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Study on the Compositional Quality of Pasteurized Milk in Khartoum State (Sudan)*

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Abstract: The present study was conducted to investigate the compositional quality and the effects of storage conditions on the quality and shelf life of pasteurized milk in Khartoum State. Three areas were selected in Khartoum North according to fluctuations in electrical supply (permanent and intermittent) and immediate marketing. Sixty samples were collected from these areas and other parallel twenty samples were stored in the laboratory (Faculty of Animal Production) at 7°C (all samples were produced by the same dairy factory). These samples were examined to determine some physical and chemical properties of pasteurized milk. The samples of pasteurized milk showed that total solids was 4.03 to 11.32%, fat content ranged between 1 to 2.8%, protein was 2.13 to 3.6%, lactose was 2.13 to 4.8%, ash was 0.33 to 0.69%, titratable acidity was 0.14 to 0.86% and the freezing point was -0.41 to -0.67. The storage conditions revealed highly significant ($p<0.001$) effects on chemical and physical properties of pasteurized milk. Moreover, the results showed that 10% of samples were positive to the phosphates test (4 and 6% in storage 1 and storage 2, respectively). The present study concluded that the pasteurized milk distributed in Khartoum State by the selected dairy factory is of low quality. Hence it was recommended that quality assurance programs should be started to ensure that quality milk and milk products are produced and consumed in the country.

Key words: Pasteurized milk, chemical composition, quality, storage conditions, Sudan

Introduction

Milk represents for humans a source of nutrition of the highest importance (Foley *et al*., 1974; Harding, 1999). Moreover, its use among infants, elders and disable persons makes its public health importance major issue (IDF, 1994). Hence efforts are made globally to produce milk from healthy animals and to preserve its quality all over the way from the farm to the tables of the consumers (Giovannini, 1998).

The heat treatment of milk prior to packaging for liquid consumption, or manufacture into milk based product, is an important critical control point to ensure that pathogenic organisms are killed. It also ensures that spoilage organisms are eliminated, or at least reduced in number, for optimum keeping quality (IDF, 1994). Moreover, the consumer is demanding a product that maintains flavor and microbial quality beyond the pull date (Gruetmacher and Bradely, 1999).

Measurement of residual phosphatase, after pasteurization, offered a mean of checking the correct pasteurization had occurred and that raw milk had not been re-introduced after pasteurization.

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Pasteurization as a heat treatment process is intended to result in only minimal chemical, physical and organoleptic changes (IDF, 1994). Similarly, pasteurization does not affect total fat content and fatty acid composition of human milk (Fidler *et al*., 2001).

It is concluded that pasteurized milk keeps from two to three times longer than does raw milk of a similar quality and bacterial content, stored at0°C (Sherman *et al*., 1941). The main factors affecting the keeping quality of pasteurized milk are raw milk quality, severity of heat treatment, Post Pasteurization Contamination (PPC) and storage temperature (IDF, 1986). When the commercial HTST pasteurized milk is processed at 72 to 74°C for 16 sec, it showed a shelf life of 10 to 15 days when stored at 4 to 8°C before or during use (Komorowski and Early, 1992). However, if milk cooled at 4°C for 1-2 h after milking, the number of bacteria increased during storage at 4°C for 72 h. Moreover it was found that proper selection of milk carton is essential to provide barrier properties against the transmission of light, short chain, or organic compounds and oxygen from the air into the package (Gilbert *et al*., 1983).

In Sudan, urban milk supply largely comes from village herds and it's marketing is by milk venders who distribute raw milk to households on donkeys. Organized dairy establishments are limited. The Sudanese dairy industry is therefore in a primitive and early stage of development and faced with several problems. 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. Therefore, it's to be expected that physical, chemical and hygienic quality of the milk would be law. Hence the objectives of this study are:

- To determine the physical and chemical properties of pasteurized milk in Khartoum state.
- To assess the effect of the storage conditions on the keeping quality of pasteurized milk.

Materials and Methods

Source of Samples

This investigation was done during the period of June to October 2002. The milk samples were produce by Dairy Land Factory. Pasteurized milk samples were collected from Khartoum North.

Shops Samples

Survey on milk distribution, preservation and marketing conditions was performed before the selection of shops to be investigated. One shop was selected from each of the three locations.

Location D

The reason behind chosen the shop in this location is that the electricity is intermittent (subjected to period of off electricity).

Location C

The shop that was selected from this area has a good distribution and marketing of pasteurized milk.

Location B

The shop in this location was selected because it has a permanent supply of cooling (standby Generator is available).

Location A (Control Samples)

Milk samples were obtained directly either from the factory or the company's chilled car distributing the products to the selected shops (the milk samples were collected and stored at the Dairy Department in control temperature at 7°C).

Five batches of milk samples were collected at 5 months, by purchasing four samples each time from each selected location (all milk samples were purchased in the same day of their processing). The milk samples were brought in an icebox to the laboratory of the Department of Dairy Production, Faculty of Animal Production, University of Khartoum for the laboratory analysis. The analysis was carried out for the duplicate samples after the first part of the experiment (storage 1) in the second two days of processing the pasteurized milk to represent part of the experiment. The analysis of the other left duplicate samples; which were stored in the same refrigerator at the selected different locations; were carried out to assess the shelf life of pasteurized milk.

In this investigation the pasteurized milk samples were subjected to the following tests: Total Solids % (TS), total protein %, fat %, lactose %, ash %, phosphates, acidity and freezing point.

Chemical Analysis

The fat content was determined by Gerber method, the protein was determined by Kjeldahl method, total solids content was determined by forced draft oven method and the ash content were done using the muffle furners (Bradley *et al*., 1993). The lactose content was determined by anthrone method (Richards *et al*., 1983). The acidity of milk samples was determined according to titration method (Foley *et al*., 1974). The freezing point was determined by using a Fiske MS Cryoscope that was manufactured by Fiske Med. Sci. Inc. USA. Qualitative analysis of phosphatase was done according to the manufacture's instructions (Heyl, chem. Pharm. Fabrik, 14167 Berlin).

Statistical Analysis

Statistical Packages for Social Sciences (SPSS 10.00) was used to analyse all data using ANOVA test and Duncan Multiple Range Test (DMRT) for mean separation.

Results

Effect of Storage Conditions on Total Solids Content of Pasteurized Milk

The minimum was 4.03% the maximum was 11.32%, the mean and standard deviation were 9.2824 and 1.1982% (Table 1). Also the data indicated that the total solids were low in storage 2 (8.7035±1.3576) and high in storage 1 (9.8614±0.6063) (Fig. 1). Moreover, the total solids content recorded significant difference ($p<0.001$) between the storage period and batches, while no significant variation was observed for location (Table 2).

Effect of Storage Condition on Fat Content of Pasteurized Milk

Table 1 shows that minimum, maximum, mean and standard deviation of fat % of pasteurized milk to be 1.00, 2.8% and 2.1251±1.993, respectively. The average fat % revealed 2.25±0.3042% and 2.257±0.3042 for storage 1 compared to storage 2 (Fig. 2). The analysis of variance documented that the fat % was significantly ($p<0.001$) affected by storage conditions (Table 2). Similarly, the same Table 2 showed that the fat % was affected significantly ($p\leq 0.001$) by batches and locations.

Effect of Storage Conditions on Protein Content of Pasteurized Milk

Table 1 showed the minimum, maximum, mean and standard deviation of protein % of pasteurized milk to be 2.13, 3.6, 2.8254 and 0.32034%, respectively, while storage 1 revealed mean of

Table 1: Comparison of mean, standard deviation, maximum and minimum compositional values of pasteurized milk

Item	Mean (%)	SD (%)	Maximum (%)	Minimum (%)
Total solid	9.2824	1.1982	11.32	4.03
Fat	2.1251	0.3042	2.80	1.00
Protein	2.8254	0.3203	3.60	2.13
Lactose	3.8177	0.5547	4.80	2.13
Ash	0.6098	0.06805	0.69	0.33
Acidity	0.2194	0.1718	0.86	0.14
Freezing point	-0.4734	0.05032	-0.410	-0.67

Table 2: Comparison of chemical and physical properties of pasteurized milk

	Location			Batch			Storage period		
Item	Mean square	F-value	Probability	Mean square	F-value	Probability	Mean square	F-value	Probability
Acidity	0.03893	1.764	0.099^{NS}	0.09784	4.433	0.002^{***}	0.659	29.844	0.000^{***}
Fat	0.157	3.633	0.001^{NS}	1.119	25.852	0.000^{***}	2.775	64.088	0.000^{***}
Protein	0.05443	2.97	0.006^{NS}	2.099	114.787	0.000^{***}	4.844	264.859	0.000^{***}
Ash	0.004024	1.285	0.264^{NS}	0.04191	13.384	0.00^{***}	0.08010	25.582	0.000^{***}
Lactose	0.02122	0.194	0.986^{NS}	6.974	63.742	0.000^{***}	3.725	34.043	0.000^{***}
TS	1.286	1.972	0.063^{NS}	17.443	26.750	0.000^{***}	53.627	82.238	0.000^{***}
Freezing point	0.002462	1.682	0.118^{NS}	0.01647	11.256	0.000^{***}	0.104	71.260	0.000^{***}

^{NS} = non significant, *** = $p \leq 0.001$

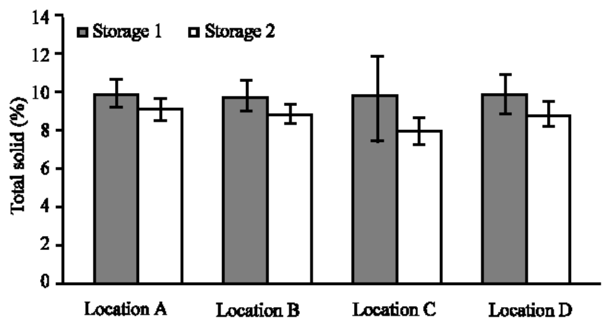

Fig. 1: The effect of the storage conditions on the T.S. of pasteurized milk; A: Control (7°C), B: permanent supply, C: Good distribution, D: Intermittent, Storage 1: Analysis after two days, Storage 2: Analysis after nine days

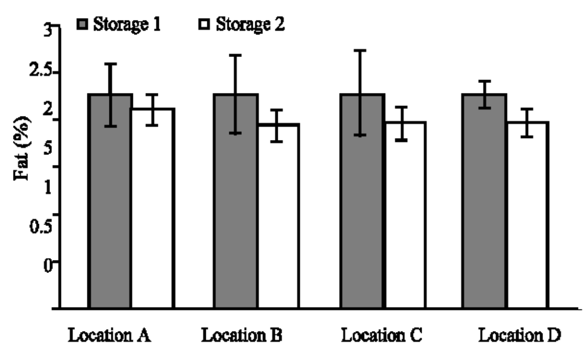

Fig. 2: The effect of storage conditions on the fat % of pasteurized milk; A: Control (7°C), B: permanent supply, C: Good distribution, D: Intermittent, Storage 1: Analysis after two days, Storage 2: Analysis after nine days

2.999%±0.236 for protein as compared to that of storage 2 (2.651±0.299) (Fig. 3). Also Table 2 revealed that protein % was significantly affected ($p \leq 0.001$) by storage periods, batches and locations.

Effect of Storage Conditions on Lactose Content of Pasteurized Milk

The mean value of lactose was found to be 3.8177±0.5547% during the present study (Table 1 and Fig. 4). The minimum value (2.13%) was found in storage 2 and the maximum (4.8%) was reported in storage 1. The lactose content was affected significantly ($p<0.001$) by periods of storage and batches (Table 2). However non significant variation was obtained for locations.

Effect of Storage Conditions on Ash Content of Pasteurized Milk

The ash content of pasteurized milk as presented in Table 1 and Fig. 5 revealed minimum, maximum, mean and standard deviation of 0.33, 0.69 and 0.6098±0.06805%, respectively. The result also revealed that there were significant variations ($p<0.001$) for storage periods and batches and non significant variations for the different locations (Table 2).

Effect of Storage Conditions on Titratable Acidity of Pasteurized Milk

Table 1 showed that minimum, maximum, mean and standard deviation of acidity to be 0.14, 0.86% and 0.2194±0.1718 for the pasteurized milk, respectively. Moreover the storage conditions, which are presented in Fig. 6, revealed minimum value of acidity for pasteurized milk at storage 1 (0.14%) and the maximum value (0.86%) at storage 2. Also the data recorded significant different ($p<0.001$) between the different storage periods and batches, while non significant variations were found for locations (Table 2).

Effect of Storage Conditions on Freezing Point of Pasteurized Milk

The minimum (-0.670), maximum (-0.410) and the mean (-0.4743±0.05032) values for freezing point of pasteurized milk (Table 1). The effect of storage conditions on freezing point of pasteurized milk revealed differences for storage 1 (-0.44785±0.002020) compared to storage 2 (-0.49891±0.005803) (Fig. 7). The reduction was found to be significant ($p<0.001$). Similarly significant variations were obtained for batches ($p<0.001$) and non significant variations were obtained for the different locations (Table 2).

Effect of Storage Conditions of Pasteurized Milk on Phosphatase

The present study revealed that 10% (4 and 6% for storage 1 and storage 2) of the samples were positive for phosphatase test in pasteurized milk. Moreover the result indicated that there were non significant differences ($p<0.05$) due to the storage conditions.

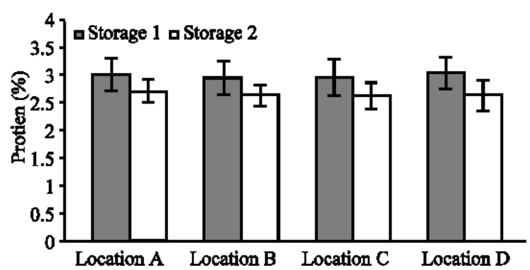

Fig. 3: The effect of storage conditions on the protein % of pasteurized milk; A: Control (7°C), B: permanent supply, C: Good distribution, D: Intermittent, Storage 1: Analysis after two days, Storage 2: Analysis after nine days

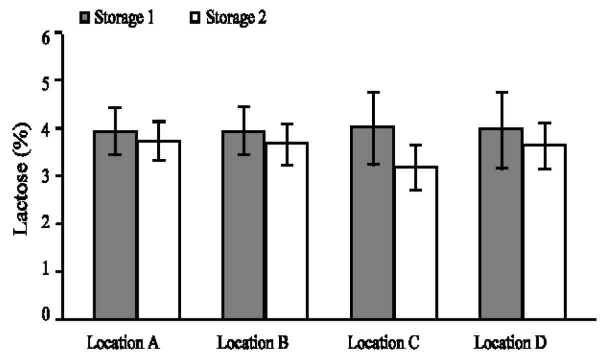

Fig. 4: The effect of the storage conditions on the lactose % of pasteurized milk; A: Control (7°C), B: permanent supply, C: Good distribution, D: Intermittent, Storage 1: Analysis after two days, Storage 2: Analysis after nine days

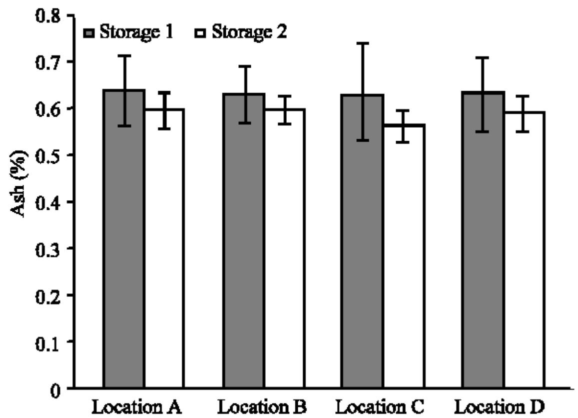

Fig. 5: The effect of the storage conditions on the ash % of the pasteurized milk

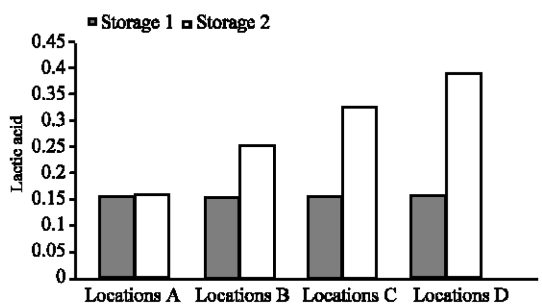

Fig. 6: The effect of the storage conditions on the acidity of different pasteurized milk samples A: Control (7°C), B: permanent supply, C: Good distribution, D: Intermittent

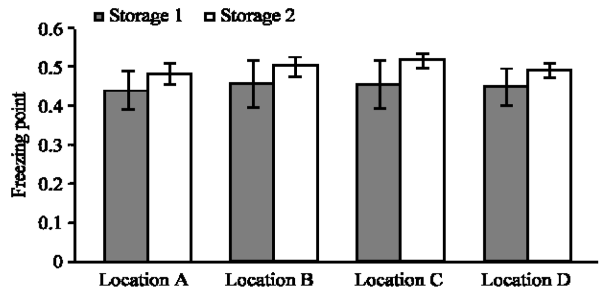

Fig. 7: The effect of the storage conditions on the freezing point of different pasteurized milk samples; A: Control (7°C), B: permanent supply, C: Good distribution, D: Intermittent, Storage 1: Analysis after two days, Storage 2: Analysis after nine days

Discussion

The mean value obtained during the present study for total solids (9.2824±1.1982%) was lower than that reported by the factory on their products (11.5%). The maximum (9.86%) and the minimum (8.705%) values of total solids were obtained in storage 2 and storage 1, respectively (Fig. 1). These changes, which occurred in the total solids, were a function of changes, which occur in the component part (Munro *et al*., 1984) particularly, lactose and proteins (Waite and Blackburn, 1963).

The present study revealed lower mean values for fat in pasteurized milk (2.125±0.3042) than that reported by the factory (2.5%). Moreover, the fat % obtained during storage 1 was higher than those of storage 2 (Fig. 2) and both, were lower than that reported by the factory in it's products. The lower values recorded may be due to improper analytical procedures and/or adulteration by extra skimming of butter, since in the factory they manufacture butter as one of the products. The lower level of fat during storage 2 may be due to lipolysis (Murphy *et al*., 1989). This lipolysis resulted from the higher count of pyschrotrophic bacteria (data is not shown). Moreover, this result was in accord to what was reported previously (Meilgaard *et al*., 1991).

Result from the present study demonstrated that the mean for total proteins was 2.854±0.3203% (Table 1). This result may be due to the growth of bacteria during storage, mainly the psychrotorphic bacteria (data is not shown). The psychrotorphic bacteria were fed by the breakdown of proteins (Harding, 1999).

The present study revealed a decreased value of lactose for pasteurized milk in storage 2 (3.654±0.5547%) compared with that of storage 1 (3.973±0.4203%) (Fig. 4). The lower values of lactose during different storage conditions might be due to fermentation by bacteria (Durga *et al*., 1986). Similarly, a significant ($p<0.01$) effect of psychrotrophic bacteria on lactose was reported (Ballou *et al*., 1995). Moreover, the lactobacilli attack the milk sugar (lactose) and convert it to lactic acid (Harding, 1999).

The average freezing points of pasteurized milk in this study was -0.4734±0.05032 (Table 1 and Fig. 7). This study also indicated that there was significant esffects of storage conditions and batches on the freezing point of pasteurized milk. These might be due to that 1% added water raise the freezing point 1% or it might be due to the reduced total solid contents as mentioned above (Watrous *et al*., 1976).

The results obtained for the acidity ranged between 0.14 and 0.86% with a mean of 0.2194±0.1718%. The minimum and maximum values obtained during the present study were in storage 1 and storage 2, respectively (Table 1 and Fig. 6). It was due to the presence of sugar fermenting organisms. Since *E. coli* was isolated from some of the samples collected during the present survey (data is not shown) which reported previously (Turner, 1946). Moreover the present results revealed that acidity was significantly affected ($p<0.001$) by storage conditions and batches. This was due to the fermentation of lactose, which was converted to lactic acid (Harding, 1999).

The present study also demonstrated that, 10% of the samples were positive to the phosphatase test. It is due to survival of *E. coli* (data is not shown) that might be due to improper pasteurization or post pasteurization contamination (Harding, 1999). Moreover, 4 samples (5%) were found to be spoiled (clot formation) during storage 2, which confirmed the results.

The present study concluded that values stated by the factory were lower than those estimated in the laboratory for some compositional content. They stated a shelf life of 10 days for the pasteurized milk and as shown in the present study some of the samples were expired before the pulled dates. This wide variations, which occur in compositional quality has been used as an indication of adulteration (Harding, 1999). We recommended that a well-equipped quality control laboratory should be established in each factory and efficient staffs have to be employed. Hence, the official authorities should carry out periodical examinations regularly. They should implement quality assurance programs and regular monitoring, in order to ensue that all factories and dairy plants are producing high quality products with standard constituents. Further studies are also needed to cover the lacking information on the factors influencing the shelf life and keeping quality of milk and milk products under Sudan conditions.

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