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Physical and Chemical Quality Appraisal of Locally Made Yoghurt Marketed in Some Regions of Cameroon

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Abstract: This work sought to evaluate the physical and chemical qualities of locally made yoghurts sold in three areas of Cameroon: Bamenda; Bafoussam and Dschang. Yoghurt samples were collected from 6, 4 and 3 producers respectively in these regions, with 3 different commercial brands. All yoghurt samples were analyzed for chemical properties (total solids (%), crude proteins (%DM), crude ash (%DM), crude fat (%DM), SNF (%DM), lactose (%DM), titratable acidity (%) and pH) and mineral composition (Potassium, Calcium, Magnesium, Phosphorus, Sodium, Iron, Zinc, Copper, Sulphur and Manganese). The result of the study showed that the physico-chemical properties and mineral compositions of the locally made yoghurts were different within and among the regions. Based on the physico-chemical composition, samples from Bamenda had the highest DM, ash, crude lipid, crude proteins and titratable acidity, making them to be the best among the locally made yoghurts, better than the branded types. This was followed by samples from Bafoussam, with those from Dschang being the least in most cases. Concerning the mineral contents, samples from Bamenda were high in phosphorus, zinc, iron, and magnesium, while those from Dschang were high in sodium, potassium and calcium. Generally, the mineral contents in all the places were significantly lower than those of the commercial brands. For the commercial brands, CC was high in Phosphorus, zinc, and magnesium, BB was high in iron and calcium while AA was high in potassium. Thus, total mineral content showed wide intervals of variation, with the branded yoghurts (commercial brands) better than the locally made varieties. However, samples from Bamenda and Dschang were better in terms of minerals than those from Bafoussam. These results show that, there is either no fixed standard of yoghurt production in Cameroon or it is not respected since a variation was equally observed among the branded samples.

Keywords: Locally Made Yoghurt, Commercial Yoghurt, Physico-chemical Properties, Cameroon

1. Introduction

Acidification of milk by fermentation is one of the oldest methods of preserving milk and there are different methods of carrying out this fermentation in various parts of the world. These methods result in a wide range of fermented milk products, including kumiss, kefir, acidophilus milk and yoghurt [1]. Yoghurt is one of the traditional cultured milk products, well known in almost all corners of the world. It originated in Bulgaria, where it is known as "Yourt" and exists in different forms with diverse local names [2]: Lebon in Lebanon including some Arabian countries; Zababy in Egypt and Sudan; Dahi or Curd in Pakistan and India [3]. The locally made type equally has different native names in most regions of Cameroon, "Shalom Yaourt" in Bamenda (North West Region) and "Kossam" in Dschang (West Region). In normal dairy processing industry, selected lactic starter cultures are used to ferment milk during preparation of variety of cultured dairy products [4]. For Yoghurt, it is generally produced with a mixed culture of *S. salivarius* sub-

spp. Thermophilus and *L. delbrueckii, sub-spp. Bulgaricus* in a 1:1 ratio [5] and this helps to increase the lactic fermentation. Fermentation of the milk sugar i.e. lactose, produces lactic acid which acts on milk protein to give yoghurt its texture and its characteristics taste.

Yoghurt locally prepared and marketed in most cities of Cameroon is commonly known as "shalom yaourt". It is the name that was given to yoghurt locally made by the first person that started this production in Bamenda. Generally, it is prepared by heating a given quantity of water to boiling point and mixing with powdered milk (the choice of powdered milk depends on the producer) to have a homogeneous solution. The temperature of the mixture is brought down by adding a given volume of cold water or mixing it continuously. After this, left over "shalom yaourt" or a cup of any commercial brand of yoghurt (Camlait or Dolait) is added and mixed. The entire mixture is tightly closed and allowed to ferment for 3-8 hours after which a given quantity of sugar and flavoring agent are added. The fermented product is stored in a refrigerator, from where it is taken to the market. Its production is either as a means of fighting against poverty, or generating income and it is consumed because of its nutritional value, moderate price and availability. Yoghurt is a semi-solid fermented and coagulated milk product whose popularity has grown and is currently consumed in most parts of the world [5]. It has a smooth texture and a mildly sour and pleasant flavor and is one of the most unique, yet universal dairy products [6]. Its uniqueness is attributable to the symbiotic fermentation involved in its production process. Among all milk fermented products, yoghurt is well-known and accepted than others in the world [7]. In addition, it is a highly nutritious and easily digestible diet due to the predigested nutrients by bacterial starters [8]. It contains almost all the nutrients present in milk but in a more assimilable form due to these nutrients that are predigested [8, 9]. Yoghurt can be a good source of essential nutrients as minerals in the human diet. It could contribute significantly to the recommended daily requirements for calcium and magnesium to maintain the physiological processes. It has a significant concentration of Ca^{++} and many other bioactive compounds to carry probiotics to the lower part of the intestine, which can significantly influence the intestinal microflora [7]. Besides calcium, yoghurts are also a good dietary source of phosphorus and its contribution to total phosphorus intake has been reported as 30-45% in western countries [10]. Other key nutrients supplied would include zinc.

Musa [11] examined yoghurt prepared from fresh cow milk and reported 3.2, 4.5 and 19.39% for fat, protein and total solids, respectively. Uraltas and Nazli [12] studied Turkish fruit yoghurt and found out that, dry matter content ranged from 22.2 to 23.5%, fat ranged from 2.2 to 2.8% and solid not fat (SNF) values ranged from 19.4 to 23.5%. Agaoglu *et al.* [13] found that the average dry matter, fat, protein and ash were 18.15, 1.2, 4.08 and 0.94%, respectively. Analyzed yoghurt prepared from fresh cow milk in the Far North Region of Cameroon was reported to have a mean pH of 3.61 to 4.30, mean dry matter content of 13.00 to 23.03g/100g, ash from 0.46 to 0.81g/100g, fat content from 1.25 to 4.05g/100g and total protein content from 2.13 to 3.63g/100g [14]. The contents of calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), phosphorus (P), iron(Fe), zinc (Zn), copper (Cu) and manganese (Mn) were Ca (697 to 1249 mg/kg), Mg (74 to 135 mg/kg), Na (207 to 350 mg/kg), and P (635 to 916 mg/kg), Fe (0.37 to 0.98 mg/kg), and Zn (2.48 to 4.44 mg/kg), Cu (0.02 to 0.16 mg/kg) and Mn (0.00mg/kg) respectively. Analysis of total content of mineral in yoghurts [15, 16], mineral composition of milk fruit-added yoghurts [17] and fermented milks fortified with minerals [18, 19] can also be found in the literature.

The quality of yoghurt depends on the chemical composition of yoghurt milk, method of production, type of flavor or ingredients added and the nature of post-incubation processing. Also, the composition of yoghurt is dependent on the type and source of milk and a range of seasonal factors; for example, whole milk or skimmed milk and season. It is also significantly influenced by manufacturing conditions (such as temperature, duration and equipment utilized) and most importantly, by the presence of other ingredients such as powdered milk or condensed milk [20]. The physical and chemical properties of yoghurt are greatly influenced by the total solids content of the yoghurt milk, especially the protein content [21]. In this respect, many studies and reviews are reported in great details in the world as shown above. However, very limited work has been done in Cameroon pertaining to this effect. Thus the present study was designed to appraise the physical and chemical quality of locally made yoghurt marketed in some regions of Cameroon in comparison to some commercial brands made by big companies in the same country.

2. Materials and Methods

2.1. YoghurtSample Collection

Thirty nine (39) samples of locally made yoghurt were collected from thirteen (13) producers on three different occasions from some Regions (Bamenda, Bafoussam and Dschang) of Cameroon. Concurrently, nine (9) samples of three (3) different commercial brands of yoghurt: (BB); (AA) and (CC) available in Cameroon were equally collected from a well-known sale point in Dschang. Samples were collected in duplicate during the month of November 2012 to August 2013. A total of fourty two (42) samples were collected all together for physico-chemical analysis. The samples, in plastic bottles, were transported in an ice-containing cooler to the Laboratory. Concurrently, three (3) commercial brands of yoghurt: (BB); (AA) and (CC) available in Cameroon were equally collected from a well-known sale point in Dschang. On arrival, mineral elements, pH, titratable acidity (TA), and density were either measured or analyzed immediately using part of the samples. The remaining samples were poured in stainless steel plates and dehydrated in a moisture extractor oven at an average temperature of 50 ± 2°C for 5 days. The dehydrated samples were separately ground using a grinder to obtain meals which were stored in polyethene papers awaiting proximate analysis.

2.2. Assessment of Proximate Composition

This was done in the nutrition laboratory (FASA), Department of Animal Production, University of Dschang, Cameroon. The A. O. A. C. [22] method was adopted for the estimation of dry matter or total solid, ash, crude protein and crude lipid.

2.3. Determination of Mineral Contents

The analyses were performed directly on fresh yoghurts without any previous treatment of the samples according to Pauwels *et al.* [23]. Each sample (10ml) was poured in a crucible and 2.5ml concentrated HCl and 7.5ml of concentrated HNO_3 solutions were added. The resulting solution was gently digested on an electric plate until the volume was reduced to about half in 30 minutes. The digest was filtered using a whatman paper into a 50ml volumetric flask and the volume of the content was made to 50ml with distilled water to obtain solution A. Aliquots of this solution were used for the estimation of K, Ca, Mg, P, Na, Fe and Zn.

P, Fe and Zn were estimated by spectrophotometry; Na and K by flame photometry, while Ca and Mg contents were determined by complexometry.

2.4. Statistical Analysis

The Analysis of Variance (ANOVA) was carried out by using the general linear model procedure of the SPSS (Version 11.0). The means were separated by Waller Duncan test. Significant differences were determined at p = 0.05.

3. Results and Discussion

The study was carried out on the physical and chemical quality appraisal of different locally made yoghurts marketed in some regions of Cameroon in comparison to some available commercial brands during the year 2012-2013. The locally made yoghurt samples were collected from Bamenda, Bafoussam and Dschang while the commercial brands were collected from a well-known sale point in Dschang. They were analyzed for physico-chemical properties including acidity, pH, protein content, total solids or dry matter, solids not fat, lactose and mineral contents (calcium, phosphorus, magnesium, sodium, potassium, iron and zinc) and the results are presented in Table 1.

Table 1. *Physico-chemical properties of "Shalom yaourt" as a function of place of production and sample.*

Place	Sample	DM or TS(%)	Ash(%DM)	Lipids(%DM)	Crude proteins (%DS)
B'da	MR	97.290±0.160^{m}	7.843 ± 0.015^{k}	35.513 ± 0.315^{l}	38.653 ± 1.065^{j}
	SY	94.260 ±0.250^{k}	6.913 ± 0.015^{i}	30.323 ±0.265^{i}	32.463 ± 0.645^{h}
	S	96.063 ± 0.120^{l}	7.350 ± 0.100^{j}	31.430 ± 0.110^{j}	30.283 ± 2.415^{g}
	D	93.333 ± 0.045^{j}	6.983 ± 0.057^{i}	26.380 ±0.420^{h}	32.523 ± 0.035^{h}
Dsch	NR	87.873 ± 0.015^{c}	4.223 ±0.005^{cd}	16.130 ± 0.090^{f}	21.810 ± 0.240^{d}
	PV	85.513 ± 0.145^{a}	3.793 ±0.035^{b}	11.443 ±0.105^{d}	17.420 ± 0.210^{c}
	Pa	92.950 ± 0.040^{i}	5.963 ± 0.055^{h}	17.150 ±0.150^{g}	26.883 ± 0.185^{f}
	G	92.540 ±0.060^{h}	2.980 ± 0.100^{a}	17.553 ±0.285^{g}	14.640 ± 0.110^{b}
	V	90.190 ± 0.060^{f}	4.370±0.120^{de}	12.253 ± 1.125^{e}	22.303 ± 0.325^{d}
Baf	C	91.760 ± 0.500^{g}	6.883 ± 0.005^{i}	32.843 ± 0.445^{k}	34.963 ± 0.5150^{i}
	T	88.540 ±0.390^{d}	5.363 ± 0.055^{g}	20.720 ±0.700^{h}	26.710 ± 0.2400^{f}
	K	86.720 ±0.080^{b}	4.460 ±0.180^{e}	16.473 ± 0.145^{f}	23.430 ± 0.300^{e}
Com B	Ce	87.573 ±0.635^{c}	4.123 ± 0.035^{c}	10.573 ± 0.395^{c}	17.200 ± 0.270^{c}
	BB	91.930 ± 0.040^{g}	3.740 ± 0.030^{b}	8.600 ± 0.010^{b}	17.863 ± 0.765^{c}
	AA	88.980 ± 0.310^{e}	4.923 ± 0.015^{f}	4.130 ±0.3400^{a}	23.773 ± 0.435^{e}
	CC	95.763 ± 0.115^{l}	3.053 ± 0.355^{a}	11.350 ± 0.120^{d}	12.560 ± 0.330^{a}

Table 1. *Continue.*

Place	Sample	SNF(%DM)	Lactose (%DM)	TA(%)	P^{H}
B'da	MR	61.776 ± 0.475^{b}	15.280 ± 0.605^{a}	0.879 ± 0.005^{de}	4.3
	SY	63.936 ± 0.515^{c}	24.560 ± 0.145^{c}	2.226 ± 0.022^{l}	3.7
	S	64.633 ± 0.235^{d}	27.000 ± 2.080^{d}	1.902 ± 0.031^{k}	3.8
	D	66.953 ± 0.465^{e}	27.446 ± 0.435^{d}	0.927 ± 0.009^{fg}	4.3
Dsch	NR	71.743 ± 0.075^{h}	45.710 ± 0.310^{g}	1.008 ± 0.027^{h}	4.2
	PV	74.070 ± 0.040^{i}	52.856 ± 0.135^{i}	1.053 ± 0.018^{i}	4.3
	Pa	75.800 ± 0.110^{k}	42.953 ± 0.240^{f}	0.705 ± 0.005^{a}	4.5
	G	74.986 ± 0.225^{j}	57.366 ± 0.235^{k}	0.939 ± 0.005^{g}	4.8
	V	77.936 ±1.065^{m}	51.263 ± 1.270^{h}	1.218 ± 0.013^{j}	4.3
Baf	C	58.916 ± 0.945^{a}	17.070 ± 1.465^{b}	0.837 ± 0.009^{c}	4.0
	T	67.820 ± 0.310^{f}	35.746 ±0.152^{e}	0.894 ± 0.013^{ef}	4.0
	K	70.246 ± 0.065^{g}	42.356 ± 0.545^{f}	0.984 ± 0.005^{h}	3.9
Com B	Ce	77.000 ± 0.240^{l}	55.676 ±0.065^{j}	0.855 ± 0.009^{cd}	3.9
	BB	83.330 ± 0.030^{n}	61.726 ± 0.825^{l}	0.759 ± 0.013^{b}	4.5
	AA	84.850 ± 0.650^{o}	56.153 ± 0.230^{j}	0.765 ± 0.045^{b}	4.5
	CC	84.413 ± 0.235^{o}	68.800 ± 0.920^{m}	0.931 ± 0.058^{g}	4.2

Values are Mean ± SD of 3 determinants. Along the columns, values with the same letter (a, b, c, d, e, f, g, h, i, j, k, l, m, n, o) are not significantly different (p > 0.05). B'da = Bamenda**;** Dsch = Dschang; Baf= Bafoussam; Com B = Commercial Brands.

3.1. Physico-chemical Properties of Analyzed Yoghurts

3.1.1. Dry Matter or Total Solid Contents of Yoghurts

Dry matter or total solid (DM or TS) of the locally made yoghurt samples (Table 1) ranged from 85.513 to 97.290% generally, with samples from Bamenda, Dschang and Bafoussam ranging from 85.513 to 97.290%, 90.190 to 92.950%, and 86.720 to 91.760% respectively. The commercial or branded yoghurt samples had a range of 88.980 to 95.763%, significantly different ($p<0.05$) among themselves with CC being the highest and AA the lowest. Within each place, samples were significantly different ($p<0.05$). The DM of samples from Bamenda was comparable to or greater than those of the commercial type except the NR and PV samples which were lower. However, that of Dschang and Bafoussam samples were lower with their highest DM values comparable to those of the lower DM commercial yoghurt samples; the least DM coming from Bafoussam samples. Chemical composition of the milk, base especially on total solids, has a major effect on the acceptability of yoghurt [24]. Total solids content of yoghurt is known to have significant effect on the degree of syneresis. A high total solids content has a significant effect on the firmness of yoghurt gel and decreasing degree of syneresis [25]. Values were reasonably high as compared to the findings of Hofi *et al.*, [26] who stated that yoghurt should have a total solid of between 15% and 16% and Muhammed *et al.*, [27] who reported a higher total solid of 17.11%. However, Weaver [28] reported that low percentage of total solids in yoghurt can lead to malfunction of the starter culture. All these lend credit to the Bamenda locally fabricated yoghurt. These variations within locally made yoghurt could be due to the fact that, milk used in production is not standardized. These results also show that, there is either no fixed standard of yoghurt production in Cameroon or it is not respected since a variation was equally observed among the commercial yoghurt samples. This is because the raw materials were supposed to be standardized and quality control measures taken to ensure good and uniform quality of end products.

3.1.2. Ash Contents (% DM) of Yoghurts

The ash content (Table 1) ranged from 2.980 to 7.843%, with samples from Bamenda, Dschang and Bafoussam ranging from 3.793 to 7.843%, 2.980 to 5.963%, and 4.123 to 6.883% respectively. The commercial yoghurt samples were from 3.053 to 4.923%, significantly different among themselves, with AA being the highest and CC the least. Generally, ash contents varied significantly ($p<0.05$) as a function of sample and place of collection, with samples from Bamenda having the highest ash contents, followed by those from Bafoussam with the least from Dschang. Also, most samples were significantly higher ($p<0.05$) than the commercial type. The study of ash content is very important to the extent that it provides an insight into nutritionally important inorganic mineral elements. It was reported that the ash content of a food sample gives an idea of the mineral elements present in the food sample which is needed for bone development, teeth formation and body functions [29].

3.1.3. Crude Lipid Contents (% DM) of Yoghurts

The crude lipid ranged from 4.130 to 35.513%, with samples from Bamenda, Dschang and Bafoussam ranging from 11.443 to 35.513%, 12,253 to 17.553%, 10.573 to 32.843% respectively (Table 1). Commercial yoghurt samples were from 4.130 to 11.350%, significantly different ($p<0.05$) among themselves, with highest value from CC and lowest from AA. Generally, all samples were significantly different ($p<0.05$) among themselves within each place with samples from Bamenda having the highest crude lipids, followed by those from Bafoussam with the least from Dschang. Also, lipid contents of all samples were significantly higher ($p<0.05$) than the commercial brands. This is understood since a high total solid content is usually accompanied by a high fat content [30]. The differences observed might be due to the absence of quality control measures or standardization, resulting in compositional variation from sample to sample. According to USDA [31], all the studied locally fabricated milk products were "yoghurt" since their fat contents were above 3.25%. Although low fat content is generally beneficial for health and shelf stability of yoghurts [32, 33], fat content has been reported to have positive influence on the physical (viscosity and consistency) and sensory characteristics [34, 35].

3.1.4. Crude Protein Contents (%DM) of Yoghurts

Crude proteins (Table 1) of the locally made yoghurt ranged from 12.560 to 38.653%, with samples from Bamenda, Dschang and Bafoussam ranging from 17.420 to 38.653%, 14.640 to 26.883% and 17.200 to 34.963% respectively. The crude protein contents of the commercial yoghurt samples were from 12.560 to 23.773%, significantly different ($p<0.05$) among themselves, with AA having the highest content and CC, the lowest. Generally, all samples were significantly different ($p<0.05$) among themselves within each place with samples from Bamenda having the highest crude proteins, followed by those from Bafoussam with the least from Dschang. The crude protein contents of most samples were significantly greater ($p<0.05$) than the commercial type. A high total solid content is usually accompanied by high protein content [30]. The crude protein contents of the yoghurt samples were relatively high as compared to the 3.5% protein content of yoghurt reported by Early [36].

3.1.5. Solids-Not-Fats (SNF) Contents of Yoghurts

The SNF ranged from 58.916 to 84.850%, with samples from Bamenda, Dschang and Bafoussam ranging from 61.776 to 74.070%, 74.986 to 77.936% and 58.916 to 77.000% respectively (Table 1), while the commercial yoghurt samples ranged from 83.330 to 84.850%. There was no significant difference ($p>0.05$) in the SNF contents between AA and CC; both of which were significantly greater ($p<0.05$) than that of BB. More so, all samples from the three different places had significantly lower ($p<0.05$) values than the commercial type. Generally, samples were significantly different ($p<0.05$) among themselves within each place with samples from Dschang having the highest SNF contents, followed by those from Bafoussam, with the least from Bamenda. The standard for solids-not-fat in the USA is 8.25% and 8.50% in UK and Australia. However, these minimum are being raised to approximately 12-15% in order to achieve the required texture and viscosity of the final product [36]. Thus the locally fabricated and commercially available yoghurts of Cameroon had exceptionally high SNF. Milk is standardized to a fixed SNF content in order to ensure consistency of end product. Since "shalom yaourt" is made with different varieties of powdered milk, there is bound to be variation. Tamime and Deeth [5] reported that the content of fat, protein and ash will affect the solids-not-fat content, so it is very important for this to be taken into consideration during the standardization of milk in order to fix the level to an acceptable standard.

3.1.6. Lactose Contents (%DM) of Yoghurts

This was from 15.280 to 68.800%, with samples from Bamenda, Dschang and Bafoussam ranging from 15.280 to 52.856%, 42.953 to 57.366% and 17.070 to 55.676% respectively (Table 1). The commercial yoghurt samples ranged from 56.153 to 68.800%, significantly different ($p<0.05$) among themselves, with the content of CC being the highest and that of AA, the least. In addition, the lactose contents of all samples from the three different places were significantly lower ($p<0.05$) than those of the commercial type. Generally, there was a significant difference ($p<0.05$) within and among localities. Samples from Dschang had the highest lactose content, followed by those from Bafoussam with the least from Bamenda. Also, the contents of all samples were significantly lower ($p<0.05$) than the commercial type. Reduction in lactose levels in fermented milk products reflects the β-galactosidase activity of the cultures used in the fermentation process. *Streptococcus thermophilus*-culture-based yoghurt contains three times more lactase than *Lactobacillus bulgaricus*-culture-based yoghurt. The actual lactase activity of mixed cultures of the two species depends on the strains selected. Also, the length of storage time before analysis may equally contribute to the variations in lactose contents especially with the commercial yoghurt samples. There is mounting evidence that lactose in foodstuffs promotes calcium absorption in humans [37] by an unknown mechanism, but that undigested lactose may interfere with calcium absorption [38]. Lactose promotes magnesium and manganese absorption in healthy infants [37].

3.1.7. Titratable Acidity (TA) of Yoghurts

This was between a range of 0.705 to 2.226% in the yoghurt samples, with those from Bamenda, Dschang and Bafoussam ranging from 0.879 to 2.226%, 0.705 to 1.218% and 0.837 to 0.984% respectively, while the commercial yoghurt samples were from 0.759 to 0.931% (Table 1). There was no significant difference ($p>0.05$) in titratable acidity between AA and BB; both of which were significantly lower ($p<0.05$) than that of CC. All samples from the three different places were significantly greater ($p<0.05$) than the commercial type, with highest values coming from Bamenda, followed by those from Dschang, and those from Bafoussam were the least. The insignificant variation in acidity (AA and BB) of different samples of plant made yoghurt or commercially available yoghurt as compared to the locally made variety is due to controlled incubation and post-production handling and controlled storage at 4°C. In the case of locally made yoghurt, uncontrolled incubation, post-production handling and storage cause increase in acidity. However, the values obtained for titratable acidity were generally above the standard of 0.7% [39]. Also, the results were in agreement with those of Younus *et al.* [9] who analyzed the quality of market yoghurt/dahi and recorded 0.89, 0.87 and 1.13 titratable acidity. The results of the present findings are also in accordance with those of Saleh *et al.* [40] who concluded that the titratable acidity of stirred yoghurt is 0.93.

3.1.8. PH Values of Yoghurts

The pH ranged from 3.7 to 4.8, with samples from Bamenda, Dschang and Bafoussam ranging from 3.7 to 4.3, 4.3 to 4.8 and 3.9 to 4.0 respectively, while values obtained with the commercial type were from 4.2 to 4.5 (Table 1). The pH of AA and BB were the same but greater than CC. Generally, there was a variation of pH values in samples within and among places, with pH values lower than those of the commercial type. Samples from Dschang had the highest pH values, followed by those from Bamenda with the least from Bafoussam. Again, the insignificant variation (AA and BB) in pH of different commercially available or branded yoghurt as compared to the locally made type could be due to the time and temperature-controlled incubation, leading to the desired pH of about 4.6; the isoelectric point of casein. For locally made yoghurt, proper fermentation conditions are not fully controlled, hence a large variation of pH in the end product is obvious. About 50% of pH values obtained from samples were not in agreement with those suggested by Gallardo-Escamilla *et al.* [41] and Tamime and Robinson [42], who recommended as desirable the obtainment of fermented milk with pH between 4.2 and 4.8. Tamime and Robinson [42] related that the obtainment of fermented milk in this pH range would result in a better rearrangement and aggregation of casein particles, contributing according to Gallardo-Escamilla *et al.* [41] to the formation of a more stable gel, avoiding the separation of phases (syneresis). Food Standard Code requires a maximum yoghurt pH of 4.50 in order to prevent the growth of any pathogenic organisms [43].

3.2. Mineral Contents of Analyzed Yoghurts

The P contents (Table 2) ranged from 44.191 to 616.207 mg/l, with samples from Bamenda, Dschang and Bafoussam ranging from 57.907 to 115.846, 44.191 to 88.519 and 45.234 to 59.618 mg/l respectively. The contents of the commercial yoghurt samples ranged from 64.008 to 616.207 mg/l, significantly different from each other, with CC being the highest and BB the least. Generally, all samples were significantly different (p<0.05) within and among localities, with samples from Bamenda having the highest phosphorus contents, followed by those from Dschang, and the least from Bafoussam samples. Also, most samples were significantly lower (p<0.05) than the commercial type.

Table 2. *Mineral contents (mg/L) of "Shalom yaourt" as a function of place of production and sample.*

Place	Sample	Phosphorus(P)	Zinc(Zn)	Iron(Fe)	Potassium(K)
Bamenda	NR	85.771 ± 0.090^{g}	0.984 ± 0.293^{a}	146.617 ± 0.739^{e}	509.085 ± 3.045^{d}
	PV	115.846 ± 0.436^{j}	11.266 ± 0.000^{c}	200.055 ± 0.555^{j}	531.023 ± 2.000^{e}
	MR	72.671 ± 0.550^{ef}	19.198 ± 0.293^{e}	136.447 ± 0.924^{d}	466.175 ± 4.011^{c}
	D	98.853 ± 0.430^{i}	13.617 ± 0.000^{d}	121.655 ± 0.555^{c}	576.150 ± 2.016^{f}
	S	75.385 ± 0.956^{f}	49.560 ±1.490^{f}	328.780 ± 1.120^{o}	931.166 ± 4.010^{l}
	SY	57.907 ± 5.299^{c}	64.560 ± 0.770^{g}	262.150 ± 2.100^{m}	500.003 ± 0.045^{c}
Dschang	Pa	44.191 ± 2.805^{a}	49.560 ± 0.540^{f}	173.220 ± 0.890^{g}	385.993 ± 0.880^{a}
	G	88.519 ± 2.748^{g}	0.984 ± 0.293^{a}	226.681 ± 0.185^{k}	978.588 ± 3.310^{m}
	V	71.387 ± 1.308^{e}	1.278 ± 0.000^{a}	192.289 ± 0.185^{i}	1007.740 ± 5.300^{n}
Bafoussam	K	54.299 ± 3.576^{b}	0.763 ± 0.0780^{a}	145.878 ± 0.707^{e}	697.618 ± 1.510^{g}
	Ce	57.439 ± 0.436^{bc}	10.000 ± 0.050^{b}	50.097 ± 1.097^{a}	697.758 ± 0.959^{g}
	C	45.234 ± 0.435^{a}	0.483 ± 0.006^{a}	88.557 ± 2.222^{b}	819.841 ± 3.135^{i}
	T	59.618 ± 0.000^{c}	0.814 ± 0.010^{a}	149.206 ± 1.206^{f}	819.805 ± 3.200^{i}
Com B	BB	64.008 ± 1.436^{d}	19.198 ± 1.468^{e}	265.696 ± 1.849^{n}	859.661 ± 4.030^{j}
	AA	91.873 ± 1.202^{h}	14.204 ± 0.000^{d}	175.832 ± 0.000^{h}	888.136 ± 0.306^{k}
	CC	616.207± 3.740^{k}	112.143 ± 2.000^{h}	248.186 ± 3.000^{l}	795.033 ± 1.050^{h}

Table 2. *Continue.*

Place	Sample	Sodium(Na)	Calcium(Ca)	Magnesium(Mg)
Bamenda	NR	83.815 ± 0.015^{b}	7360.000 ± 9.000^{i}	388.800 ± 2.400^{e}
	PV	109.556 ± 2.650^{e}	10560.000 ± 15.000^{m}	631.800 ± 2.900^{g}
	MR	83.805 ± 0.400^{b}	4960.000 ± 8.000^{f}	3304.800 ± 3.900^{k}
	D	84.198 ± 0.519^{bc}	5200.000 ± 11.0000^{g}	2916.000 ± 5.000^{j}
	S	129.419 ± 4.217^{g}	4800.000 ± 14.000^{e}	3888.000 ± 8.000^{l}
	SY	118.530 ± 0.491^{f}	6560.000 ± 17.000^{h}	534.466 ± 3.901^{f}
Dschang	Pa	43.820 ± 0.207^{a}	2800.000 ± 5.000^{b}	243.000 ± 1.000^{d}
	G	192.921 ± 2.905^{j}	10963.333 ± 15.275^{n}	1846.766 ± 6.750^{i}
	V	168.130 ± 2.030^{h}	7360.000 ± 20.000^{i}	5248.733 ± 8.700^{n}
Bafoussam	K	106.006 ± 2.000^{d}	9360.000 ± 5.000^{k}	145.800 ± 0.600^{c}
	Ce	86.761 ± 2.150^{c}	3680.000 ± 10.000^{c}	48.600 ± 0.200^{a}
	C	106.106 ± 0.853^{d}	4560.000 ± 9.000^{d}	145.800 ± 1.300^{c}
	T	106.040 ± 0.950^{d}	8640.000 ± 5.000^{j}	97.200 ± 0.600^{b}
Com B	BB	171.496 ± 1.500^{i}	15120.000 ± 50.000^{o}	1263.200 ± 6.009^{h}
	AA	171.163 ± 2.019^{i}	10000.000 ± 30.000^{l}	5103.000 ± 13.000^{m}
	CC	107.016 ± 0.975^{de}	2560.000 ± 5.000^{a}	6026.400 ± 25.700^{o}

Values are Mean ± SD of 3 determinants. Along the columns, values with the same letter (a, b, c, d, e, f, g, h, i, j, k, l, m, n, o) are not significantly different (p > 0.05). Com B = Commercial Brands.

Zn contents (Table 2) ranged from 0.483 to 112.143 mg/l, with samples from Bamenda, Dschang and Bafoussam ranging from 0.984 to 64.560, 0.984 to 49.560 and 0.483 to 10.000 mg/l respectively. The commercial yoghurt samples had a range of 14.204 to 112.143 mg/l, significantly different (p<0.05) from each other, with CC being the highest and AA the least. Generally, the variation observed within samples and from one place to another was not significant (p>0.05), except those from Bamenda. Samples from Bamenda had the highest zinc content, followed by those from Dschang, with Bafoussam being the last. More so, only samples from Bamenda were significantly higher than the commercial brands, except CC.

The Iron contents (Table 2) ranged from 50.097 to 328.780 mg/l, with samples from Bamenda, Dschang and Bafoussam ranging from 121.655 to 328.780, 173.220 to 226.681 and 50.097 to 149.206 mg/l respectively. The commercial samples were from 175.832 to 265.696 mg/l, significantly different (p<0.05) from each other, with BB being the highest and AA the least. Generally, there were significant differences (p<0.05) in Fe contents of samples within and among places. Samples from Bamenda had the highest Iron contents, followed by those from Dschang with the least from Bafoussam. In addition, the Iron contents of most samples were significantly lower than those of the commercial type, except AA.

The K contents (Table 2) ranged from 385.993 to 1007.740 mg/l. Samples from Bamenda, Dschang and Bafoussam had a ranged of 466.175 to 931.166, 385.993 to 1007.740 and 697.618 to 819.805 mg/l respectively. The contents of the commercial types were from 795.033 to 859.661 mg/l, significantly different ($p<0.05$) from each other, with AA presenting the highest value and CC, the least. Generally, there was a significant variation ($p<0.05$) in K contents of samples within a locality and from place to place. Samples from Dschang had the highest potassium contents, followed by those from Bafoussam with the least from Bamenda. More so, the values of samples from Bamenda, except S, were significantly lower ($p<0.05$) than the commercial types. Meanwhile K contents of samples from Dschang, except Pa, were significantly higher than the commercial types. Lastly, samples from Bafoussam were significantly lower than the commercial samples with the exception of CC.

The sodium contents (Table 2) ranged from 43.820 to 192.921 mg/l, with samples from Bamenda, Dschang and Bafoussam ranging from 83.805 to 118.530, 43.820 to 168.130 and 86.761 to 106.006 mg/l respectively. The commercial yoghurt samples were from 107.016 to 171.163 mg/l, with no significant variation ($p>0.05$) between BB and AA, both of which were significantly greater ($p<0.05$) than CC sodium content. Generally, the variation observed within samples, except those from Bafoussam, and from one place to another was significant. Samples from Dschang had the highest sodium content, followed by Bamenda and Bafoussam. The Na contents of samples were significantly lower than commercial types, except CC.

The calcium contents (Table 2) ranged from 2560.000 to 15120.000 mg/l, with samples from Bamenda, Dschang and Bafoussam ranging from 4800.000 to 10560.000, 2800.000 to 10963.333 and 3680.000 to 9360.000 mg/l respectively. The commercial types ranged from 2560.000 to 15120.000 mg/l, significantly different from each other, with BB content being the highest and CC the least. Generally, the values of all samples were significantly different ($p<0.05$) within a place and among places, with samples from Dschang having the highest calcium contents, followed by those from Bafoussam with the least from Bamenda. Also, the calcium contents of samples were significantly lower ($p<0.05$) than commercial yoghurt samples, except CC.

The magnesium contents (Table 2) ranged from 48.600 to 6026.400 mg/l, with samples from Bamenda, Dschang and Bafoussam ranging from 388.800 to 2916.000, 243.000 to 5248.733 and 48.600 to 145.800 mg/l respectively. The contents of the commercial samples were from 1263.200 to 6026.400 mg/l, significantly different from each other, with CC being the highest and BB the least. Generally, all samples were significantly different ($p<0.05$) within a locality and as a function of place, with samples from Bamenda having the highest magnesium contents, followed by those from Dschang with the least from Bafoussam. The contents of all samples from Bafoussam were significantly lower ($p<0.05$) than the commercial types. Those from Bamenda were equally significantly lower with the exception of BB (commercial type); meanwhile the contents of samples from Dschang, except V, were lower as well.

Na/K ratio in the body is of great concern for prevention of high blood pressure; Na/K ratio less than 1 is recommended. Hence, in the present study, all the samples would probably prevent high blood pressure or could be recommended to such patients. Modern diets which are rich in animal proteins and phosphorus may promote the loss of calcium in the urine [44]. This had led to the concept of the Ca/P ratio. If the Ca/P ratio is low (low calcium, high phosphorus intake), more than the normal amount of calcium may be lost in the urine, decreasing the level of calcium in bones. Food is considered good if the ratio is above 1 and poor if the ratio is less than 0.5 [45]. The Ca/P ratio in the present study was above 1 indicating that these yoghurt samples will serve as good sources of minerals for bone formation.

Results obtained for calcium, magnesium and zinc were higher than those obtained by De la Fuente *et al.* [46] while those of sodium, potassium and phosphorus were lower. There are numerous factors which affect yoghurts chemical composition, mainly the methods of fortification used to increase the solid content, which is a common practice during yoghurt manufacture. A wide range of total solids and other minerals (sodium and potassium) was also found in the yoghurts studied by De la Fuente *et al.* [46] indicating the possible addition of different dairy fractions or products. However, this supply can represent an advantage from a nutritional point of view as a source of essential nutrients in diet in comparison with other dairy products.

4. Conclusion

Based on the physico-chemical composition, yoghurt samples from Bamenda had the highest DM, ash, crude lipid, crude proteins and TA, making them to be the best among the locally made yoghurts, better than the branded types. This was followed by samples from Bafoussam, with those from Dschang being the least in most cases.

Concerning the mineral contents, samples from Bamenda were high in phosphorus, zinc, iron, and magnesium, while those from Dschang were high in sodium, potassium and calcium. This would indicate that the compositions of the different types of powdered milk used by producers are different. Some of these minerals may be abundant in some of this powdered milk. Most of these producers are not educated; there is need for the Government to sponsor educational programs for producers so that they can be sensitized on the different powdered milk found in the market so that there can be uniformity in the end products. Generally, the mineral contents in all the places were significantly lower than those of the commercial varieties. Sample CC was high in Phosphorus, zinc, and magnesium, BB was high in iron and calcium while AA was high in potassium. Thus, total mineral content showed wide intervals of variation, with the commercial or branded yoghurts being better than the locally made varieties. However, samples from Bamenda and Dschang were better in terms of minerals than those from Bafoussam.

The variations observed in physico-chemical composition between locally made yoghurts as well as branded or commercially available yoghurts can be attributed to several factors such as type of milk used, method of preparation, type and proportion of ingredients used.

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