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Composition of raw cow milk and artisanal yoghurt collected in Maroua (Cameroon)

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The composition of milk is of most importance to the dairy industry and human health. This study was conducted to provide data on the composition of raw cow milk and artisanal yoghurt collected in Maroua (Cameroon). Milk and yoghurt samples were collected from 11 breeding sites and 12 producers in the city of Maroua, respectively. The following parameters were determined: pH, dry matter, ash, fat, lactose, total protein, non-casein nitrogen (NCN), non-protein nitrogen (NPN), true protein, whey protein, casein, amino acid composition, α-lactalbumin, β-lactoglobulin, αS1-casein, αS2-casein, β-casein, κ-casein and mineral composition. The results showed that, the composition of the milk and yoghurt varied from one sample to another. The chemical composition of some of the milk and yoghurt studied differed from the corresponding samples in previous studies. For example the mean pH of the raw cow milk (6.25) and artisanal yoghurt (3.84) were lower. The mean NPN levels of the cow milk and yoghurt (0.21g/100g) were higher. The mean fat content of milk (4.48 g/100 g) was higher. The protein fraction was lower in yoghurt while Fe, Cu and Mn levels were lower in both cow milk and yoghurt. The data reported in this paper would be helpful in dairy technology and public health.

Key words: Composition, cow milk, artisanal yoghurt, Maroua, Cameroon.

INTRODUCTION

Milk is a translucent white liquid produced by the mammary glands of mammals (William and Bowen, 2005). Milk and milk products are excellent high quality foods, providing nutrients (Aboul et al., 2005). They have an important place in the human diet. Milk has been described as being almost a complete food for man. It contains carbohydrates, protein, fats, vitamins, mineral elements and water. The quality and the composition of milk are very important to the dairy industry and human health because milk composition is related to milk process ability (Ozrenk and Selcuk Inci, 2008).

For centuries, milk production in Cameroon has been characterized by a traditional system using local zebu cows (Goudali, White Fulani and Red Fulani). The total milk production is estimated at 174000 tonnes/year (MINEPIA, 2009). It varies from 0.5 (in the dry season) to 3 L per day in the rainy season and per cow on a 180-day lactation period (MINEPIA, 2009). The total consumption

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Abbreviations: TN, Total nitrogen; **NCN,** non-casein nitrogen; **NPN,** non-protein nitrogen.

of milk and dairy products in Cameroon is estimated at 297,000 tonnes/year. Per capita annual consumption was 19.8 Kg in 2009. The production of cow milk in the Far North Region of Cameroon is 41 760 tonnes/year (ACDIC, 2006). Milk collection is difficult, due to the dispersion and remoteness of farms to the industrial processing units. Infrastructure for collection, storage and transport are almost inexistent. These infrastructural problems result to the deterioration of fresh milk before entering processing areas and even consumption, reducing revenues and profitability of the business.

Milk of lactating cows are often consumed in the country or incorporated in the preparation of maize, millet/sorghum and rice porridge. A large part of the milk is transformed into artisanal yoghurt by different Common Initiative Groups settled in the area. Several authors from various countries have studies on the composition of cow milk. The composition of cow milk varies considerably due to a number of factors: season, diet, age, stage of lactation, physiological status, genetic, environmental and region of production (Iggman et al., 2003; Farah et al., 2006; Slots et al., 2009; Mapekula et al., 2011; Frelich et al. 2012; Myburgh et al., 2012). The results obtained are specific to the country of study.

In Cameroon, several studies have been carried out on the composition of foods and dishes (Ponka et al., 2006; Fokou et al., 2009), but the composition of milk and dairy products has received little attention. Therefore, the aim of this study was to determine the composition of raw cow milk and artisanal yoghurt collected in Maroua, a town in the Far North Region of Cameroon.

MATERIALS AND METHODS

Collection area

The study area was Maroua, a town in the Far North region of Cameroon. This town is located between latitude 10 and 13° North and between longitude 13 and 16° East. Its population is estimated at about 200 000 inhabitants (RGPH, 2010). The climate is tropical Sudano-Sahelian type with two seasons: a long dry season of about eight months, from October to May and a short rainy season of four months, from June to September. Rainfall is low with an average precipitation between 900 and 1000 mm per year. Temperatures range from 17°C in November to 40°C in April. The vegetation is mainly thorny steppe and carpet grasses or ephemeral. The soils are clayey-sandy black or greyish (Donfack et al., 1996). The main activities are agriculture (with the cultivation of millet, corn, sorghum, cotton, vegetables among others), livestock (cattle, goats, swine, and poultry farming), crafts (jewellery, tannery) and trade.

Sampling

Surveys were conducted in Maroua city to identify cow' breeding sites and structures of artisanal yoghurt production. Fresh raw cow milk samples were therefore collected from 11 breeding sites: Hodango (M1), Medenguer (M2), Dabai (M3), Tondewo (M4), Mayelbehi (M5), Palama (M6), Doubazao (M7), Palaodi (M8), Lougadadou (M9). Hardé (M10), Doulgo (M11). Each of the 11 fresh milk samples was packaged in sterile bottles and transferred immediately to laboratory in the bucket containing ice because there was no cold chain for the storage of milk in the breeding sites. The 11 breeding sites had the same characteristics. In each site, there was a mixture of Goudali, White Fulani and Red Fulani cows. All the cows were thin. Milking was done by hand. Ages calves varied from 1 to 12 months. Lactating cows were fed essentially with millet pellicles, millet stalks, grass, salt and cotton crab. The only difference was observed with the amount of food served to cows per site.

Artisanal yoghurt samples were collected from 12 producers in the city of Maroua and labelled YA, YB, YC, YD, YE, YF, YG, YH, YI, YJ, YK and YL. For the manufacture of yoghurt, each producer used as ingredients a mixture of raw cow milk obtained from farmers of Maroua city, industrial yoghurt as a starter source and sugar in different proportions. For yoghurt preparation, whole cow milk was heated to boiling to destroy the pathogenic organisms at 80°C for 10 min. It was then transferred to a container and cooled to 40°C. Industrial Dolait yoghurt was added as a starter source (*Lactobacillus bulgaricus* and *Streptococcus thermophilis).* The proportion of sugar used is in general 1 kg for 10 l of milk. Once the starter, was completely mixed, it was then incubated at 41-43°C for 6-8 h to complete the preparation. Yoghurt is cooled and stored under normal refrigeration conditions. The milk collected in each site was a mixture of milk from the milking of several lactating cows. In the laboratory, each of the 11 milk samples and 12 artisanal yoghurt samples was packaged in sterile bottles and stored at -20°C, until analysis.

Chemical analysis

pH and proximate composition

pH was measured using an H1 9024Microcomputer pH meter (Hanna Instruments, Portugal). Dry matter was determined by drying 5 g of sample at 103°C for 7 h in a capsule containing sand according to IDF (1987). Fat was determined according to IDF (1997). Ash was determined after incineration of sample at 550°C for 7 h according to IDF (1964a), and total nitrogen (TN) content of sample, non-casein nitrogen (NCN) and non-protein nitrogen (NPN) fractions were prepared according to IDF (1964b). For NCN, the sample was acidified to pH 4.6 with a mixture of 10% (v/v) acetic acid and 1 M acetate buffer. For NPN, about 40 ml of 15% (v/v) trichloroacetic acid were added to 10 ml of milk. NCN and NPN samples were filtered through Whatman papers (Whatman Int. Ltd., Maidstone, UK) No. 42 and 40, respectively. TN, NCN and NPN were determined by the Kjeldhal method (IDF standard 20B 1993). Nitrogen content was converted into equivalent protein content using 6.38, 6.25 and 6.19 as conversion factors for TN, NCN and NPN contents, respectively (Karman and Van Boekel, 1986). Whey protein was calculated from the difference between NCN and NPN, casein N from TN and NCN, and true protein from TN and NPN, respectively.

Amino acid analysis

Total amino acid content was determined after hydrolysis of samples by 6 N hydrochloric acid at 110°C for 24 h in a vacuum sealed glass tubes according to Davies and Thomas (1973). The amino acid analysis of the hydrolysed samples was then carried out by cation exchange chromatography on a Biochrom 30 automatic amino acid analyzer (Biochrom Ltd, Cambridge, G.B.) according to Spackman et al. (1958) using lithium citrate buffers as eluants and ninhydrin post-column reaction system. Tryptophan was not determined.

Dairy protein quantification

α-Lactalbumin and β-Lactoglobulin contents were determined on

Table 1. pH and proximate composition of raw cow milk (g/100g) collected in Maroua (Cameroon).

Sample	pH	Dry matter	Ash	Fat	Lactose	Total protein	NPN	NCN	True protein	Whey protein	Casein
M1	6.12 ± .01^{g}	14.07±0.09^{d}	0.67±0.02^{abc}	5.60±0.10^{d}	6.19±0.07^{a}	3.33±0.06^{c}	0.16±0.00^{g}	0.69±0.00^{i}	3.17±0.06^{d}	0.53±0.00^{fg}	2.64±0.06^{c}
M2	6.41 ± 0.00^{d}	11.40±0.06^{h}	0.70±0.02^{abc}	3.20±0.10^{g}	3.96±0.06^{e}	2.91±0.01^{f}	0.19±0.00^{ef}	0.76±0.00^{f}	2.72±0.01^{g}	0.57±0.00^{e}	2.15±0.01^{f}
M3	6.58 ± 0.01^{b}	11.92±0.03^{g}	0.70±0.06^{abc}	3.05±0.05^{h}	4.02±0.02^{e}	4.26±0.02^{a}	0.23±0.00^{c}	1.07±0.02^{c}	4.03±0.02^{a}	0.84±0.00^{b}	3.19±0.00^{a}
M4	5.86±0.01^{i}	11.20±0.01^{i}	0.58±0.05^{def}	2.78±0.02^{i}	4.54±0.04^{c}	3.29±0.01^{c}	0.18±0.00^{f}	0.70±0.00^{i}	3.11±0.01^{de}	0.52±0.00^{g}	2.59±0.01^{c}
M5	6.03±0.01^{h}	12.49±0.06^{e}	0.62±0.01^{cd}	3.83±0.03^{f}	4.53±0.02^{c}	3.17±0.02^{d}	0.15±0.00^{g}	0.70±0.00^{i}	3.02±0.02^{e}	0.55±0.00^{ef}	2.47±0.02^{d}
M6	6.32±0.00^{e}	12.20±0.01^{f}	0.71±0.02^{a}	3.00±0.00^{h}	4.70±0.05^{c}	3.66±0.01^{b}	0.32±0.00^{a}	1.20±0.01^{a}	3.34±0.01^{c}	0.88±0.00^{a}	2.46±0.02^{d}
M7	6.26±0.01^{f}	11.29±0.07^{hi}	0.50±0.00^{f}	4.08±0.02^{e}	2.93±0.11^{g}	2.64±0.03^{g}	0.21±0.00^{d}	1.00±0.00^{d}	2.43±0.03^{h}	0.79±0.00^{c}	1.64±0.03^{h}
M8	6.72±0.01^{a}	11.84±0.09^{g}	0.68±0.03^{abc}	3.78±0.02^{f}	5.14±0.13^{b}	3.05±0.04^{e}	0.28±0.00^{b}	1.14±0.00^{b}	2.77±0.04^{g}	0.86±0.00^{ab}	1.91±0.04^{g}
M9	6.11±0.01^{g}	16.12±0.03^{b}	0.63±0.02^{bcd}	6.60±0.00^{b}	4.31±0.00^{d}	3.64±0.03^{b}	0.18±0.00^{f}	0.73±0.00^{h}	3.46±0.03^{b}	0.55±0.00^{ef}	2.91±0.03^{b}
M10	6.48±0.01^{c}	14.78±0.00^{c}	0.58±0.02^{def}	5.80±0.00^{c}	3.91±0.03^{e}	2.91±0.01^{f}	0.23±0.00^{c}	0.74±0.00^{gh}	2.68±0.01^{g}	0.51±0.00^{g}	2.17±0.00^{ef}
M11	5.85±0.01^{i}	16.37±0.02^{a}	0.54±0.00^{ef}	7.60±0.00^{a}	3.22±0.06^{f}	3.07±0.07^{e}	0.20±0.00^{d}	0.83±0.01^{e}	2.87±0.07^{f}	0.63±0.00^{d}	2.25±0.06^{e}
Mean	6.25±0.27	13.06±1.87	0.63±0.07	4.48±1.57	4.31±0.86	3.26±0.43	0.21±0.05	0.87±0.19	3.05±0.43	0.66±0.15	2.40±0.42

NCN, Non-casein nitrogen ; NPN, non-protein nitrogen. Mean values in the same column with different superscript letters are significantly different (P< 0.05).

the filtrates obtained after acid precipitation of caseins at pH 4.6 (NCN filtrates). These extracts were further acidified to pH 2 by dilution in a trifluoroacetic acid solution (final concentration: 0.1 %). The analysis was then carried out using a Dionex ICS 3000 HPLC system (Thermo Fisher S.A., Voisins le Bretonneux, France) by reverse phase separation on a C4 Vydac (214TP5415) type column. The acetonitrile gradient for elution was 37 to 50 % for 15 min at 40°C and the absorbance was measured at 214 nm in a Dionex Ultimate 3400 RS Variable Wavelength Detector. The caseins: α-s1casein, α-s2casein, β-casein and k-casein were determined by means of the same equipment and the same wavelength as above but the protocol was modified as follows: rough protein were reduced by incubation with 20 mM dithiothreitol for 1 h at 37°C then filtered through 0.45 µm membrane and finally acidified to pH 2 by dilution in a 0.1 % trifluoroacetic acid solution before injection in the high performance liquid chromatography (HPLC) and elution by a 30 to 46% acetonitrile gradient for 30 min at 40°C (Jaubert and Martin, 1992).

Lactose quantification

Lactose was determined on clarified supernatants obtained after deproteinization of samples by 3% sulfosalicylic acid for 1 h at 4°C, followed by centrifugation and filtration of the supernatants on 0.45 µm membranes. These filtrates were then diluted in ultra pure water (MilliQ, Millipore) to adjust the concentration of lactose to the standard curve. The analysis was carried out by ionic chromatography in a Dionex ICS 3000 HPLC system (Thermo Fisher S.A., Voisins le Bretonneux, France) by using of a Dionex Carbopac PA1, (4 x 250 mm) column. Elution was driven by a 12 to 200 mM sodium hydroxyde gradient for 22 min at 30°C. Lactose content was finally quantified by pulsed amperometric detection.

Mineral contents

Mineral content (calcium, magnesium, sodium, potassium, iron, copper, zinc, and manganese) were determined by atomic absorption spectrometer (Varian 220FS Spectr AA, Les Ulis, France) (Brulé et al., 1974). Phosphorus was determined by colorimetry according to IDF (1990).

Statistical analysis

Data on the compositions of milk and yogurt samples were evaluated by means of one-way analysis of variance using statistical package SPSS 16.0. Differences between samples were tested according to Tukey test and considered to be significant when P<0.05.

RESULTS AND DISCUSSION

Raw cow milks

pH and proximate composition of raw cow milk

Table 1 shows the pH and proximate composition of raw cow milk (dry matter, ash, fat, lactose, total protein, NPN, NCN, true protein, whey protein and casein). The mean pH of the milk was 6.25. This value was lower compared with the pH value of fresh raw cow milk (6.6-6.8) reported by Alais (1984). It was also lower compared to the value of 6.76 found by Ahmad et al. (2008) in raw cow milk (Holstein breed of *Bos taurus*) of France. The low value of milk pH obtained may be due to infection of the udder of the animal (Morgan, 1999). The mean dry matter content was 13.06 g/100 g. It was similar to 13.0 g/100 g reported by Mapekula et al. (2011) in milk from local crossbred cows in South Africa.

The mean ash content was 0.63 g/100 g. This value was close to 0.65 g/100g found by Sanz Ceballos et al. (2009) in Holstein Friesian cow milk of south eastern Spain, but lower than 0.79 found by Bonfoh et al. (2005) in raw milk composition of Malian zebu cows (*Bos indicus*).

The mean fat was 4.48 g/100 g. This value was higher than 3.42 and 3.25 g/100 g found by Sanz Ceballos et al. (2009) in Holstein Friesian cow milk and Mapekula et al. (2011) in milk from local Nguni cows in South Africa, respectively. When milk has higher level fat, then it should be used to produce butter. The mean lactose content was 4.31 g/100 g. This value was close to 4.47/100g found by Sanz Ceballos et al. (2009) in Holstein Friesian cow milk. The total protein content ranged from 2.64 (M7) and 4.26 g/100 g (M3) with a mean of 3.26 g/100 g. This value was close to 3.30/100 g found by Mirzadeh et al. (2010) in Holstein cow milk of Lordegan Region of Iran. The protein content of milk is an essential feature of its market value since higher protein content enhances performance of technological transformation. Milk with high protein content is good for cheese production. These milk samples therefore represent a good raw material for the dairy industry. The means NPN and NCN were 0.21 and 0.87 g/100 g, respectively. These values were higher than that found by Ahmad et al. (2008) in raw cow milk (0.09 and 0.74 g/100 g) for NPN and NCN, respectively.

The lowest content of true protein (2.43 g/100 g) was found in (M7) while the highest (4.03 g/100 g) was found in (M3) with a mean of 3.05 g /100 g. This value was compared to 3.03/100 g found by Mayer et al. (2012) in cow milk of Austria. The whey protein content ranged from 0.51 g/100 g (M10) to 0.88 g /100 g (M6) with a mean of 0.66 g/100 g. This value was compared to 0.68 g/100g found by Czerniewcz et al. (2006) in Holstein-Friesian cows of Warmia in Olsztyn. The mean casein was 2.40 g/ 100 g. This value was closer to 2.61/100 g found by Ahmad et al. (2008) in raw cow milk. The physiological differences of the animal, stage of lactation and some common factors such as season, feed, breed, time and sequence of milking could be responsible for the differences observed in the composition of cow milk (Iggman et al., 2003; Farah et al., 2006; Slots et al., 2009; Mapekula et al., 2011; Frelich et al. 2012; Myburgh et al., 2012).

Amino acid composition of raw cow milk

The amino acid composition of the 11 cow milk samples is shown in Table 2. M7, with low protein content, had the lowest level of all amino acids except alanine, cysteine and methionine; while M9 had the highest level of all amino acid except glycine, cysteine and methionine. These values of amino acid were higher than those reported earlier by Mapekula et al. (2011) in milk from local crossbred cows in South Africa. The mean values of aspartic acid (2.42 g/kg), threonine (1.45 g/kg), serine (1.67 g/kg), alanine (1.06 g/kg), cysteine (0.21 g/kg), methionine (0.66 g/kg), isoleusine (1.57 g/kg), leucine (2.95 g/kg), tyrosine (1.53 g/kg), phenylalanine (1.50 g/kg), lysine (2.57 g/kg) and arginine (1.04 g/kg) were compared to the values found by Sanz Ceballos et al. (2009) in Holstein Friesian cows of south eastern Spain.

Protein fraction composition of raw cow milk

Table 3 shows the protein fraction composition of raw cow milk (α-lactalbumin, β-lactoglobulin, αS1-casein, αS2-casein, β-casein and κ-casein). The content of α-lactalbumin was between 0.62 (M2) and 1.10 g/kg (M6) with a mean of 0.84 g/kg. This value was similar to the value of 0.82 g/kg found by Mackle et al. (1999) in Friesian cows of New Zealand, but lower than 1.05 g/kg found by Barłowska et al. (2012) in cow milk. For the β-lactoglobulin content, the lowest value was found in M11 (3.21 g/kg) while the highest was in M8 (4.87 g/kg). The mean was 3.92 g/kg. This value was closer to 3.25 found by Barłowska et al. (2012) in cow milk. The content of αS1-casein ranged from 1.00 (M8) to 8.35 g/kg (M2) with a mean of 4.08 g/kg. The content of αS2-casein varied from 0.09 (M8) to 0.86 g/kg (M9) with a mean of 0.39 g/kg. The content of β-casein varied from 1.87 (M5) to 6.05 g/kg (M4) with a mean of 3.86 g/kg. The content of κ-casein was found in relatively low amount in M6 (1.02 g/kg) while high amount was found in M4 (2.76 g/kg). The β-lactoglobulin, αS1-casein + αS2-casein, β-casein and κ-casein means (3.92, 4.47, 3.86 and 1.98 g/kg), respectively, were lower than the values reported by Mackle et al. (1999) in Friesian cows of New Zealand (4.7, 12.70, 11.00 and 2.9 g/kg), respectively, for β-lactoglobulin, αS1-casein + αS2-casein, β-casein and κ-casein. The variation in milk samples and milk yield within a species depends on so many factors. Some of these factors are genetics, stage of lactation, daily variation, parity, type of diet, age, udder health and season (Iggman et al., 2003; Farah et al., 2006; Slots et al., 2009; Mapekula et al., 2011; Frelich et al. 2012; Myburgh et al., 2012).

Mineral composition of raw cow milk

Table 4 shows the content of Ca, Mg, Na, K, P, Fe, Zn, Cu and Mn in raw cow milk. Ca and Mg means were 1217 and 103 mg/kg, respectively. These values were higher than the corresponding values of 1135 and 94 mg/kg reported by Sanz Ceballos et al. (2009), in Holstein Friesian cows of South Eastern Spain. For the Na and K content, the means were 310 and 1384 mg/kg, respectively. These values were lower than the respective values of 430 and 1500 mg/kg reported by Sboui et al. (2009) for South Tunisian cows. P, Fe, Zn and Cu P means were 776, 0.72, 3.34 and 0.04 mg/kg, respectively. These values were lower than the corresponding values of 870, 0.9, 4.63 and 0.14 mg/kg found by Sanz Ceballos et al. (2009) in Holstein Friesian cows of South Eastern Spain. Mn was found in small amounts in the 11 milk samples.

Table 2. Amino acid composition of raw cow milk (g/Kg) collected in Maroua (Cameroon).

Sample	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	Mean
Asp	2.51±0.00^{c}	2.24±0.01^{e}	2.56±0.03^{bc}	2.63±0.00^{ab}	2.47±0.01^{c}	2.66±0.07^{a}	2.02±0.06^{f}	2.33±0.00^{d}	2.71±0.02^{a}	2.08±0.01^{f}	2.47±0.03^{c}	2.42±0.22
Thr	1.41±0.01^{cd}	1.29±0.01^{e}	1.50±0.02^{bc}	1.56±0.01^{b}	1.42±0.01^{cd}	1.56±0.09^{b}	1.16±0.03^{e}	1.45±0.01^{cd}	1.74±0.00^{a}	1.38±0.01^{de}	1.49±0.03^{bc}	1.45±0.14
Ser	1.72±0.01^{bc}	1.59±0.00^{e}	1.77±0.03^{b}	1.87±0.01^{a}	1.74±0.01^{bc}	1.65±0.08^{d}	1.39±0.04^{g}	1.64±0.01^{de}	1.91±0.00^{a}	1.46±0.01^{f}	1.70±0.00^{c}	1.67±0.15
Glu	6.16±0.02^{bcd}	5.68±0.00^{f}	6.30±0.06^{bc}	6.7±0.03^{a}	6.36±0.05^{b}	5.79±0.28^{f}	5.08±0.14^{g}	5.98±0.17^{cde}	6.87±0.00^{a}	5.23±0.00^{g}	5.96±0.03^{de}	6.01±0.54
Gly	0.65±0.02^{de}	0.60±0.00^{f}	0.65±0.01^{de}	0.69±0.00^{bc}	0.64±0.01^{e}	0.75±0.02^{a}	0.55±0.02^{g}	0.63±0.01^{ef}	0.71±0.00^{b}	0.55±0.00^{g}	0.67±0.01^{cd}	0.64±0.06
Ala	1.05±0.02^{c}	0.94±0.00^{d}	1.14±0.01^{a}	1.14±0.01^{a}	1.06±0.01^{c}	1.16±0.03^{a}	0.92±0.03^{d}	1.11±0.00^{ab}	1.16±0.00^{a}	0.89±0.01^{d}	1.07±0.01^{bc}	1.06±0.095
Val	2.03±0.02^{c}	1.87±0.00^{de}	2.05±0.02^{c}	2.23±0.03^{b}	2.06±0.01^{c}	1.93±0.05^{d}	1.74±0.07^{f}	1.93±0.00^{d}	2.32±0.00^{a}	1.84±0.01^{e}	2.08±0.01^{c}	2.01±0.16
Cys	0.17±0.02^{d}	0.17±0.00^{d}	0.23±0.00^{ab}	0.23±0.02^{ab}	0.19±0.00^{bcd}	0.27±0.02^{a}	0.19±0.01^{bcd}	0.22±0.03^{bc}	0.23±0.02^{ab}	0.18±0.00^{cd}	0.21±0.00^{bcd}	0.21±0.03
Met	0.85±0.00^{a}	0.75±0.02^{bc}	0.83±0.01^{ab}	0.91±0.03^{a}	0.84±0.00^{a}	0.46±0.01^{e}	0.66±0.02^{c}	0.50±0.03^{de}	0.56±0.00^{d}	0.36±0.05^{f}	0.52±0.08^{de}	0.66±0.18
Ile	1.65±0.02^{bcd}	1.39±0.00^{e}	1.64±0.02^{bcd}	1.73±0.03^{ab}	1.62±0.01^{bcd}	1.54±0.11^{d}	1.34±0.04^{e}	1.56±0.00^{cd}	1.82±0.00^{a}	1.36±0.01^{e}	1.67±0.01^{bc}	1.57±0.15
Leu	3.01±0.01^{c}	2.76±0.01^{e}	3.05±0.02^{c}	3.24±0.02^{b}	3.07±0.03^{c}	3.07±0.03^{c}	2.64±0.07^{f}	2.92±0.02^{d}	3.39±0.01^{a}	2.67±0.02^{ef}	3.05±0.04^{c}	2.95±0.23
Tyr	1.58±0.01^{cd}	1.38±0.01^{e}	1.63±0.01^{bc}	1.71±0.02^{ab}	1.60±0.02^{cd}	1.40±0.07^{e}	1.28±0.06^{f}	1.53±0.01^{d}	1.79±0.00^{a}	1.30±0.01^{e}	1.70±0.02^{b}	1.53±0.17
Phe	1.55±0.02^{b}	1.39±0.01^{c}	1.55±0.02^{b}	1.69±0.01^{a}	1.56±0.01^{b}	1.40±0.07^{c}	1.29±0.05^{d}	1.43±0.01^{c}	1.73±0.00^{a}	1.35±0.01^{cd}	1.59±0.02^{b}	1.50±0.13
Lys	2.60±0.01^{cd}	2.34±0.02^{e}	2.70±0.03^{bc}	2.78±0.02^{b}	2.67±0.02^{c}	2.65±0.09^{c}	2.18±0.07^{f}	2.53±0.02^{d}	2.94±0.00^{a}	2.24±0.02^{ef}	2.69±0.01^{bc}	2.57±0.22
His	0.82±0.00^{bc}	0.74±0.01^{de}	0.83±0.01^{bc}	0.90±0.01^{a}	0.85±0.01^{b}	0.80±0.03^{c}	0.68±0.03^{f}	0.76±0.00^{d}	0.93±0.00^{a}	0.72±0.01^{ef}	0.85±0.00^{b}	0.81±0.07
Arg	1.10±0.03^{b}	1.00±0.00^{c}	1.10±0.00^{b}	1.10±0.00^{b}	1.07±0.058^{bc}	1.03±0.58^{bc}	0.87±0.058^{d}	1.00±0.00^{c}	1.20±0.00^{a}	0.90±0.01^{d}	1.10±0.01^{b}	1.04±0.09
Pro	3.11±0.00^{b}	2.78±0.00^{c}	3.11±0.07^{b}	3.48±0.02^{a}	3.14±0.03^{b}	2.81±0.11^{c}	2.62±0.06^{d}	2.87±0.02^{c}	3.60±0.00^{a}	2.79±0.07^{c}	3.20±0.01^{b}	3.04±0.29

Mean values in the same row with different superscript letters are significantly different ($P < 0.05$).

Table 3. Protein fraction composition of raw cow milk (g/kg) collected in Maroua (Cameroon).

Sample	α-Lactalbumin	β-Lactoglobulin	αS1-casein	αS2-casein	β-casein	κ-casein
M1	1.04±0.01^{b}	4.12±0.25^{cd}	7.47±0.18^{a}	0.70±0.03^{b}	4.63±0.08^{b}	2.72±0.01^{a}
M2	0.62±0.01^{h}	3.88±0.01^{de}	8.35±0.46^{a}	0.52±0.02^{c}	5.09±0.16^{b}	2.24±0.00^{b}
M3	0.65±0.01^{g}	4.62±0.00^{ab}	5.25±0.25^{b}	0.15±0.04^{e}	2.68±0.05^{cd}	1.75±0.07^{c}
M4	0.93±0.01^{c}	3.54±0.05^{ef}	7.54±0.74^{a}	0.44±0.07^{cd}	6.05±0.40^{a}	2.76±0.25^{a}
M5	0.85±0.01^{d}	3.35±0.03^{f}	2.97±0.36^{c}	0.16±0.01^{e}	1.87±0.14^{d}	1.17±0.18^{ef}
M6	1.10±0.00^{a}	4.60±0.29^{ab}	1.31±0.51^{de}	0.46±0.07^{cd}	2.57±0.13^{cd}	1.02±0.02^{f}
M7	0.85±0.01^{d}	4.29±0.04^{bc}	1.75±0.02^{de}	0.14±0.01^{e}	2.98±0.11^{c}	1.21±0.30^{def}
M8	0.85±0.01^{d}	4.87±0.04^{a}	1.00±0.08^{e}	0.09±0.02^{e}	3.00±0.17^{c}	1.61±0.03^{cde}
M9	0.85±0.02^{d}	3.42±0.09^{f}	5.88±0.10^{b}	0.86±0.03^{a}	5.15±0.06^{b}	3.04±0.00^{a}
M10	0.78±0.00^{e}	3.22±0.00^{f}	1.19±0.04^{de}	0.41±0.01^{d}	3.45±0.35^{c}	1.66±0.11^{cd}
M11	0.70±0.00^{f}	3.21±0.00^{f}	2.23±0.40^{cd}	0.36±0.01^{d}	5.05±0.75^{b}	2.64±0.27^{ab}
Mean	0.84±0.14	3.92±0.6	4 .08±2.78	0.39±0.24	3.86±1.34	1.98±0.71

Mean values in the same column with different superscript letters are significantly different ($P < 0.05$).

Table 4. Mineral composition of raw cow milk (mg/Kg) collected in Maroua (Cameroon).

Sample	Ca	Mg	Na	K	P	Fe	Zn	Cu	Mn
M1	1228±4.78[e]	107±0.05[b]	361±1.52[b]	1561±1.95[b]	814±2.84[c]	0.87±0.00[a]	2.30±0.34[e]	0.04±0.00[bc]	0.02±0.00[b]
M2	1301±6.42[b]	113±0.20[ab]	313±0.84[e]	1680±5.84[a]	811±5.12[c]	0.66±0.08[d]	1.03±0.02[f]	0.03±0.00[c]	0.03±0.00[ab]
M3	1246±7.65[d]	119±5.62[a]	295±1.86[fg]	1555±8.50[b]	864±0.00[b]	0.67±0.03[cd]	3.32±0.24[d]	0.03±0.00[cd]	0.05±0.02[a]
M4	1151±7.50[g]	94±1.21[cd]	298 ±3.45[f]	1385±2.16[d]	711±16.65[ef]	0.80±0.07[abc]	4.70±0.17[b]	0.06±0.00[a]	0.02±0.01[b]
M5	1120±7.67[h]	87±1.72[de]	289±0.78[g]	1367±4.44[e]	870±37.04[b]	0.64±0.01[d]	3.94±0.16[cd]	0.04±0.00[bc]	0.02±0.00[b]
M6	1551±3.56[a]	114±0.59[ab]	384±0.86[a]	1428±5.99[c]	998±8.31[a]	0.65±0.03[d]	6.21±0.16[a]	0.05±0.00[a]	0.02±0.00[b]
M7	963±5.38[i]	79±0.34[f]	242±3.67[i]	1212±1.76[g]	626±1.92[i]	0.64±0.03[d]	1.37±0.35[f]	0.02±0.00[e]	0.01±0.00[b]
M8	1238±1.52[de]	99±4.70[c]	301±4.34[f]	1269±4.00[f]	738±27.27[de]	0.85±0.08[ab]	4.21±0.44[bc]	0.03±0.00[cd]	0.01±0.00[b]
M9	1276±6.20[c]	117±0.42[a]	334±0.83[c]	1376±3.89[de]	783±12.87[cd]	0.64±0.02[d]	3.24±0.32[d]	0.04±0.00[bc]	0.02±0.00[b]
M10	1186±1.54[f]	118±0.40[a]	322±0.49[d]	1282±9.83[f]	681±0.00[gh]	0.72±0.00[bcd]	3.95±0.10[cd]	0.04±0.00[bc]	0.02±0.00[b]
M11	1127±6.30[h]	82±0.30[ef]	267±2.33[h]	1104±4.73[h]	636±0.00[hi]	0.74±0.07[abcd]	2.41±0.12[e]	0.02±0.00[e]	0.03±0.00[ab]
Mean	1217±140.67	103±14.63	310±39.00	1384±162.65	776±109.37	0.72±0.094	3.34±1.47	0.04±0.01	0.02±0.01

Mean values in the same column with different superscript letters are significantly different (*P*< 0.05).

The mean was 0.02 mg/kg. This value was also lower than 0.056 mg/kg found by Enb et al. (2009) in cow milk from Egypt. The physiological differences in the animals, stage of lactation and factors such as season, feed, breed, time and sequence of milking could be responsible for the differences observed in the composition of the cow milk (Iggman et al., 2003; Farah et al., 2006; Slots et al., 2009; Mapekula et al., 2011; Frelich et al. 2012; Myburgh et al., 2012).

Artisanal yoghurt

pH and proximate composition of artisanal yoghurt

Table 5 shows the pH and proximate composition of artisanal yoghurt (dry matter, ash, fat, lactose, total protein, NPN, NCN, true protein, whey protein and casein). The mean pH of yoghurt was 3.84. This value was lower than 4.3 reported by Abdulrahman et al. (1998) in fermented dairy products consumed in Bahrain. The mean dry matter content was 20.11 g /100 g. This value was higher than 10.40 g/100 g found by Enb et al. (2009) in artisanal yoghurt from cow milk of Egypt. The lowest ash content was found in YD while the highest was found in YL with a mean value of 0.61 g /100 g. The fat content was between 1.25 (YD) and 4.05 g/100 g (YH) with a mean of 2.66 g/100 g. YE had the lowest lactose content while the highest was found in YK. The mean was 2.41 g /100 g. The total protein content ranged from 2.13 (YC) and 3.63 g /100 g (YL) with a mean of 2.83 g/100 g. The mean values for ash, fat, lactose and total protein were lower than those found by Abdulrahman et al. (1998) in fermented dairy products consumed in Bahrain. The mean values of NPN and NCN were 0.21 and 0.36 g /100 g, respectively. The lowest content of true protein was found in YC while the highest was found in YL. The mean was 2.62 g /100 g. The whey protein content ranged from 0.02 (YB) to 0.41 g/100 g (YG) with a mean of 0.14 g /100 g. The casein content varied from 1.89 (YE) to 3.23 g/100 g (YL) with a mean of 2.48 g/100 g. These varia-tions in chemical composition between artisanal yoghurts can be attributed to several factors such as type of milk used, method of preparation, type and proportion of ingredients used.

Amino acid composition of artisanal yoghurt

Table 6 presents the amino acid composition of artisanal yoghurt. YL, with high protein content had the highest level of all amino acid. The main determinant of food protein quality is the content and availability of essential amino acids (Robbins et al., 2010). These nutrients have been shown to play an important role in the growth, reproduction and maintenance of the human body (FAO/WHO/UNU, 2007).

Protein fraction composition of artisanal yoghurt

Table 7 shows the protein fraction composition of artisanal yoghurt. The mean values of α-lactalbumin,

Table 5. pH and proximate composition of artisanal yoghurt (g/100g) collected in Maroua (Cameroon).

Sample	pH	Dry matter	Ash	Fat	Lactose	Total protein	NPN	NCN	True protein	Whey protein	Casein
YA	3.95± 0.00^{c}	20.26±0.05^{f}	0.61±0.01^{cd}	2.30±0.00^{g}	2.71±0.01^{c}	2.75±0.00^{g}	0.22±0.00^{d}	0.27±0.01^{h}	2.53±0.00^{f}	0.05±0.01^{ef}	2.48±0.00^{f}
YB	3.61± 0.00^{j}	23.03±0.03^{a}	0.67±0.00^{b}	2.95±0.05^{d}	3.05±0.11^{b}	2.90±0.00^{e}	0.29±0.00^{a}	0.31±0.00^{g}	2.61±0.00^{e}	0.02±0.00^{g}	2.59±0.00^{e}
YC	3.73± 0.00^{g}	17.27±0.02^{i}	0.51±0.01^{fg}	2.40±0.00^{fg}	1.88±0.02^{ef}	2.13±0.00^{k}	0.19±0.00^{g}	0.33±0.01^{fg}	1.94±0.00^{i}	0.14±0.01^{d}	1.80±0.00^{j}
YD	3.73± 0.00^{g}	13.00±0.05^{j}	0.46±0.01^{g}	1.25±0.05^{j}	1.62±0.02^{gh}	2.29±0.01^{i}	0.17±0.00^{h}	0.36±0.00^{e}	2.12±0.01^{h}	0.19±0.00^{c}	1.93±0.01^{i}
YE	3.8± 0.00^{e}	23.04±0.01^{a}	0.50±0.00^{g}	2.05±0.05^{h}	1.54±0.01^{h}	2.23±0.00^{j}	0.16±0.00^{i}	0.34±0.00^{ef}	2.07±0.00^{h}	0.18±0.00^{c}	1.89±0.00^{i}
YF	3.78± 0.00^{f}	22.42±0.04^{b}	0.64±0.00^{bc}	2.45±0.05^{f}	2.66±0.03^{c}	3.24±0.01^{b}	0.21±0.00^{e}	0.25±0.00^{h}	3.03±0.02^{b}	0.04±0.00^{efg}	2.99±0.01^{b}
YG	3.88± 0.00^{d}	19.51±0.06^{g}	0.65±0.01^{bc}	3.60±0.00^{b}	2.92±0.07^{b}	3.21±0.04^{b}	0.23±0.01^{d}	0.63±0.03^{a}	2.98±0.04^{bc}	0.41±0.02^{a}	2.61±0.04^{e}
YH	3.67± 0.00^{i}	21.71±0.13^{d}	0.58±0.05^{de}	4.05±0.05^{a}	2.27±0.03^{d}	3.07±0.04^{d}	0.25±0.01^{c}	0.27±0.00^{h}	2.82±0.04^{d}	0.03±0.01^{fg}	2.80±0.04^{d}
YI	3.69± 0.00^{h}	20.46±0.02^{e}	0.61±0.02^{cd}	2.75±0.05^{e}	1.76±0.02^{fg}	2.84±0.00^{f}	0.20±0.00^{f}	0.43±0.00^{c}	2.64±0.00^{e}	0.23±0.00^{b}	2.41±0.00^{g}
YJ	3.79± 0.00^{ef}	18.93±0.01^{h}	0.55±0.00^{ef}	1.90±0.00^{i}	1.92±0.02^{e}	2.58±0.00^{h}	0.22±0.00^{d}	0.46±0.00^{b}	2.36±0.00^{g}	0.24±0.00^{b}	2.12±0.00^{h}
YK	4.12± 0.00^{b}	19.59±0.09^{g}	0.69±0.00^{b}	2.75±0.05^{e}	4.04±0.05^{a}	3.12±0.00^{c}	0.16±0.00^{i}	0.22±0.00^{i}	2.96±0.00^{c}	0.06±0.00^{e}	2.90±0.00^{c}
YL	4.30± 0.00^{a}	22.07±0.01^{c}	0.81±0.02^{a}	3.45±0.05^{c}	2.61±0.09^{c}	3.63±0.00^{a}	0.28±0.00^{b}	0.40±0.00^{d}	3.35±0.01^{a}	0.12±0.00^{d}	3.23±0.00^{a}
Mean	3.84±0.19	20.11±2.77	0.61±0.09	2.66±0.76	2.41±0.71	2.83±0.44	0.21±0.04	0.36±0.11	2.62±0.42	0.14±0.11	2.48±0.45

NCN, Non-casein nitrogen; NPN, non-protein nitrogen. Mean values in the same column with different superscript letters are significantly different (P< 0.05).

Table 6. Amino acid composition of artisanal yoghurt (g/Kg) collected in Maroua (Cameroon).

Sample	YA	YB	YC	YD	YE	YF	YG	YH	YI	YJ	YK	YL	Mean
Asp	2.03±0.02^{e}	2.18±0.03^{d}	1.60±0.00^{g}	1.66±0.01^{g}	1.60±0.00^{g}	2.30±0.00^{c}	2.38±0.05^{b}	2.21±0.04^{d}	2.07±0.02^{e}	1.84±0.00^{f}	2.35±0.00^{bc}	2.64±0.01^{a}	2.07±0.32
Thr	1.32±0.01^{f}	1.40±0.03^{e}	1.02±0.02^{j}	1.08±0.00^{h}	1.03±0.00^{i}	1.50±0.00^{c}	1.59±0.04^{b}	1.44±0.01^{d}	1.30±0.01^{f}	1.21±0.02^{g}	1.57±0.01^{b}	1.71±0.00^{a}	1.35±0.22
Ser	1.35±0.01^{d}	1.39±0.01^{cd}	1.04±0.02^{f}	1.12±0.00^{ef}	1.07±0.01^{f}	1.57±0.00^{b}	1.62±0.07^{b}	1.45±0.02^{c}	1.33±0.02^{d}	1.18±0.01^{e}	1.63±0.00^{b}	1.72±0.01^{a}	1.37±0.22
Glu	5.31±0.01^{d}	5.51±0.02^{c}	4.12±0.02^{h}	4.41±0.02^{f}	4.31±0.00^{fg}	6.18±0.00^{b}	6.18±0.20^{b}	5.63±0.09^{c}	5.29±0.05^{d}	4.61±0.01^{e}	6.24±0.01^{b}	6.63±0.00^{a}	5.37±0.81
Gly	0.49±0.00^{e}	0.56±0.01^{d}	0.38±0.00^{h}	0.42±0.00^{fg}	0.40±0.00^{gh}	0.62±0.01^{b}	0.61±0.01^{b}	0.58±0.02^{c}	0.51±0.01^{e}	0.44±0.01^{f}	0.63±0.01^{b}	0.65±0.00^{a}	0.52±0.09
Ala	0.88±0.01^{e}	1.04±0.00^{bc}	0.71±0.00^{g}	0.74±0.00^{g}	0.71±0.01^{g}	1.01±0.01^{cd}	1.05±0.02^{b}	1.00±0.03^{d}	0.91±0.01^{e}	0.81±0.01^{f}	1.06±0.01^{b}	1.15±0.01^{a}	0.92±0.14
Val	1.60±0.02^{e}	1.73±0.01^{d}	1.26±0.00^{h}	1.33±0.01^{g}	1.31±0.00^{g}	1.93±0.00^{b}	1.94±0.04^{b}	1.80±0.04^{c}	1.63±.00^{e}	1.41±0.01^{f}	1.92±0.00^{b}	2.10±0.00^{a}	1.66±0.27
Cys	0.08±0.00^{bc}	0.07±0.00^{bc}	0.06±0.00^{c}	0.07±0.00^{bc}	0.05±0.00^{c}	0.05±0.00^{c}	0.12±0.06^{ab}	0.13±0.02^{ab}	0.12±0.03^{ab}	0.11±0.00^{bc}	0.09±0.00^{bc}	0.17±0.00^{a}	0.09±0.04
Met	0.11±0.00^{cd}	0.00±0.00^{h}	0.03±0.00^{g}	0.05±0.00^{ef}	0.05±0.00^{ef}	0.15±0.00^{b}	0.08±0.01^{d}	0.09±0.02^{d}	0.10±0.00^{cd}	0.05±0.00^{ef}	0.12±0.00^{c}	0.21±0.00^{a}	0.09±0.06
Ile	1.27±0.05^{de}	1.30±0.00^{cd}	1.00±0.00^{g}	1.03±0.05^{fg}	1.00±0.00^{g}	1.50±0.00^{b}	1.47±0.05^{b}	1.37±0.05^{c}	1.20±0.00^{e}	1.10±0.00^{f}	1.50±0.00^{b}	1.60±0.00^{a}	1.28±0.21
Leu	2.45±0.01^{d}	2.61±0.04^{c}	1.93±0.01^{g}	2.00±0.00^{f}	2.00±0.00^{f}	2.91±0.00^{b}	2.96±0.05^{b}	2.75±0.05^{c}	2.50±0.00^{d}	2.12±0.00^{e}	2.92±0.01^{b}	3.19±0.00^{a}	2.53±0.41
Tyr	1.13±0.01^{bc}	1.18±0.03^{b}	0.88±0.00^{de}	0.99±0.00^{c}	0.84±0.00^{e}	1.02±0.00^{e}	1.19±0.02^{b}	1.13±0.02^{bc}	1.02±0.12^{c}	0.96±0.00^{cd}	1.13±0.00^{bc}	1.40±0.00^{a}	1.07±0.15
Phe	1.21±0.01^{e}	1.26±0.03^{d}	0.94±0.00^{h}	1.00±0.00^{g}	0.96±0.00^{gh}	1.45±0.00^{b}	1.47±0.03^{b}	1.37±0.03^{c}	1.23±0.01^{de}	1.06±0.00^{f}	1.46±0.00^{b}	1.60±0.00^{a}	1.25±0.21
Lys	2.11±0.00^{f}	2.25±0.01^{e}	1.67±0.00^{i}	1.75±0.01^{h}	1.70±0.00^{hi}	2.48±0.00^{c}	2.54±0.00^{b}	2.31±0.04^{d}	2.15±0.02^{f}	1.88±0.00^{g}	2.52±0.00^{bc}	2.70±0.00^{a}	2.17±0.34
His	0.64±0.01^{e}	0.69±0.00^{d}	0.50±0.00^{h}	0.55±0.00^{g}	0.51±0.00^{h}	0.77±0.00^{b}	0.78±0.02^{b}	0.73±0.02^{c}	0.67±0.01^{d}	0.58±0.00^{f}	0.78±0.00^{b}	0.89±0.00^{a}	0.67±0.12
Arg	0.86±0.01^{e}	0.89±0.01^{d}	0.67±0.01^{h}	0.72±0.01^{g}	0.71±0.03^{g}	0.93±0.00^{c}	0.99±0.01^{b}	0.92±0.01^{c}	0.85±0.01^{e}	0.76±0.00^{f}	1.00±0.00^{b}	1.11±0.01^{a}	0.87±0.13
Pro	2.44±0.00^{e}	2.66±0.03^{d}	1.93±0.02^{h}	2.05±0.01^{g}	2.00±0.01^{gh}	3.00±0.00^{b}	3.01±0.11^{b}	2.80±0.10^{c}	2.48±0.02^{e}	2.15±0.00^{f}	2.95±0.05^{b}	3.16±0.03^{a}	2.55±0.42

Mean values in the same row with different superscript letters are significantly different (P < 0.05).

Table 7. Protein fraction composition of artisanal yoghourt (g/kg) collected in Maroua (Cameroon).

Sample	α-Lactalbumin	β-Lactoglobulin	αS1-casein	αS2-casein	β-casein	κ-casein
YA	$0.00±0.00^{h}$	$0.42±0.02^{f}$	$4.63±0.16^{b}$	$0.15±0.02^{d}$	$5.63±0.37^{d}$	$0.00±0.00^{d}$
YB	$0.00±0.00^{h}$	$0.00±0.00^{g}$	$5.20±0.09^{a}$	$0.21±0.00^{bc}$	$6.41±0.10^{bc}$	$0.00±0.00^{d}$
YC	$0.24±0.00^{e}$	$0.83±0.03^{e}$	$2.01±0.06^{e}$	$0.09±0.00^{e}$	$1.69±0.04^{h}$	$0.00±0.00^{d}$
YD	$0.35±0.00^{d}$	$1.30±0.02^{d}$	$3.25±0.27^{c}$	$0.17±0.01^{cd}$	$2.83±0.22^{g}$	$0.00±0.00^{d}$
YE	$0.35±0.01^{d}$	$1.33±0.03^{d}$	$4.56±0.04^{b}$	$0.28±0.01^{a}$	$4.43±0.06^{e}$	$0.00±0.00^{d}$
YF	$0.20±0.00^{f}$	$0.41±0.01^{f}$	$5.05±0.06^{ab}$	$0.17±0.01^{cd}$	$6.97±0.02^{b}$	$0.22±0.01^{c}$
YG	$1.01±0.01^{a}$	$3.68±0.03^{a}$	$2.34±0.24^{de}$	$0.13±0.03^{de}$	$3.52±0.18^{f}$	$0.89±0.04^{b}$
YH	$0.00±0.00^{h}$	$0.43±0.03^{f}$	$1.83±0.05^{e}$	$0.17±0.04^{cd}$	$6.05±0.07^{cd}$	$0.85±0.15^{b}$
YI	$0.58±0.01^{b}$	$1.86±0.02^{b}$	$5.44±0.19^{a}$	$0.22±0.01^{b}$	$5.14±0.02^{d}$	$0.00±0.00^{d}$
YJ	$0.59±0.02^{b}$	$1.71±0.02^{c}$	$4.62±0.31^{b}$	$0.15±0.00^{d}$	$4.15±0.26^{e}$	$0.00±0.00^{d}$
YK	$0.09±0.00^{g}$	$0.41±0.00^{f}$	$2.71±0.08^{d}$	$0.20±0.00^{bc}$	$5.66±0.10^{d}$	$0.00±0.00^{d}$
YL	$0.44±0.01^{c}$	$0.43±0.02^{f}$	$2.78±0.28^{cd}$	$0.15±0.02^{d}$	$7.74±0.35^{a}$	$1.65±0.08^{a}$
Mean	0.32±0.29	1.07±0.98	3.70±1.31	0.17±0.05	5.02±1.72	0.30±0.52

Mean values in the same column with different superscript letters are significantly different ($P < 0.05$).

Table 8. Mineral composition of artisanal yoghurt (mg/Kg) collected in Maroua (Cameroon).

Sample	Ca	Mg	Na	K	P	Fe	Zn	Cu	Mn
YA	$1005±5.12^{f}$	$96±0.32^{e}$	$294±0.76^{e}$	$1383±0.63^{f}$	$766±1.46^{d}$	$0.55±0.04^{b}$	$3.09±0.04^{cde}$	$0.14±0.05^{ab}$	$0.00±0.00^{a}$
YB	$1129±0.37^{d}$	$109±1.34^{d}$	$319±0.32^{c}$	$1528±2.31^{b}$	$815±5.12^{c}$	$0.51±0.01^{bc}$	$3.97±0.08^{b}$	$0.06±0.01^{bcd}$	$0.00±0.00^{a}$
YC	$719±3.65^{f}$	$81±0.24^{g}$	$282±1.60^{f}$	$1109±0.14^{k}$	$683±5.10^{f}$	$0.98±0.04^{a}$	$2.96±0.28^{de}$	$0.07±0.03^{bcd}$	$0.00±0.00^{a}$
YD	$697±3.01^{k}$	$74±0.45^{h}$	$207±0.03^{i}$	$991±3.83^{l}$	$635±3.69^{g}$	$0.37±0.04^{cd}$	$2.48±0.10^{f}$	$0.12±0.00^{abc}$	$0.00±0.00^{a}$
YE	$798±8.24^{i}$	$80±0.08^{g}$	$216±0.54^{h}$	$1140±3.64^{j}$	$639±3.37^{g}$	$0.52±0.10^{bc}$	$2.81±0.01^{ef}$	$0.04±0.01^{cd}$	$0.00±0.00^{a}$
YF	$1080±3.97^{e}$	$110±0.17^{d}$	$329±0.30^{b}$	$1406±5.01^{e}$	$755±0.00^{d}$	$0.50±0.08^{bc}$	$3.98±0.01^{b}$	$0.09±0.06^{abcd}$	$0.00±0.00^{a}$
YG	$1158±6.40^{c}$	$125±1.16^{b}$	$326±7.04^{bc}$	$1351±2.29^{g}$	$816±8.37^{c}$	$0.57±0.01^{b}$	$4.41±0.24^{a}$	$0.05±0.01^{bcd}$	$0.00±0.00^{a}$
YH	$1005±2.34^{f}$	$108±0.91^{d}$	$304±4.82^{d}$	$1207±7.27^{i}$	$714±6.07^{e}$	$0.54±0.02^{b}$	$3.45±0.04^{c}$	$0.02±0.00^{d}$	$0.00±0.00^{a}$
YI	$972±6.61^{g}$	$106±0.57^{e}$	$288±2.07^{ef}$	$1472±0.01^{d}$	$756±0.00^{d}$	$0.48±0.00^{bc}$	$3.31±0.07^{cd}$	$0.06±0.01^{bcd}$	$0.00±0.00^{a}$
YJ	$872±1.36^{h}$	$91±1.36^{f}$	$251±0.62^{g}$	$1253±7.20^{h}$	$713±4.36^{e}$	$0.24±0.04^{d}$	$3.03±0.07^{df}$	$0.05±0.02^{bcd}$	$0.00±0.00^{a}$
YK	$1249±7.53^{a}$	$119±0.77^{c}$	$350±0.19^{a}$	$1487±3.82^{c}$	$855±3.94^{b}$	$0.52±0.10^{bc}$	$4.44±0.01^{a}$	$0.05±0.03^{bcd}$	$0.00±0.00^{a}$
YL	$1209±0.64^{b}$	$135±0.50^{a}$	$350±0.97^{a}$	$1808±1.70^{a}$	$916±24.26^{a}$	$0.57±0.01^{b}$	$4.32±0.20^{ab}$	$0.16±0.07^{a}$	$0.00±0.00^{a}$
Mean	991±180.98	103±18.33	293±49.39	1345±215.509	755±83.10	0.53±0.17	3.52±0.66	0.07±0.05	0.00±0.00

Mean values in the same column with different superscript letters are significantly different ($P< 0.05$).

β-lactoglobulin, αS1-casein, αS2-casein, β-Casein and κ-casein were 0.32, 1.07, 0.17, 3.70, 0.17, 5.02 and 0.30 g/kg). These variations in chemical composition between artisanal yoghurts samples can be attributed to several factors such as type of milk used, method of preparation, type and proportion of ingredients used.

Mineral composition of artisanal yoghurt

Table 8 shows the contents of Ca, Mg, Na, K, P, Fe, Zn, Cu and Mn in artisanal yoghurts. YL had the highest level of all these minerals except Ca and Fe. Mn was not detected in yoghurt samples. The means for Ca (991 mg/kg), Mg (103 mg/kg), Na (293 mg/kg), and P (755 mg/kg) were lower than those found by Abdulrahman et al. (1998) which reported respective values of (1670, 134, 750 and 1170 mg/kg) in fermented dairy products consumed in Bahrain. The means for Fe (0.53 mg/kg), and Zn (3.52 mg/kg) were higher com-pared with those found by Enb et al. (2009) which reported respective values of 0.49 and 2.63 mg/kg in artisanal yoghurt from cow milk from Egypt, but the mean for Cu (0.07 mg/kg) was lower than the value of 0.12 mg/kg found by Enb et al. (2009). These variations in mineral composition between traditional yoghurt samples can be attributed to several factors such as type of milk used, method of preparation, type and proportion of ingredients used.

Conclusion

The chemical composition of raw cow milk and artisanal yoghurt consumed in Maroua (Cameroon) varied from one sample to another. In general, some chemical of the values for the milk and yo-ghurt studied differed from those of previous stu-dies. This was particularly true for pH, NPN, pro-tein fraction (α- lactabumin, β-lactoglobulin, αS-casein, β-casein and κ-casein), some minerals and amino acids. Information on chemical compo-sition of milk and traditional yoghurt available in this study would be helpful for food scientists, nutritionists and public health workers interested in nutritive values of local foods. Further investigations on composition of other artisanal dairy products, such as cheese and dairy sweets, are highly recommended, in order to provide adequate data on food composition in Cameroon. Chemical determination should be expanded to include fatty acid and vitamins.

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