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Effect of the method of processing on quality and oxidative stability of anhydrous butter fat (samn)

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In this study four samn samples prepared from cow milk using two processing methods (traditional T1, T2 and factory processed T3, T4) were investigated for their physico-chemical properties, fatty acids composition, oxidative stability and sensory properties. The traditionally processed samples showed a significance difference (p < 0.05) in peroxide value and acid value in comparison to factory processed ones. The peroxide value was 2.5 meq O_2/kg of samn for both T3 and T4 samples, which was higher than the peroxide value of T1 and T2, which was 1.5 and 2.0, respectively. The acid value of T3, T4, T1 and T2 are 2.58, 2.54, 1.122 and 1.121, respectively. The results showed that the FFA% of T3, T4, T1 and T2 are 1.29, 1.27, 0.6 and 0.6, respectively. The major fatty acids of the four samn samples were palmitic, oleic, stearic, myristic and capric acid. T3 and T4 contain high percentage of palmitc acid 37.29 and 39.23%, respectively. Traditionally processed sample T1 contains high amount of oleic acid (26.1%) in comparison with the other three samples. Method of processing affects samn properties, quality and oxidative stability, where traditionally processed samples were significantly preferred (P ≤ 0.05) by the panelists for their color, odor, taste and overall acceptability to the factory processed samples.

Key words: Samn, fatty acid, oxidative stability, sensory evaluation.

INTRODUCTION

In Sudan most milk producers, process the milk produced in their farms into many products such as sour milk (roob) yoghurt (zabadi), cream (gishda), butter (zibdeh), cheese (jibneh) and samn (samn). Samn or clarified butter is a widely consumed food commodity in Sudan. Production of samn in Sudan takes place in villages at house hold level (Bugara, Butana areas); it is preparation is based on the heating of cow, sheep or goats milk then fermented overnight or more and then the sour fermented milk is churned in a sac made of tanned sheep or goat skin or other special container (garaa) gourd until butter granules are formed then heated in a large pot or pan until all water has evaporated and protein has settled to the

bottom. The cooked and clarified butter is then spooned off to avoid disturbing the milk solids on the bottom of the pan. Unlike butter, samn can be stored for long periods without refrigeration and is kept in an airtight container (dark glass bottles) to prevent oxidation and remains moisture-free (FAO, 1990).

Al-Khalifah and Al-Kahtani (1993) studied the physical and chemical characteristics of Saudi samn extracted from cow's and sheep's milk. They found that the iodine number was lower, but saponification number was higher in sheep's samn. And the 1,2-diacylglycerides were absent in sheep samn. The range of vitamin A was 315 - 376 µg/100 g and of cholesterol 252 - 284 mg/ 100 g. Samn has been used as medicine to treat patients with skin and allergic diseases. Samn also contains conjugated linoleic acid (CLA) to an extent of 1%. CLA has been shown to reduce the formation of inflammatory mediators like prostaglandins, leukotrienes and interleuk-

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ins (Kumar et al., 1999).

The main factors accelerating the rate of lipid oxidation are high temperature, light and trace elements (copper, iron, etc). Oxidation is inhibited by exclusion of oxygen, refrigeration and packaging in opaque or colored containers (O'Connor, 1995).

Samn contains approximately 65% saturated, 30% monounsaturated and 5% polyunsaturated fatty acids. Some of the fatty acids are found in very small amounts but contribute to the unique and desirable flavor of samn. For example, the C14:0 and C16:0 *ß*-hydroxy fatty acids spontaneously form lactones upon heating which enhance the flavor of samn (hptt//www.milkfacts.info/ nutritionfact). However, in the indigenous Ayurvedic system of medicine, samn is used in the preparation of a number of formulations for treating allergy, skin and respiratory diseases and is considered to induce many beneficial effects on human health (Jacobson, 1987).

Because of low moisture content (0.5%), samn has better shelf-life than other indigenous dairy products. However, it undergoes deterioration which spoils its appetizing flavor, making it unpalatable and toxic (Rangappa and Achaya, 1974; Vashney, 1997).

Literature related to effect of processing parameters on samn quality and stability is still lacking. However, the stability of locally produced cow's samn, which is the most popular samn product in Sudan, has not yet been investigated. Therefore the objectives of this study were to carry out investigations of four commonly consumed cow samn products from different sources; two samples processed by tradition method and other two samples were factory processed.

MATERIALS AND METHODS

Materials

All solvents used were of analytical grade. Petroleum ether, chloroform, methanol and diethyl ether, starch, potassium iodide, glacial acetic acid and sodium thiosulfate were obtained from (Merck, Darmstadt, Germany).
Four samples of samn were used; the first sample was purchased from Khartoum north local market which was produced from cow milk using local traditional method (T1). The second sample was prepared in the laboratory using local traditional method (T2) with cow milk. The third and fourth samples (T3 and T4) (imported, factory processed) were obtained from Khartoum north local market. The four samples were investigated for their physico-chemical properties, quality parameters, oxidative stability and sensory evaluation.

Traditional method of processing

Samn samples were prepared in redundant manner practiced in the Department of Animal Production, College of Agricultural Studies, Sudan University of Science and Technology, by traditional method using fresh cow milk which was boiled immediately then cooled and left to ferment overnight. The fermented cow milk was agitated and the small granules of the formed butter were collected continuously.

The collected butter was churned by a plastic container closed tightly, and butter obtained was boiled in a metal pan at 100 - 120°C to evaporate the water (overheating was avoided as it burns the curd and impairs the flavor). The final product was judged by the light brown color for the samn residue and straw yellow for the samn product. The obtained samn was kept in glass bottles at 4°C until further analysis.

Physical and chemical parameters of processed samn samples

Color, specific gravity, refractive index, triglycerides, phospholipids, peroxide value, acid value and FFA%, were determined according to AOCS official reapproved methods (1997).

Oxidation of processed samn

Samn sample (150 g) weighed into 250 mL Erlenmeyer flasks were oxidized at 70°C in the dark in a shaking water bath (Clifton – Nickel- Electro LTD England). The oxidative stability was evaluated by analyzing the peroxide value (PV) of samn samples periodically after 1, 4, 8, 24, 32, 56 and 72 h. All analyses were done in triplicate and mean ± standard deviation was calculated.

Fatty acid composition by gas chromatography/mass spectrometry (GC/MS)

Fatty acid methyl esters of samn samples were prepared by esterification with alkali catalyst. Injection-volume was 1 µl. The methyl esters were assayed using GC/MS-QP2010 instrument, Shimadzu, Tokyo, Japan equipped with flame ionization detector, DB-WAX column, 0.25 x 30 m df = 0.25 µm. Column temperature was 60 - 250°C (10 C/min); injection temperature was 250°C, I/F temperature was 250°C. The carrier gas was He (100 kPa), and reagent gas was isobutene.

Sensory evaluation of the processed samn

Four samn samples, two traditionally and two factory prepared were subjected to panel tests, the preference of judges towards these samples was tested using ranking test and 9-point hedonic test, to determine if there was a significant difference between the samples. Twenty five panelists were selected and the test was conducted in the Food Analysis Laboratory of the Food Science and Technology Department, College of Agricultural Studies, Sudan University of Sciences and Technology.

Hedonic test

A total of 25 untrained panelists (15 females and 10 males) 18 – 50 years old were chosen to taste the four samn samples for characterization of their organoleptic properties (color, odor and taste). The members of the panel were drawn from the academic staff and students of Food Science Department, Sudan University of Science and Technology who are familiar with sensory analysis techniques. For that a hedonic test, which includes descriptive terms using numerical scores for each quality parameter, was used. The panelists were asked to express their preferences (like or dislike) of the processed samples. These included samn made by traditional method and samn made by factory processing method. The samples were presented so that each sample had an equal chance to be tasted first, second, third or last. The results obtained

Table 1. Chemical and physical parameters of two traditionally processed (T1 and T2) and factory processing (T3 and T4) samn samples*.

Parameter	T1	T2	T3	T4
Peroxide value	1.5 ± 0.07[a]	2.0 ± 0.1 [b]	2.5 ± 0.1 [c]	2.5 ± 0.08 [c]
Acid value	1.22 ± 0.1 [a]	1.21 ± 0.07 [a]	2.58 ± 0.2 [b]	2.54 ± 0.1 [b]
FFA (%)	0.61 ± 0.06 [a]	0.60 ± 0.1 [a]	1.29 ± 0.15 [b]	1.27 ± 0.1 [b]
Refractive index (30°C)	1.4627 ± 0.08 [a]	1.4617 ± 0.2 [a]	1.4658 ± 0.2 [b]	1.4670 ± 0.2 [b]
Colour Y\R	5.9/5.9 [a]	5.8/1.3 [b]	7.3/1.5 [c]	1.5/1.7 [d]
Specific gravity (60°C)	0.91 ± 0.1 [a]	0.90 ± 0.1 [a]	0.90 ± 0.1 [a]	0.91 ± 0.1 [a]

*All determinations were carried out in triplicate and mean value ± standard deviation (SD) reported.
[a,b,c,d] Different letters within the same row mean significant difference ($p > 0.05$, $n = 25$ trained panelists).

Table 2. Fatty acid composition (%) of two traditionally processed (T1 and T2) and factory processing (T3 and T4) samn samples.

Fatty acid		T1	T2	T3	T4
Capric	C10:0	3.22 ± 0.1 [a]	2.81 ± 0.5 [b]	1.32 ± 0.1 [c]	2.60 ± 0.1 [b]
Lauric	C12:0	1.14 ± 0.1 [a]	2.95 ± 0.4 [b]	2.45 ± 0.1 [c]	2.24 ± 0.1 [c]
Myristic	C14:0	15.13 ± 0.2 [a]	11.34 ± 0.1 [b]	10.23 ± 0.2 [c]	14.50 ± 0.2 [a]
Palmitic	C16:0	34.25 ± 0.3 [a]	35.71 ± 0.1 [a]	37.29 ± 0.1 [b]	39.23 ± 0.1 [c]
Palmitoleic	C16:1	1.44 ± 0.2 [a]	3.60 ± 0.2 [b]	6.32 ± 0.3 [c]	1.80 ± 0.1 [a]
Stearic	C18:0	15.02 ± 0.4 [a]	16.0 ± 0.1 [a]	11.28 ± 0.1 [b]	10.13 ± 0.2 [b]
Oleic	C18:1	26.1 ± 0.1 [a]	23.1 ± 0.2 [b]	25.21 ± 0.1 [c]	25.40 ± 0.1 [c]
Linoleic	C18:2	1.40 ± 0.1	1.20 ± 0.3	2.9 ± 0.2	2.0 ± 0.1
Others		2.3 ± 0.1 [a]	3.2 ± 0.2 [b]	3.0 ± 0.5 [b]	2.1 ± 0.3 [a]
SFA		68.76 [a]	68.81 [a]	63.38 [b]	68.7 [a]
PUFA		28.94 [a]	27.9 [a]	33.62 [b]	29.2 [a]
PUFA/SFA		0.42 [a]	0.40 [a]	0.53 [b]	0.42 [a]

SFA = Saturated fatty acids; PUFA = polyunsaturated fatty acids; PUFA/SFA = sum of all polyunsaturated/sum of all saturated fatty acids.
[a,b,c,d] Different letters within the same row mean significant difference ($p > 0.05$, $n = 25$ trained panelists).

by the panelists were converted to score ranging from like extremely (9) to dislike extremely (1) (Larmond, 1982). The scores were subjected to statistical analysis.

Ranking test

Twenty judges were selected to rank four samn samples in relation to color taste and odor. The samples were presented so that each had an equal chance to be tasted first, second or last. This was maintained by indicating the order of tasting for each judge in the score sheet. The ranks obtained by the panelist were converted to scores according to the method of Meilgaard et al. (1999). The sample that ranked first was given + 0.85, second +0.00 and third – 0.85; then the scores were subjected to statistical analysis.

Statistical analysis

The analyses were performed with three replicates. The mean values and standard deviation (SD) were calculated and tested using the Student-t-test ($P \leq 0.05$). The sensory scores for the samn samples were each subjected to determine if there were

statistically significant ($P \leq 0.05$) preferences in sensory attributes using statistical analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Samn chemical parameters

In this study physical and chemical parameters of four samn samples were measured using standards methods and the fatty acid composition using GC/MS-QP2010 was successfully carried out. The data for the physico-chemical properties and the fatty acid composition of the samples are summarized in Tables 1 and 2, respectively. Each sample was analyzed in triplicate. The data were reported as mean ± SD for each sample.

Table 1 shows the result of physical and chemical parameters of the four samn samples, two traditionally processed (T1 and T2) and factory processing (T3 and T4). The data generally indicate a significance difference

(p < 0.05) between the four samn samples. From the above mentioned table the peroxide value is 2.5 for both T3 and T4 samples, which is higher than the peroxide value of T1 and T2 (1.5 and 2.0 meq O_2/kg of samn, respectively) All these results are higher than results reported by CODEX standard (2006) which is 0.6 meq O_2/kg. This difference may be due to the difference in processing methods and to the difference in storage conditions especially temperature. From Table 1, the acid value of T3, T4, T1 and T2 are 2.58, 2.54, 1.122 and 1.121, respectively. The results of T3, T4 are the highest. The results showed that the FFA% of T3, T4, T1 and T2 are 1.29, 1.27, 0.6 and 0.6, respectively. Free fatty acid of T3 and T4 were higher than the level recommended by CODEX (2006) where they mentioned 0.4% for FFA% of samn.

Samn physical parameters

The physical parameters of the four samples are shown in Table 1. No difference in the specific gravity of all samples (0.90) while there is a significance difference (p < 0.05) between all the samples concerning the color. T3 and T4 showed highest RI compared to T1 and T2.

Fatty acid composition

In addition to the physical and chemical parameters of the studied samples which are important features for samn utilization, the knowledge of the fatty acid composition is important for the use of the samn for different applications. The major fatty acids of the four samn samples, as determined by GC/MS (Table 2), were palmitic, oleic, stearic, myristic and capric acid; unusual fatty acids were not found. From Table 2 it is clear that T4 sample contain high percentage of palmitc acid (39.23%) followed by T3 (37.29) in comparison to T1 and T2 (34.25 and 35.71%). T4 also contains the highest amount of palmitic acid between the four samples. Traditionally processed sample T1 which was collected from local market contains high amount of oleic acid (26.1%) in comparison with the other three samples. There were no significant difference between factory processed (T3 and T4) samples in oleic acid content. The differences in fatty acid composition may be related to the raw materials used (milk, cream and butter) in processing of these products. The data generally indicate a significance difference (p < 0.05) between the four samn samples.

From Table 2 the proportion of total SFA of the four samn samples was very high (ranged 63.38 – 68.81%), which considered higher than SFA of Indian cow samn (60%) reported by Nath and Ramamurthy (1988). The sum of lauric (C12:0), myristic (C14:0) and palmitic (C16:0) acids, which have adverse implications in health

were 50.00 and 50.52% in traditionally processed samples and 49.97 and 55.97% in factory processed samples, respectively. Essential fatty acids are important for the biological and nutritional value of dietary fats. The percentage of polyunsaturated fatty acids PUFA in the four samn samples (T1, T2, T3 and T4) was 28.94, 27.9, 33.62 and 29.2%, respectively, which were significantly (p < 0.05) lower than that reported by Abu-Lehia (1989) for Saudi cow ghee.

Samn oxidative stability

Generally fats are tested to measure degree of deterioration (such as oxidation or rancidity) as well as their stability against peroxidation such as change in peroxide value and to check fat properties against possible misrepresentation or adulteration. Changes in the peroxide value (PV) as a measure of the primary oxidation in the four samples during storage at 70ºC are shown in Figure 1. From this figure the initial PVs of T1, T2, T3 and T4, are 1.5, 2.0, 2.0 and 2.0 meq O_2/kg of samn, respectively. At the end point of oxidation, the four samn samples reached PVs of 4.2, 3.8, 6.0 and 5.7, respectively. In T3 and T4 samples, the peroxide value increased sharply and faster than that of T1 and T2 which means that the traditionally made samples were more stable than factory processed samples.

Traditionally processed samples T1 and T2 showed very slight increase in PV throughout the first 24 h and then there was a very little increase with storage time from 2.4 to 4.2 meq O_2/kg samn in T1 and from 2.4 to 3.8 in the last 48 h. In the case of T3 and T4 there was slight increase with storage time from 3.8 to 6.0 meq O_2/kg samn in T3 and from 2.3 to 5.70 meq O_2/kg samn up to the end point of oxidation. The factory processed samples T3 and T4 showed lower stability, which can be explained by the increase in PV, AV and FFA (Table 1). Mean values of samn samples are significantly different (p < 0.05) at the end point of oxidation.

Sensory evaluation of four samn samples using hedonic test

Evaluation of color and flavor by sensory and instrumental analysis is important for new product development. However, physical measurements cannot determine consumer response or preference because psychological or sensory responses are difficult to mimic (Szczesniak, 1987).

The results obtained by the panelists were converted to score ranging from like extremely (9), neither like nor dislike (5) to dislike extremely (1) following IFT 1981 guides. The scores were subjected to statistical analysis and results showed a significant difference (P ≤ 0.05)

Table 3. Mean sensory scores for two traditionally processed (T1 and T2) and factory processing (T3 and T4) samn samples (9-point hedonic scale).

Sensory attributes	T1	T2	T3	T4
Color	7.4[a]	8.4[b]	6.7[c]	6.2[d]
Odor	7.6[a]	8.0[b]	6.6[c]	6.0[d]
Taste	7.8[a]	8.1[b]	6.5[c]	5.7[d]
Overall preference	7.4[a]	8.4[b]	6.8[c]	5.6[d]

[a,b,c,d] Different letters within the same row mean significant difference ($p > 0.05$, n = 25 trained panelists). Hedonic scale: 1, dislike extremely; 5, neither like nor dislike; 9, like extremely; mean values of 25 panelists.

between the average scores for color, odor and taste in the four samn samples. T2 (processed by traditional method) was preferred by the panelists.

The analyses of the mean sensory scores for the four samn products are shown in (Table 3). A cursory look at the table shows that the hedonic scores of T1 and T2 samn products were generally high indicating a strong consumer appeal for these samples. In term of color, T1 and T2 were both scored 7.4 and 8.4, respectively, ahead of T3 and T4 which score 6.7 and 6.2, respectively. Furthermore, in terms of color, the traditionally processed samn were significantly preferred ($P \leq 0.05$) to the factory processed samples.

Similar specific analyses for the sensory attributes of odor were made and shown in Table 3. The traditionally processed samn were both scored 7.6 and 8.0, respectively, ahead of the factory processed samples which score 6.6 and 6.0, respectively. Furthermore, in terms of odor, the traditionally processed samples were significantly preferred ($P \leq 0.05$) to the factory processed samples. In terms of taste and overall preference, the traditionally processed samples were significantly preferred ($P \leq 0.05$) to the factory processed samples. Generally, the traditionally processed sample T2 which was prepared in the laboratory was significantly preferred ($P \leq 0.05$) to the rest of thr samples.

Sensory evaluation of four samn samples using ranking test

Ranking test for color, odor and taste of the samn samples were evaluated by 25 panelists under white fluorescence light in an odor free room in the Department of Food Science and Technology, at Sudan University of Science and Technology. Panelists were asked to indicate their degree for preference of samples by ranking, best to worst. An appearance ranking test of samn was done and then the panelists evaluated their preference for appearance of samn by ranking. Three digit random numbers were used to identify the samples. They were asked to evaluate their preference for color, odor and taste for the 4 samples by ranking.

From the results of analysis of variance (ANOVA) of the ranks, obtained by the panelists for four samn samples T1, T2, T3 and T4 using statistical chart of Larmond, (1982) with degrees of freedom in the numerator and degrees of freedom in the denominator. By comparing the values calculated with the value in the Tables at 5% level, it is clear that the difference was significant between the traditionally processed and factory processed samn samples. The panelists ranked traditionally processed samples first followed by factory processed ones. The color, odor and taste of traditionally processed samn was significantly better than that of the factory processed samn.

Conclusions

The traditionally processed samples (T1 and T2) and factory processing (T3 and T4) showed a significance difference ($p < 0.05$) in the physical and chemical properties. Results indicated that fatty acids and quality measurement can easily be used to investigate samn and that traditionally processed samn showed better stability and can sustain excessive heating than factory processed samn. The method of samn processing can affect quality and oxidative stability. A consumer panel indicated that color, odor and taste were critical quality factors that can be used to differentiate between traditionally and factory processed samn.

REFERENCES

Abu-Lehia IH (1989). Physical and chemical characteristics of camel milk fat and its fractions. Food Chem. 34:261-271

Al-Khalifa A, Al-Kahtani H (1993). Composition of ghee (Samn Barri's) from cow's and sheep's milk. Food Chem. 46: 373-375

AOCS (1997). Official methods and recommended practices of the American Oil Chemists' Society, 4th edition, edited by AOCS. Champaign, IL. Method Ib-64 Brameley PM, Elmadfa I, Kafatos A, Kelly FG, Manios Y, Roxborough HE, Schuch W, Sheehy PJA,Wagner K-H. 2000. Review: Vitamin E. J. Sci. Food Agric. 80: 913-938.

Codex STAN A-2 (1973), Rev.1-1999 Codex standard for milk fat products, Amended 2006.

O'connor CB, Tripathi BR (1995). Milk processing techniques - fermented milks, An introduction to milk. Audiotutorial Module 1. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia. p. 24

FAO (1990). The technology of traditional milk products in developing countries. Animal production and health, paper No. 85. Rome, Italy.

http://www. milkfacts.info/nutritionfact Retrieved on 20.12.2007

IFT (1981). Sensory evaluation guide for testing food and beverage products. Food Technol. 35(11): 50–59.

Jacobson MS (1987). Cholesterol oxides in Indian butter: possible causes of unexplained high risk of atherosclerosis in Indian immigrant populations. Lancet (ii): 8560-8656.

Kumar MV, Sambsishs K, Lokesh B, Sambaiah K (1999). The anhydrous milk fat lowers serum prostaglandins and secretion of leukotrienes by rat peritoneal macrophages. Prostaglandins Leukotrienes and Essential Fatty Acids 61 (4): 249–254.

Larmond E (1982). Laboratory methods for sensory evaluation. Research Branch, Canada Department of Agriculture. Publication 1636, Ottawa, Canada.

Meilgaard M, Civille GV, Carr BT, Strauss S (1999). Sensory evaluation techniques. 3rd Edition CRC Press. p. 52.

Nath BS, Ramamurthy MK (1988). Cholesterol in Indian milk fat. Lancet p. 2.

Niranjan TG, Kumar MV, Lokesh BR, Krishnakantha TP (1999). 39 Influence of unsaponifiable matter from butter on Lymphocyte proliferation and Erythrocyte fragility in Rats. Nutr. Res. 19:1671-1682.

Rangappa KS, Achaya KT (1974). Indian Dairy Products. New Delhi: Asia Publishing House. p. 327.

Vashney NN (1997). Dairy professional's ready reckons. In: Dairy India, 5th edn (edited by P.R. Gupta). New Delhi: P.R. Gupta Printers. p. 364.

Szczesniak AS (1987). Correlating sensory with instrumental texture measurements, an overview of recent developments. J. Texture Studies 18:1-15.