Effect of heat treatment and storage period on the quality of traditionally fermented goat milk yoghurt

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ABSTRACT

The objectives of the study were to investigate the effect of heat treatment and storage period on the chemical, microbiological analyses and sensory characteristics of yoghurt produced from goat milk. Milk was either raw or subjected to boiling or pasteurization and stored at 6 ºC for 1, 7 or 15 days. The results showed that the moisture, ash, protein, fat, and carbohydrate contents of raw goat's milk were 89 %, 0.75%, 3.36 %, 4.00 %, and 2.89%, respectively, while boiled milk contained 87.2 %, 0.70 %, 3.43 %, 3.96 % and 4.71% and pasteurized milk contained 88.33%, 0.68%, 3.50%, 4.2% and 3.29%, respectively. All types of yoghurts showed a gradual increase in protein and fat, while a gradual decrease was observed in moisture, ash and carbohydrates contents during storage. All types of yoghurts showed a gradual decrease in pH and lactose content while there were increases in the acidity and total soluble solid (TSS) at the first day of storage. This decrease continued until the seventh day of storage, while the acidity gradually increased. The microbiological analyses revealed an increase in the microbial counts during storage and the highest increases were found in yoghurt samples prepared from raw milk. Moreover, coliforms were not detected in all samples. All types of yoghurt were highly accepted by the panelists who gave highest scores of flavour to the raw milk yoghurt.

INTRODUCTION

Goats are an important part of the livestock in Africa, in terms of food production and cultural activities. Lebbie (2004) estimated that they contribute about 17% of meat and 12% of milk production from ruminant livestock. However, in many parts of the world, goat milk is valued for its use in making distinctive cheeses, and as a source of milk for infants who are allergic to cow milk (Haenlein, 2004).

Haenlein (2004) showed the characteristics of goat milk, especially the protein composition, short and medium chain fatty acids and softer curd formation. These may be important for human health, but many aspects still require further research. Variations in the sub-fractions of casein affect yield and quality of cheeses, especially αs1-casein. Research has focused on these topics and their relationship to genetic differences (Martin *et al.,* 2002). Goat milk and its products of yogurt, cheese and powder are important in human nutrition since they can feed starving and malnourished people in the developing world and treat people afflicted with cow milk allergies and gastro-intestinal disorders.

The chemical composition of goat milk, regular yoghurt and salted yoghurt are: Total solids of 12.2 %, 12.0 % and 31.9 %, respectively; total fats of 4.40 %, 4.20% and 10.20 %, respectively; ash contents of 0.58 %, 0.60 % and 2.26 %, respectively and pH of 6.53, 3.67 and 3.77, respectively.

Sudan is one of the largest African countries which has a big livestock population and is considered the second in Africa (Ministry of Animal Resources, 1998). Many nomads rear sheep and Nubian goats for milk and meat (Abdel Aziz *et al*; 1982; AOAD, 1990; Muffarah, 1995). Cows are the main source for milk supplies; they produce 90% of the world total supply of milk, followed by goat and sheep (AOAD, 1983). The objectives of this study were to determine the effect of heat treatment and storage period on the chemical, microbiological and sensory quality of yoghurt made from goat milk.

MATERIALS AND METHODS

Materials

Goat milk (Nubian goat breed) was obtained from a local farm, village of Ibrahim Abdalah, region of Elmadina Arab, Gezira State, Sudan. Goat milk was transported in sterilized containers to the Dairy Laboratory of the Department of Food Science and Technology, University of Gezira, for further analyses and processing.

Yoghurt preparation

The traditional product of set yoghurt, was made from three types of goat milk {raw, pasteurized (63°C for 30 min) and boiled milk}. After cooling, each type of milk was inoculated with a starter culture (Kapo), 5% w/w of previously prepared yoghurt. Then the product was incubated at 45 °C for 16 to 20 hr., cooled to 6 ºC and stored in a refrigerator for 1, 7 and 15 days.

Proximate analysis

Proximate analyses were carried out on the three types of milk and the produced yoghurts in order to determine moisture content, crude protein, crude fat, crude fiber and ash according to AOAC (1990) methods. Carbohydrates content were obtained by difference (carbohydrate (%) = 100 – total of (moisture, protein, fat, crude fiber and ash).

Determination of pH and titrable acidity

The pH of milk and yoghurt samples was measured using a digital pH meter (PN 9410.GL.Britian) according to AOAC (1980).

The titremetric determination of acidity of milk and yoghurt samples was accomplished where 5 ml of the sample were pipetted into a 100 ml conical flask. The pipette was washed with 5 ml distilled water, then six drops of phenolphthalein indicator were added. The sample was then titrated with 0.1 N NaOH until a stable pink colour was formed. The titrable acidity was expressed as percent lactic acid from the following formula.

Milk titrable acidity (%) = ml of NaOH x 0.1 x 90

Where: 90 is the amount of lactic acid reacted with 1.0 ml of 0.1 N NaOH.

Total soluble solids (%)

The total soluble solids (%) was determined according to the modified method of AOAC (1990).

Lactose determination

The procedure of AOAC (1980) was used for the determination of lactose.

Microbiological analyses

Microbiological analyses were conducted in order to determine the total viable count using plate count agar, coliform count using MacConkey agar and yeast and mould agar using potato dextrose agar for goat milk and yoghurt samples.

Sensory evaluation

All types of yoghurt were subjected to sensory evaluation using 10 panelists at the first day of storage. The storage temperature was 6 ºC. The panelists were asked to rank the samples for color, texture, flavor and overall acceptability using a 9 point hedonic scale with 1 as the extremely bad score and 9 as the excellent.

Statistical analysis

Data were subjected to the analysis of variance procedure (ANOVA). Means were separated using the least significant difference (LSD) test.

RESULTS AND DISCUSSION

Proximate composition

The results of the proximate composition of goat milk (raw, pasteurized and boiled) are shown in Table 1. The moisture content of the raw milk was the highest and found to be 89%, while it was 88.33% and 87.2 for the pasteurized and boiled one, and this value is higher than that reported by Zenb (2003) and Joseph (1986), who reported the values of 85.8% and 87.2% for raw goat milk, respectively.

The ash content of goat milk samples (raw, boiled and pasteurized) was found to be 0.75%, 0.70% and 0.68%, respectively. The obtained ash value of raw goat milk is higher than that reported by Mustafa (2005) who reported a value of 0.41 %, and it was lower than the value reported by Zenb (2003) who reported the value 0.84%, but it was in close agreement with the value of 0.7% reported by Joseph (1986).

The protein content of goat milk samples (raw, boiled and pasteurized) were found to be 3.36%, 3.43% and 3.50%, respectively. The obtained protein value of whole goat milk is lower than that reported by Zenb (2003) who reported the value 4.22%, but it is in close agreement with the value reported by Joseph (1986) and Mustafa (2005), who stated the values 3.7% and 3.5%, respectively.

The fat content of goat milk samples (raw, boiled and pasteurized) were found to be 4.00%, 3.96% and 4.2%, respectively. The obtained fat value of raw goat milk is in close agreement with the value reported by Joseph (1986) and Zenb (2003), who stated the values of 4.1% and 4.18 %, respectively.

The carbohydrate content of goat milk samples (raw, boiled and pasteurized), was found to be 2.89%, 4.71% and 3.29%, respectively. The obtained value of whole goat milk, was less than that reported by Joseph (1986) who reported a value of 4.3%.

Table 1. Chemical composition of milk types (%).

Milk types	Moisture	Ash	Protein (%)	Fat	Carbohydrate
Raw	89.00	0.75	3.36	4.00	2.89
Boiled	87.20	0.70	3.43	3.96	4.71
Pasteurized	88.33	0.68	3.50	4.20	3.29

Acidity, pH, lactose and total soluble solids

The results of pH, acidity, lactose, and total soluble solids (TSS) of goat milk are shown in Table 2. The pH of goat milk samples were 6.93, 6.80 and 6.70 in raw, boiled and pasteurized milk, respectively, and they were approximately similar to the values reported by Mustafa

(2005) who reported a value of 6.70 ± 0.1. The titrable acidity (lactic acid %) of goat milk samples were 0.40, 0.50 and 0.43, and they were higher compared to that reported by Mustafa (2005) who reported a value of 0.14. The lactose contents of goat milk samples were 4.33%, 4.43% and 4.50% and they were lower compared to that reported by Zenb (2003) who reported a value of 4.96%. The total soluble solids of goat milk samples were 11.00%, 12.80% and 11.66% for raw, boiled and pasteurized milk, respectively, and the value of the raw one was lower than that reported by Mustafa (2005) who reported a value of 11.71%.

Table 2. pH, acidity, lactose and total soluble solids of various milk types.

Milk types	pH	Acidity	Lactose(%)	Total soluble solids
Raw	6.93	0.40	4.33	11.00
Boiled	6.80	0.50	4.43	12.80
Pasteurized	6.70	0.43	4.50	11.66

Effect of refrigerated storage on the chemical composition of yoghurt

The results of the chemical composition of goat milk yoghurt samples produced from raw, boiled and pasteurized milk are shown in Table 3. These results show that the moisture content of all goat yoghurt types at the first day of storage slightly decreased compared with the goat milk samples, and they were 87.9%, 84.86% and 85.23 % in the yoghurt produced from raw, boiled and pasteurized milk, respectively. Also, the ash and the carbohydrate contents were slightly decreased. The ash contents were 0.70%, 0.64% and 0.60% for the yoghurt produced from raw, boiled and pasteurized milk, respectively and the carbohydrate contents were 2.44%, 3.75% and 3.22% for the yoghurt produced from raw, boiled and pasteurized milk, respectively. However, an appreciable increase was observed in the protein contents which were 5.76%, 5.53% and 5.45% in yoghurt produced from raw, boiled and pasteurized milk, respectively. Moreover, the fat contents also increased and they were 5.2%, 5.4% and 5.5% for the yoghurt produced from raw, boiled and pasteurized milk, respectively.

On the other hand, after seven days of storage, the moisture content was still less than that of milk. No decrease in protein content and a slight decrease in fat and carbohydrate contents were observed during storage period. The protein contents were 5.0%, 5.26% and 5.33%, while the fat contents were 4.2%, 4.7% and 4.9% and the carbohydrate contents were 2.94%, 2.71% and 2.79%, for the yoghurt produced from raw, boiled and pasteurized milk, respectively. However, the ash content slightly increased and was found to be 0.76%, 0.70% and 0.68%, for the yoghurt produced from raw, boiled and pasteurized milk, respectively.

Table 3. Chemical composition of yoghurt produced from goat milk

Days of storage	Milk types	Moisture	Ash	Protein (%)	Fat	Carbohydrate
	Raw	87.90	0.70	5.76	5.2	2.44
1	Boiled	84.86	0.64	5.53	5.4	3.75
	Pasteurized	85.23	0.60	5.45	5.5	3.22
	Raw	87.20	0.76	5.00	4.2	2.94
7	Boiled	84.69	0.70	5.26	4.7	2.71
	Pasteurized	86.30	0.68	5.33	4.9	2.79
	Raw	89.50	0.70	5.43	4.0	0.37
15	Boiled	87.80	0.66	5.58	4.6	1.36
	Pasteurized	88.73	0.62	5.76	4.7	0.19

Table 3. (continued).

Days of storage	Milk types	pH	Acidity	Lactose(%)	T SS
	Raw	4.50	1.50	4.00	15.13
1	Boiled	4.30	1.70	4.30	20.00
	Pasteurized	4.60	1.30	4.46	17.80
	Raw	4.30	1.63	3.86	12.80
7	Boiled	4.20	1.86	3.86	16.86
	Pasteurized	4.40	1.50	4.40	15.66
	Raw	4.02	2.13	3.36	10.50
15	Boiled	4.00	2.00	4.26	14.00
	Pasteurized	4.05	1.76	4.20	14.26

The results also show that, at the 15th day of storage, the moisture contents of all yoghurt samples were highly increased and they were 89.5%, 87.8% and 88.73%, while the ash, protein, fat and carbohydrate contents were decreased.

The results of pH, acidity, lactose, and total soluble solids (TSS) of the yoghurt produced from raw, boiled and pasteurized goat milk are shown in Table 4. In the first day of storage, the pH gradually decreased during fermentation of yoghurt and they were found to be 4.5, 4.3 and 4.6 for yoghurt produced from raw, boiled and pasteurized goat milk, respectively. On the other hand, the titrable acidity content increased by fermentation of yoghurt and was found to be 1.5%, 1.7% and 1.3% for yoghurt produced from raw, boiled and pasteurized goat milk, respectively. The lactose content was decreased during fermentation of yoghurt, and they were found to be 4.0%, 4.30% and 4.46% for yoghurt produced from raw, boiled and pasteurized goat milk, respectively. As for total soluble solids contents, they were decreased during fermentation to 15.13%, 20% and 17.8% in the first day of storage, respectively.

The reduction in pH continued after the 7th day of yoghurt storage and recorded the values 4.3, 4.2 and 4.4 for the yoghurt produced from raw, boiled and pasteurized goat milk, respectively, while the acidity was gradually increased synchronously with the reduction of pH and was found to be 1.63, 1.86 and 1.5 for the yoghurt produced from raw, boiled and pasteurized goat milk, respectively. The reduction of lactose contents in all samples continued and were found to be 3.86%, 3.86% and 4.40% while the total soluble solids contents decreased during fermentation and were found to be 12.80%, 16.86 %and 15.66% for the yoghurt produced from raw, boiled and pasteurized goat milk, respectively.

The reduction in pH was very clear after the 15th day of the storage when the values were 4.02, 4.00 and 4.05. In addition, the lactose content and the TTS were reduced while the acidity increased. As for TSS contents, they were decreased during fermentation period and the

values were lower than those after 7 days of storage in all yoghurt types.

Microbiological characteristics

The microbiological characteristics of fresh goat milk samples and yoghurt samples are presented in Tables 4 and 5. The total count of bacteria of goat milk samples (raw, boiled and pasteurized) were 5.8 x 10^3 , 2.5 x 10^2 and 2.1 x 10^2 c.f.u/ml, respectively and all the samples were free from coliform and yeast.

Table 5 shows the microbiological characteristics of yoghurt during storage at 6°C for 1, 7 and 15 days. The yoghurt samples prepared from raw, boiled and pasteurized milk revealed high counts of bacteria and absence of yeasts, moulds and coliforms. On the other hand, the yeast and mould counts appeared and increased gradually during storage for 7 days and 15 days, however, the coliform was not detected in all yoghurt samples during the entire storage period. At the first day of yoghurt storage, the total count of bacteria was higher in yoghurt produced from raw goat milk (3.6 x 10^6 c.f.u/ml) than boiled (9.8 x 10^4 c.f.u/ml) and pasteurized (4.3 x 10^4 c.f.u/ml) milk.

After 15 days of storage, the total count of bacteria continued increasing to 3 x 10^8, 2.6 x 10^6 and 1.0 x 10^6 c.f.u/ml in yoghurt produced from raw, boiled and pasteurized milk, respectively. As for the yeast and mould count, it was found to be 6.0 x10^5, 5.8 x 10^4 and 3.6 x10^3 c.f.u/ml in yoghurt produced from raw, boiled and pasteurized milk, respectively.

Table 4. Microbiological characteristics (c.f.u/ml) of goat milk types.

Milk types	Total viable count	Coliform	Yeast and mould
Raw	5.8 x 10^3	Nil	Nil
Boiled	2.5 x 10^2	Nil	Nil
Pasteurized	2.1 x 10^2	Nil	Nil

Table 5. Microbiological characteristics (c.f.u/ml) of yoghurt produced from goat milk.

Days of storage	Milk types	Total viable count	Coliform	Yeast
	Raw	3.6×10^{6}	Nil	Nil
1	Boiled	9.8×10^{4}	Nil	Nil
	Pasteurized	4.3×10^{4}	Nil	Nil
	Raw	2.84×10^{8}	Nil	8×10^{4}
7	Boiled	6.6×10^{5}	Nil	8×10^{3}
	Pasteurized	2.56×10^{5}	Nil	5×10^{2}
	Raw	3×10^{8}	Nil	6.0×10^{5}
15	Boiled	2.6×10^{6}	Nil	5.8×10^{4}
	Pasteurized	1.0×10^{6}	Nil	3.6×10^{3}

Sensory evaluation

The sensory characteristics of processed yoghurt are presented in Table 6. The results indicate that there were no significant differences ($P > 0.05$) in color between the yoghurt samples produced from raw, boiled and pasteurized goat milk; however, there were significant differences when comparing these parameters with the control yoghurt. In contrast, significant differences ($P > 0.05$) were observed in texture, flavor and overall acceptance. Yoghurt produced from raw goat milk had the worst texture and the best flavor as compared to the other types.

The overall acceptability of yoghurt samples showed significant differences ($P < 0.05$). The yoghurt produced from raw goat milk had the lowest overall acceptability as compared to the other types.

Table 6. Mean scores for sensory evaluation of yoghurt.

Milk type	Colour	Flavour	Texture	Overall acceptance
Raw	6.1b	6.8a	5.3b	5.5b
Boiled	6.5b	6.4b	6.4a	6.5a
Pasteurized	6.3b	6.6b	6.3a	6.6a
Cow milk	7.5a	6.5b	6.0a	6.5a

Means in columns bearing the same letters are not significantly different at $p < 0.05$

CONCLUSIONS

In conclusion, it is recommended to pasteurize or boil milk for the production of yoghurt with higher shelf-life, lower microbial load and best quality.

REFERENCES

Abdel – Aziz, A., A. B. Musa and B. H. Ali. 1982. A study on the productive features of male Nubian goat. Sudan Journal of Animal Science Husbandry 25 (2): 132 – 136.

AOAC. 1990. Official methods of analysis: Association of Official Analytical Chemists (AOAC). 5th edition. Washington, DC. pp. 69-88.

AOAC. 1980. Association of Official Analytical Chemist 1980. Official methods of analysis. 13th ed. Arlington, VA., USA.

AOAD, 1983. Technical and Economic Feasibility of the Improvement, Production and Marketing of Milk in the Dueim area. Arab Organization for Agricultural Development, Khartoum, Sudan.

AOAD, 1990. Goat Resources in Arab States. II. Sudan. Arab Organization for Agricultural Development, Khartoum, Sudan. Report (in Arabic).

Haenlein G. F. 2004. Why goat milk; In: Topics of Profitable Feeding and Milking of Dairy Goat. Dairy Extension Bulletin. pp. 92 – 102, University of Delaware, New York, USA.

Joseph;Z.B. 1986. Sudan Food Composition Tables, National Chemical Laboratories, Ministry of Health Khartoum, Sudan.

Lebbie, S.H.B.2004. Goats under household conditions. Small Ruminant Research 51: 131-136.

Martin,P., M. Szymanowska, L. Zwierzchowski and C. Leroux. 2002. The impact of genetic polymorphism on the protein composition of ruminant milks. Reproduction Nutrition Development 42: 433-435.

Ministry of Animal Resources. 1998. Administration of Planning and Economy of Animal Resources, Khartoum, Sudan.

Muffarah, M. B. 1995. Goat Breed and Varieties in Sudan. Proceedings of a training, course on sheep and goat production. Arab Center for Studies of Arid Zones and Dry Lands (ASCAD), Khartoum, 17 – 27, January, 1995.

Mustafa, A. R. 2005. Manufacture and Quality Assessment of Yoghurt using Pure Strains of Lactic Acid Bacteria. M.Sc. Thesis, University of Gezira, Wad Medani, Sudan.

Zenb, M. C. 2003. A Study of the Isolation and Identification of Lactic Acid Bacteria and Yeast from Raw Milk. M.Sc. Thesis, University of Khartoum, Sudan.

أثر التسخين و فترة التخزين علي جودة الزبادي التقليدي المصنع من لبن الماعز

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الخلاصة

هدفت هذه الدراسة لمعرفة تأثير التسخين و فترة التخزين على الخواص الكيميائية، الميكروبية والحسية للزبادي المنتج من لبن الماعز. استعمل اللبن طازجاً أو مغلي أو مبستر و تم تخزين الزبادي عند درجة حرارة 6 درجة مئوية لمدة يوم واحد أو 7 أيام أو15 يوماً. أظهرت النتائج أن محتوي الرطوبة، الرماد، البروتين، الدهن و الكاربوهيدريت للبن الماعز الخام كان 89% ،0.75%، 3.36 %، 4.00% و 2.89% علي التوالي بينما احتوى لبن الماعز المغلي على 87.2%، 70%، 3.43%، 3.96% و 4.71% و اللبن المبستر على 88.33%، 0.68 %، 3.50% ، 4.00% و 3.29 %. كل أنواع الزبادي أظهرت زيادة تدريجية في البروتين والدهن بينما هنالك تناقص في نسبة الرطوبة والرماد والكاربوهيدريت خلال فترة التخزين. كل أنواع الزبادي أظهرت تناقصاً تدريجياً في كل من الأس الهيدروجيني ومحتوي اللاكتوز، بينما كان هنالك ارتفاعا في كل من الحموضة والمواد الصلبة الكلية وذلك في اليوم الأول من التخزين. هذا النقصان استمر حتى اليوم السابع للتخزين ، بينما ازدادت الحموضة تدريجياً . أظهرت الاختبارات الميكروبية ازدياد الأعداد الميكروبية خلال تخزين الزبادي و أن أكثر الزيادة كانت في الزبادي الذي تم تصنيعه من اللبن الطازج، علاوة على ذلك خلت جميع أنواع الزبادي من البكتيريا القولونية. كل أنواع الزبادي نالت قبولاً كبيراً بواسطة المحكمين و الذين أعطوا درجات كبيرة لنكهة الزبادي المصنع من اللبن الطازج.