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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 O₂/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 palmitic 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-
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.

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. Petrole um ether, Samn samples were prepared in redundant manner practiced in the traditional method of processing Materials

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

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

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
<th>T4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peroxide value</td>
<td>1.5 ± 0.07&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.0 ± 0.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.5 ± 0.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.5 ± 0.08&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Acid value</td>
<td>1.22 ± 0.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.21 ± 0.07&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.58 ± 0.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.54 ± 0.1&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>FFA (%)</td>
<td>0.61 ± 0.06&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.60 ± 0.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.29 ± 0.15&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.27 ± 0.1&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Refractive index (30°C)</td>
<td>1.4627 ± 0.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.4617 ± 0.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.4658 ± 0.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.4670 ± 0.2&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Colour Y/R</td>
<td>5.9/5.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.8/1.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>7.3/1.5&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.5/1.7&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Specific gravity (60°C)</td>
<td>0.91 ± 0.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.90 ± 0.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.90 ± 0.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.91 ± 0.1&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

*All determinations were carried out in triplicate and mean value ± standard deviation (SD) reported.
<sup>a,b,c,d</sup> 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.

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

SFA = Saturated fatty acids; PUFA = polyunsaturated fatty acids; PUFA/SFA = sum of all polyunsaturated/sum of all saturated fatty acids.
<sup>a,b,c,d</sup> 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 ≤ 0.05). The sensory scores for the samn samples were each subjected to determine if there were statistically significant (P ≤ 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 O₂/kg of samn, respectively). All these results are higher than results reported by CODEX standard (2006) which is 0.6 meq O₂/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, 1.12 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 palmitic 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 70°C 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 O₂/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 O₂/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 O₂/kg samn in T3 and from 2.3 to 5.70 meq O₂/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 (Szczeniak, 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)
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 ≤ 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 ≤ 0.05) to the factory processed samples. In terms of taste and overall preference, the traditionally processed samples were significantly preferred (P ≤ 0.05) to the factory processed samples. Generally, the traditionally processed sample T2 which was prepared in the laboratory was significantly preferred (P ≤ 0.05) to the rest of the 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 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
