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Comparison of Some Compositional Quality Measurements of Market Milk in Khartoum State (Sudan)

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Abstract: The present study was designed to evaluate the compositional quality of the milk offer for sale in Khartoum State. The milk samples (120) were collected equally during summer and winter from five shops in each of the four different selected areas in the three big cities of Khartoum State. The milk samples collected revealed average values of 2.9±0.05%, 3.70±1.12, 12.61±1.72 and 0.563±0.106% protein, fat, total solids and ash, respectively. The average values of titratable acidity, pH, freezing point and temperature of the milk samples collected from Khartoum State were 0.176±0.029%, 6.50±0.30, -0.535±0.034 and 25.2±15.19°C, respectively. Moreover highly significant differences ($p<0.001$) were found for the values of total solids, pH and temperature due to variations of the areas from which the milk samples were collected. Similarly the values of protein and ash of the milk samples showed significant variations at $p<0.01$ and $p<0.05$, respectively. Also higher significant differences ($p<0.01$) were estimated when comparing the total solids content of the milk samples collected from the different cities and the pH values of the milk samples collected during summer and winter seasons. However non significant differences were reported for the other measurements when comparing the milk samples from different areas and cities and for the samples collected during summer season. Moreover non significant differences were estimated for the milk constituents during winter season. The high temperature indicated that most of the milk samples were boiled at shops before sale which was proved by the inactivation of phosphatase enzymes. The relatively high freezing point of some milk samples might suggest the adulteration of milk either by addition of water or skimming of fat as it was found that the total solids and fat contents of some milk samples were low. On the other hand detection of formalin revealed that all the examined milk samples were free form formalin. The present study recommended the establishment of regulations and pricing structure of milk according to its compositional quality.

Key words: Market milk, chemical constituents, quality, season, Khartoum State, Sudan

Introduction

The composition and functional properties of cow's milk are of considerable importance to the dairy farmer, manufacturer and consumer (Walker *et al*., 2004). As milk quality is an important aspect of dairy production, many penalty or premium programs have been instituted in several dairy industries to provide incentive for producers to improve milk quality (Dekkers *et al*., 1995). To consumers, quality means that the product tastes good and that it keeps well in their home refrigerator

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(Boor, 2001). However milk is not a commodity with uniform composition but is more widely influenced by environmental and genetic factors than any other biological fluid (Harding, 1999).

Methods of adulteration are addition of water, extraction of butter fat, addition of preservatives and coloring matter (Hunderson, 1971). He also stated that many methods are used to determine adulteration of milk and these include determination of freezing point, nitrate test, determination of butter fat and the specific gravity. A freezing point value of -0.571 is considered normal for milk and milk that freezes at or below this value is presumed to be free of added water (Marshal, 1992). Physical and chemical analysis done on milk samples collected from Brazil revealed that 18 samples (42.85%) had changes in cryoscopic points indicating addition of water (Beloti *et al*., 1999). Boor *et al*. (1998) found the mean value of the freezing points of raw milk samples from bulk tanks milk in New York State was -0.543.

Dairy marketing is a complicated business because milk is a perishable product (El Aggab, 1996). In Sudan, urban milk supply largely comes from village herds and its marketing is mostly by milk venders who distribute raw milk to households on donkeys since organized dairy establishments are limited (El magli and El Zubeir, 2006). Moreover Mustafa (1994) reported that milk in Khartoum State is mainly marketed through the middle men and reaches the consumers via retail market or from producers directly to consumers. Middle men are numerous in number and each supplying one or two retailers as she reported. The Sudanese dairy industry is therefore in a primitive and early stage of development and faced with several problems that include bad or improper handling of raw milk, problems of transportation and distribution, lack of infrastructure, high temperature, lack of principles of quality control, poor husbandry practices and neglecting of sanitary standards by the distributors are the major impediments (Elmagli and El Zubeir, 2006). Therefore, is to be expected that physical, chemical and hygienic quality of the milk would be law as they reported. Hence the present study is a contribution to the evaluation of compositional quality of market milk in Khartoum State by assessment of some chemical and physical properties of market milk collected during summer and winter and investigation of adulteration of milk by water and formalin.

Materials and Methods

Source of Milk Samples

In this study 120 milk samples were collected from 60 shops in Khartoum State, sixty samples during summer (August-September 2003) and the other 60 during winter (December 2003- January 2004) at both season twenty milk samples were collected from each big city in Khartoum State.

Collection of Milk Samples

Milk samples were collected from four selected areas in each city from five shops. The collection was done at the evenings using sterilized labeled bottles. The milk samples were kept in the refrigerator at 4°C and transported in an ice box to the laboratory of the Department of Dairy Production, Faculty of Animal Production, University of Khartoum.

Analysis of Milk Samples

All the tests were carried in duplicate. The total solid was determined according to the modified method of AOAC (1990). Similarly the fat content was determined by Gerber method, the protein contents were determined by Kjeldahl method and the ash content was done by muffle furenes according to AOAC (1990). The pH of the milk samples was measured by pH meter. Thermometer (Chem. Thermometer, Milch glass Kalla) was used to determine the degree of temperature of the sample at the time of collection (Marshall, 1992). The titratable acidity was determined according to AOAC (1990). Freezing point was determined by a Fiske Ms Cryoscope (Fiske Med. Sci. Inc. USA) using the standards supplied by IAEA.

The qualitative analysis of phosphatase in milk was estimated using Lactognost tablets and powder which were obtained from Heyl, Chem. Pharm- Fabric 14167, Berlin, Germany. The procedure was done according to manufacturers' instructions.

Statistical Analysis

The analysis was carried out using SPSS program (Statistical Package for Social Sciences). All the data of this experiment were analyzed statistically by using complete randomized design and least significant difference tests. One way ANOVA was used to determine the effect of season, city and area on milk samples.

Results

Chemical Analysis of the Raw Milk Samples

Total Protein Content

The total mean for protein value of milk samples collected from Khartoum State was found to be 2.98±0.5%. The mean total protein values of milk were 3.08±0.59, 2.91±0.41 and 2.93±0.47% for the samples collected from Khartoum North, Khartoum and Omdurman, respectively. Similarly during summer and winter the mean total protein values were 3.08±0.66 and 3.08±0.53%, 3.04±0.42 and 2.79±0.36% and 2.9±0.48 and 2.94±0.46%, respectively (Table 1). There were non-significant

Table 1: Comparison of the chemical composition of the raw milk samples collected from different cities of Khartoum State during winter and summer

		Protein (%)			Fat (%)		
Cities	Seasons	Mean±SD	Min.	Max.	Mean±SD	Min.	Max.
Khartoum North	Winter	3.08±0.53	2.2	3.9	3.76±1.02	1.6	6.0
	Summer	3.08±0.66	1.7	3.9	3.94±1.22	1.4	6.2
	Sub total	3.08±0.59	1.7	3.9	3.87±1.12	1.4	6.0
Khartoum	Winter	2.79±0.36	2.3	3.5	3.04±1.34	1.3	5.9
	Summer	3.04±0.42	2.2	3.8	3.89±0.81	2.0	5.0
	Sub total	2.91±0.41	2.2	3.8	3.46±1.17	1.3	5.9
Omdurman	Winter	2.97±0.46	2.0	3.9	3.55±1.1	1.8	6.0
	Summer	2.90±0.48	1.8	3.5	3.94±1.02	2.1	5.9
	Sub total	2.93±0.47	1.8	3.9	3.75±1.07	1.8	6.0
Khartoum State	Winter	2.94±0.46	2.0	3.9	3.45±1.18	1.3	6.0
	Summer	3.01±0.53	1.7	3.9	3.94±1.02	1.4	6.2
	Total	2.98±0.5	1.7	3.9	3.7±1.124	1.3	6.0

In this and the following tables: M = Mean, Std = Standard deviation, Min = Minimum, Max = Maximum

Table 1: Continued

		Total solids (%)			Ash (%)		
Cities	Seasons	Mean±SD	Min.	Max.	Mean±SD	Min.	Max.
Khartoum North	Winter	12.67±1.26	9.6	14.5	0.53±0.103	0.3	0.7
	Summer	12.21±1.56	9.0	14.3	0.57±0.108	0.4	0.7
	Sub total	12.44±1.42	9.0	14.5	0.55±0.106	0.3	0.7
Khartoum	Winter	12.69±1.88	7.0	16.5	0.58±0.118	0.3	0.8
	Summer	11.65±2.2	7.8	16.0	0.57±0.108	0.3	0.8
	Sub total	12.17±2.09	7.8	16.0	0.578±0.112	0.3	0.8
Omdurman	Winter	13.53±1.23	11.7	16.4	0.545±0.115	0.3	0.7
	Summer	12.95±1.54	10.2	16.0	0.575±0.085	0.4	0.7
	Sub total	13.24±1.41	10.2	16.0	0.56±0.101	0.3	0.7
Khartoum State	Winter	12.96±1.52	7.0	16.5	0.545±0.115	0.3	0.7
	Summer	12.27±1.84	7.8	16.0	0.575±0.085	0.4	0.7
	Total	12.62±1.72	7.8	16.0	0.563±0.106	0.3	0.8

In this and the following tables: M = Mean, Std = Standard deviation, Min = Minimum, Max = Maximum

Table 2: Comparison of pH and titratable acidity of the raw milk samples collected from different cities in Khartoum State during summer and winter

		Titratable acidity			pH		
Cities	Seasons	Mean±SD	Min.	Max.	Mean±SD	Min.	Max.
Khartoum North	Winter	0.154±0.012	0.12	0.17	6.67±0.15	6.3	6.8
	Summer	0.2±0.033	0.16	0.3	6.15±0.28	5.4	6.4
	Sub total	0.177±0.034	0.12	0.3	6.41±0.34	5.4	6.8
Khartoum	Winter	0.161±0.022	0.13	0.21	6.63±0.20	6.1	6.9
	Summer	0.195±0.018	0.15	0.22	6.4±0.3	5.9	6.8
	Sub total	0.178±0.026	0.13	0.22	6.53±0.27	5.9	6.8
Omdurman	Winter	0.161±0.019	0.14	0.2	6.7±0.11	6.5	6.8
	Summer	0.184±0.026	0.14	0.24	6.4±0.31	5.9	6.8
	Sub total	0.173±0.026	0.14	0.24	6.56±0.27	5.9	6.8
Khartoum State	Winter	0.158±0.018	0.12	0.21	6.66±0.16	6.1	6.9
	Summer	0.193±0.03	0.14	0.3	6.3±0.32	5.4	6.8
	Total	0.176±0.003	0.12	0.3	6.5±0.31	5.4	6.9

differences in protein values of the milk samples collected from different cities and during different seasons, however there was significant difference ($p \leq 0.001$) between the areas from which the milk was collected in protein value as shown in Table 4.

Fat Content

The total mean for fat content of milk samples collected from Khartoum State was 3.7±1.12%, while the mean fat values of milk were 3.87±1.12, 3.46±1.17 and 3.75±1.07% for the milk samples collected from Khartoum North, Khartoum and Omdurman, respectively (Table 1). The mean values of fat content during summer and winter were 3.94±1.22 and 3.76±1.02%, 3.89±0.81 and 3.04±1.34% and 3.94±1.02 and 3.55±1.1%, respectively as shown in Table 1. There were non significant differences between the milk samples collected from the different cities, areas and seasons as shown in Table 4.

Total Solids Content

The average total solids value of milk samples collected from Khartoum State was 12.61±1.72% and the maximum was 16.0% and the minimum was 7.8%. The mean total solids values were found to be 12.44±1.42, 12.17±2.09 and 13.24±1.41% for the milk samples that collected from Khartoum North, Khartoum and Omdurman, respectively (Table 1). During summer and winter the mean total solids revealed 12.21±1.56 and 12.67±1.26%, 11.56±2.2 and 12.69±1.88% and 12.95±1.54 and 13.53±1.23%, respectively (Table 1). The data showed significant differences for the milk collected from the different cities ($p \leq 0.01$) and areas ($p \leq 0.001$), while non significant differences were reported for seasonal variations (Table 2).

Ash Content

The milk samples collected from Khartoum State revealed total mean ash content of 0.563±0.106%, the minimum was 0.3% and the maximum was 0.8%. The mean values of ash content were 0.55±0.106, 0.578±0.112 and 0.56± 0.101% for the samples collected from Khartoum North, Khartoum and Omdurman, respectively (Table 1). The mean values of ash content during summer and winter were 0.57±0.108 and 0.53±0.103%, 0.57±0.108 and 0.58±0.118% and 0.575±0.085 and 0.545±0.155%, respectively (Table 1). Significant differences ($p \leq 0.05$) were obtained for ash content of the milk samples collected from the different areas, while non significant differences were found between the cities and seasons in the values of ash (Table 4).

Table 3: Comparison of temperature and freezing point of raw milk samples during summer and winter from different cities of Khartoum State

		Temperature (°C)			Freezing point (°C)		
Cities	Seasons	Mean±SD	Min.	Max.	Mean±SD	Min.	Max.
Khartoum North	Winter	21.19±15.44	6.0	53.0	-0.533±0.034	-0.58	-0.43
	Summer	28.8±16.37	10.0	56.0	-0.526±0.038	-0.5	-0.41
		25.38±16.08	6.0	56.0	-0529±0.035	-0.059	-0.41
Khartoum	Winter	20.6±15.17	7.0	55.0	-0.533±0.048	-0.57	-0.41
	Summer	31.3±18.57	10.0	65.0	-0.529±0.036	-0.59	-0.47
		25.95±17.6	7.0	65.0	-0.531±0.042	-0.59	-0.41
Omdurman	Winter	20.0±10.74	8.0	50.0	-0.5465±0.02	-0.58	-0.50
	Summer	29.25±10.81	11.0	55.0	-0542±0.019	-0.57	-0.51
		24.63±11.62	8.0	55.0	-0.544±0.019	-0.58	-0.5
Sub total	Winter	20.85±13.74	6.0	55.0	-0.537±0.036	-0.58	-0.41
	Summer	29.78±15.37	10.0	65.0	-0.532±0.032	-0.59	-0.41
	Total	25.32±15.19	6.0	65.0	-05347±0.003	-0.59	-0.41

Table 4: Comparison of chemical composition of the raw milk samples collected from different cities in Khartoum State using one way ANOVA analysis

	Significant level			
Chemical constituents	Cities	Areas	Summer	Winter
pH	0.061^{NS}	0.001***	0.006**	0.326^{NS}
Protein (%)	0.245^{NS}	0.002**	0.162^{NS}	0.123^{NS}
Fat (%)	0.248^{NS}	0.291^{NS}	0.948^{NS}	0.144^{NS}
Total solids (%)	0.014**	0.001***	0.08^{NS}	0.124^{NS}
Ash (%)	0.507^{NS}	0.015*	0.984^{NS}	0.284^{NS}
Titratable acidity	0.706^{NS}	0.082^{NS}	0.162^{NS}	0.35^{NS}
Temperature	0.927^{NS}	0.001***	0.865^{NS}	0.903^{NS}
Freezing point	0.92^{NS}	0.001***	1.507	0.379^{NS}

NS = Non Significant ($p>0.05$), * = significant at $p\leq0.05$** = significant at $p\leq0.01$, *** = significant at $p\leq0.001$

The pH Values

Table 2 shows that the total mean pH value for the milk samples collected from Khartoum State was 6.5±0.30. Moreover, the minimum was 5.4 and the maximum was 6.8. The milk samples revealed mean pH values of 6.41±0.341, 6.53±0.27 and 6.56±0.27% for the samples collected from Khartoum North, Khartoum and Omdurman, respectively (Table 2). Similarly the mean pH values were 6.15± 0.28 and 6.67±0.15%, 6.4±0.3 and 6.63±0.20% and 6.4±0.31 and 6.7±0.11% during summer and winter, respectively (Table 2). The milk samples showed highly significant differences between the milk samples collected from the different areas ($p\leq0.001$) and summer season ($p\leq0.01$). However non significant differences ($p>0.05$) were obtained due to variation of cities and winter season (Table 4).

Titratable Acidity

Table 2 shows that the acidity of the milk samples collected from Khartoum State was 0.176±0.029%, the minimum was 0.12% and the maximum was 0.3%. The mean values were 0.177±0.034, 0.178±0.026 and 0.173±0.026% for the samples collected from Khartoum North, Khartoum and Omdurman, respectively (Table 3). The mean values of acidity were 0.2±0.033 and 0.154±0.012%, 0.195±0.017 and 0.161±0.022% and 0.184±0.026 and 0.161±0.019%, respectively (Table 2). There were non significant differences between the milk samples collected from the different cities, areas and seasons (Table 4).

Temperature

The average mean value for the temperature of the milk samples collected from Khartoum State was 25.32±15.19°C. The minimum was 6.0°C and the maximum was 65.0°C. The mean values were

25.38±16.08, 25.95±17.6 and 24.63±11.62°C for the samples collected from Khartoum North, Khartoum and Omdurman, respectively (Table 3). Similarly during summer and winter the mean values were 28.8±16.37 and 21.19±15.44°C, 31.3±18.57 and 20.6±15.17°C, 29.25±10.81 and 20±10.74°C, respectively (Table 3). Highly significant differences ($p \leq 0.001$) were found in the temperature of the milk samples collected from different areas, while non significant differences in the milk samples collected from the different cities during different seasons were reported (Table 4).

Freezing Point Values

The mean freezing point of the milk samples collected from Khartoum State was -0.535±0.034°C, the minimum was -0.59°C and the maximum was -0.41°C. Mean values of -0.529±0.035, -0.531±0.042 and -0.544±0.019°C were found in the milk samples collected from Khartoum North, Khartoum and Omdurman, respectively (Table 3). During summer and winter mean values of -0.526± 0.038 and -0.533±0.034°C, -0.529±0.036 and -0.533± 0.048°C and -0.542±0.019 and -0.547±0.02°C were obtained, respectively. There were significant differences ($p \leq 0.001$) in the freezing point values of the milk samples due to the variations of the areas from which the milk was collected, however non significant differences were reported due to the variations of cities and seasons (Table 4).

Phosphatase Test Result

The present data shows that the total positive phosphatase test were found to be 53 (44.17%) of the total milk samples. They were 27 (50.94%), 8 (15.09%) and 18 (33.96%) in Khartoum North, Khartoum and Omdurman, respectively.

Formalin Test

All the examined milk samples (100%) were negative to the formalin test.

Discussion

The results showed low means for protein values than those reported by Salih (2001) and Mohamad (2000). This might be due to adulteration of milk or type of breed and the feeding in the farm (Chamberlain, 1990). Milk composition varies between herds and cows within herds, enabling its segregation on farm, rather than during processing (Dooley *et al*., 2005). However Boor (2001) reported that consumers expect fluid milk products to be nutritious, fresh testing and wholesome. There was little variation in mean protein content of raw milk collected during summer and winter. The low value of fat might be due to adulteration of milk and/or type of feeding animal in the farms (Salih, 2001). The increase during summer might be due to the high environmental temperature over 30°C raises fat percentage concentration (Chamberlain, 1990).

The average total solids value of raw milk samples was lower than that of Mohamad (2000) and Salih (2001). It was also observed that total solid content of milk was higher during winter (12.96±1.52%) than during summer (12.27±1.84%) as shown in Table 1.

The total mean ash content of raw milk samples collected from Khartoum State found during the present study was less than the total ash content obtained by Mohammad (2000) and Salih (2001). It was also observed that during winter the mean ash content of milk samples was 0.545±0.115% which was higher than that collected during summer 0.575±0.085% (Table 1).

The present result was in agreement with Al -Tarazi *et al*. (2003) who found that the pH of the milk samples ranged from 6.2 to 6.8. Similarly Chamberlain (1990) stated that acidity of milk is normally in the range of pH 6.5- 6.8. During winter the pH of milk was higher (6.66±0.16) than during summer (6.3±0.32) (Table 2). This might be due to high temperature during summer and growth and multiplication of bacteria (Dirar, 1975; Aleksieva and Krusher, 1981).

The mean values of acidity of milk samples of the present study was lower than that reported by Mohamad (2000). Moreover, in Jordan Al-Tarazi, *et al*. (2003) found that only 74 of 160 milk samples had titratable acidity values ≤0.18% and the mean value was 0.199±0.033%. It was also observed that titratable acidity of raw market milk during summer was higher (0.193±0.03%) than that during winter (0.158±0.018%) as shown in Table 2. This could be due to higher temperature in summer and higher bacterial number during summer samples (not shown data)

The average mean value of the temperature of the milk samples was high (25.32±15.19°C) as shown in Table 3, which was similar to Haj Mahmoud (2002) who found that 54% of the milk samples had temperature ranging between 28-31°C and 34% had a range between 21-27°C. She concluded that milk was handled in temperature, which might facilitate the growth and multiplication of pathogenic and non pathogenic bacteria during production, transportation and distribution, which might lead to spoilage of milk and change the product to non safe food. During winter the mean temperature of raw milk was 20.85±13.74°C, while during summer was 29.78±15.37°C (Table 3). This might be due to higher atmospheric temperature in summer, since the cooling of milk is not practiced efficiently in Khartoum State as it was observed during the present study. However it was also observed that many supermarkets boil their milk before sale.

Mean freezing point of most of the milk samples collected from Khartoum State were in the normal ranges. Marshal (1992) stated that a freezing point of -0.517 is considered normal for milk and milk that freezes at or below this value is presumed to be free of added water. The lower values obtained for freezing point might indicate adulteration by skimming of fat or addition of water. This supported Haj Mahmoud (2002) finding that 9% of milk samples in Sudan could have adulteration by additional water and Boor *et al*. (1998) in New York State found the mean value of the freezing point was -0.543. These might be due as reported by Watrous *et al*. (1976) that 1% added water raise the freezing point 1% or it might be due to the reduced in total solid contents as shown in Table 1

The result of the phosphatase test showed that 44.17% of the total milk samples were negative to phosphatase test. This might be due to the practice of boiling the milk, which offered for sale in some shops. All the samples were negative to the formalin test, this indicated that the milk of Khartoum State, which was surveyed during the present study had no adulteration of formaldehyde. The present study recommended that milk must be produced, distributed, handled and marketed under the control of milk commission and the commission must have a sanitary inspectors and veterinarians to enforce its methods and standards. Establishment and applications of Sudanese standards and grades for marketing milk and pricing structure should include the grade and the quality of milk. Adulteration of milk is one of mal practices and therefore milk should be tested to ensure that it is free from adulterants and preservatives.

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