A., Collu E., Dudognon E., Moureau C., Schmitt C., Pace H., Lessis M. And Borges F., 2014. “Food safety” Ensaia, University of Lauraine. pp. 55.

7. Cloetens L, Panee J, Akesson B., 2013. The antioxidant capacity of milk - The application of different methods in vitro and in vivo. Cell. Mol. Biol. 59:43-57.

8. Dandare S., Ezéonwumelu I., Abubakar M., 2014. Comparative analysis of nutrient composition of milk from different breeds of cows. European Journal of Applied Engineering and Scientific Research, 3(2): 33-36.

9. DSCN (Directorate of Statistics and National Accounting), 2001. Household living conditions and poverty profile in the Far North of Cameroon in 2001, pp. 133.

10. Dubois M., Gilles K., Hamilton J., Rebers P., Smith F., 1956. Colorimetric Method for Determination of Sugars and Related Substances. Analytical Chemistry 28: 350-56.

11. FAO, 2020. Milk Facts. Retrieved Dec 27, 2021, from Milk Facts (fao.org)

12. Gondimo E., Abdelsalam D., Markhous N., Mahamat D., Serge N., Abdelsalam T., 2024. Evaluation of the physicochemical quality of raw milk produced and marketed in Moundou (Chad). Int. J. Biol. Chem. Sci. 18(2): 430-438. http://www.ifgdg.org.

13. INRA (2017). The antioxidant power of dairy products: an unknown property of their protective potential. Nutritional Research and Information Center, No. 155, pp. 1-6.

14. Karadag A., Ozcelik B., Saner S., 2019. Review of methods to determine antioxidant capacities. Food Analytical Methods, 41-60. DOI: httpI://dx.doi.org/10.1007/s12161-008-9067-7.

15. Khan I., Nadeem M., Imran M., Ullah R., Ajimal M., and Hayat M., 2019. Antioxidant properties of milk and dairy products: a comprehensive review of the current knowledge. Lipids in health and disease.

16. Khan IT, Nadeem M, Imran M, Ayaz M, Ajmal M, Ellahi MY, Khalique A. 2017. Antioxidant capacity and fatty acids characterization of heat-treated cow and buffalo milk. Lipids in Health and Disease. (1): 163. https://doi.org/10.1186/s12944-017-0553-z.

17. Maïworé J., Baane M., Amadou T., Ouassing A., Ngoune T., and Montet D., 2018. Influence of milking conditions on the physicochemical and microbiological qualities of raw milk collected in Maroua, Cameroon. Afrique Science.

18. Mariétou S., Vinsoun M., and Georges Anicet O., 2015. Chemical composition and bacteriological quality of raw and pasteurized milk in Burkina Faso. Afrique SCIENCE 11(1) ISSN 1813-548X, http://www.afriquescience.info.

19. Michel M., 1968. Determination of Amino Acids and Amines by Ninhydrin. Practical Improvement. Yearbook of Animal Biology, Biochemistry, and Biophysics 8: 557-563. 20. Miller G., 1972. Use of Dinitrosalicylic Acid Reagent for Determination of Reducing Sugars. Analytical Chemistry 31:

21. OECD and FAO, 2017. Chapter 7. Milk and Dairy Products. OECD-FAO Agricultural Outlook 2018-2027

22. Otmane R., Remadni M., Badi Y., 2022. Comparative Study of the Physicochemical Characteristics of Different Raw Milks (Camel, Goat, and Cow) from the El-Oued and Bougous Region (El-Tarf Province). Rev. Sci. Technol., 28(2). 23. Pouletto M., Elgendy R., Ianni A., Marone E., Giantin M., Grotta L., Ramazzotti S., Bennato F., Dacasto M., Martino G., 2020. Nutrigenomic Effects of Long-Term grape Pomace Supplementation in Dairy Cows. Animals, 10, 714. PubMed

24. Ranganna S., 1979. Determination of Titratable Acidity. 7, Churchille Living Stone 142.

25. Re R., Pellegrini N., Proteggente A., Pannala A., Yang M., Rice-Evans C., 1999. Antioxidant Activity Applying an Improved ABTS Radical Cation Decolorization Assay. Free Radical and Biological Medicine 26(9-10): 1231-1237.

26. Stobiecka M., Krol J., and Brodziak A., 2022. Antioxidant Activity of Milk and Dairy Products. Animals. 12, Pp 245. https://doi.org/10.3390/ani2030245.

27. Sun T., Tang J. and Powers R., 2005. Effect of Pectolytic Enzyme Preparations on the Phenolic Composition and Antioxidant Activity of Asparagus Juice. Journal of Agricultural and Food Chemistry 113: 964-969.

28. Tadesse A., Dawit G., Birhane H., Fsahatsion H., Hagos H., Girmay K., 2024. The effect of season and agro-ecology on physicochemical properties of cow’s raw milk in Central and North-Western Zone of Tigray, Ethiopia. Heliyon 10 (3 9050). https://doi.org/10.1016/j.heliyon.2024.e39050.

29. Tesfay T., Kebede A., and Seifu E., 2015. Physicochemical properties of cow mik produced and marked in Dire Dawa town, Eastern Ethiopia. Food Science and Quality Management. (42). ISSN 2224-6088.

30. Wafa N., 2018. Study of the physicochemical and microbiological quality of milk from sheep raised in steppe conditions in the Tébessa region. Dissertation.

31. Yilmaz-Ersan L., Ozcan T., Akpinar-Bayizit A., and Sahint S., 2018. Comparison of antioxidant capacity of cow and ewe milk kefirs. Journal of Dairy Science. Vol 101:3788-3798.

32. Zanini D., Silva M., Elizama A., Mônica R., Eliana S., Rafael R., 2018. Spectrophotometric Analysis of Vitamin C in Different Matrices Utilizing Potassium Permanganate. European International Journal of Science and Technology 7(1): 70-84.