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Research Article
Physicochemical and Sensory Characteristics of Stirred Yoghurt Flavoured with Mango (*Mangifera indica* L.) During Storage Period

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Abstract

Objective: This study was conducted to determine the physicochemical and sensory characteristics of yoghurt flavoured with mango during the storage period. **Methodology:** Yoghurt was manufactured from sheep milk with the addition of 15% (w/v) mango (slice and juice), gum arabic (0.35% w/v) and starter culture (3% w/v of 1:1 combination of *Streptococcus thermophilus* and *Lactobacillus bulgaricus*), in addition to the control sample and stored at 4.4°C for 10 days. Physicochemical (fat, protein, total solids, solids-non-fat, ash and acidity) and sensory characteristics (colour, flavour, consistency and overall acceptability) were determined at 1, 3, 7 and 10 days intervals. **Results:** The results showed that fat, ash and acidity were significantly ($p<0.001$) higher in control sample (4.29, 0.73 and 1.11%, respectively), while total solids and solids-non-fat contents were significantly ($p<0.001$) higher in yoghurt made with mango juice (19.78 and 16.51%, respectively) and the protein content was not significantly affected. During the storage period, the protein ($p<0.05$) and ash ($p<0.001$) contents significantly decreased towards the end, while acidity significantly ($p<0.05$) increased. Fat, total solids and solids-non-fat contents showed a non-significant irregular pattern during the storage period. Sensory evaluation showed that the taste significantly ($p<0.001$) scored best in control sample (2.74), while flavour ($p<0.01$) and overall acceptability ($p<0.001$) scored best in yoghurt made with mango juice (2.73 and 3.73, respectively). No significant variation was found in colour and consistency between the treatments. Towards the end of storage period, the colour significantly ($p<0.05$) deteriorated, while consistency and overall acceptability ($p<0.05$) improved and the taste and flavour were not affected. **Conclusion:** It was concluded that mangoes are more suitable to use as flavouring materials in yoghurt manufacture.

Key words: Mangoes, physicochemical, sensory, stirred yoghurt, storage period

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Yoghurt is the most popular fermented dairy product widely consumed all over the world. It is obtained by lactic acid fermentation of milk by the action of starter culture containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus*. The main role of these two genera in yoghurt manufacture is the acidification of milk and synthesis of aromatic compounds[1,2]. Yoghurt is derived from the Turkish word "Jugurt" reserved for any fermented milk with acidic taste[3]. Some studies using species of lactic acid bacteria showed promising health benefits of yoghurt for certain gastrointestinal conditions, including lactose intolerance, constipation, diarrheal diseases, colon cancer, inflammatory bowel disease, *Helicobacter pylori* infection and allergies[4].

Consumption of yoghurt has been shown to induce measurable health benefits linked to the presence of live bacteria[5]. A number of human studies have clearly demonstrated that yoghurt containing viable bacteria (*Streptococcus thermophilus and Lactobacillus delbrueckii* ssp. *bulgaricus*) improved lactose digestion and eliminated symptoms of lactose intolerance, thus these cultures clearly fulfill the current concept of probiotics[5].

In the set yoghurt the product is packaged immediately after inoculation with the starter culture and incubated in the packages, while for stirred yoghurt the milk is inoculated by culture, incubated in tank followed by breaking the curd and packaged after cooling[6].

Different types of fruits are used in the production of fruit yoghurt all over the world. However, it is estimated that in the German Federal Republic, the share of domestic fruits such as strawberries, cherries, raspberries and apricots is 75-80%, while that of exotic fruits such as mango, kiwi fruit, papaya and guava is about 15%[7]. Mango is the most important commercial fruit in the tropics and is a very popular fruit among millions of people in the world. Mango tree is spread in East and West Asia, Africa, United States of America and some tropical islands. Many cultivars of excellent fruit quality are currently grown such as Abusamaka, Dibsha, Alphonse, Galbeltor, Zibda and Shendi. However, the majority of the mango crop in Sudan is harvested from seedling cultivars, such as Kitchener. Although the quality of fruit of these seedling cultivars is fairly good, they are usually too fibrous and not suitable for export especially to European markets[8]. Mango fruit is a drupe, 100-400 g in weight and variable in forms and sizes. The skin is thick or thin, greenish yellow, yellow or orange coloured. The pulp is pale golden yellow or red yellow, while the texture is firm, soft or juicy and sometimes fibrous. The pulp has a subacid taste and a characteristic flavour. The nutritional composition in mangoes is very high. Many cultivars of mangoes are grown in almost all states of the Sudan. Most of mangoes are consumed locally as fresh fruits in cities and producing areas[9].

In the Sudan there are more than 50 varieties of mango, divided into two main groups, namely baladi or fibrous group and the introduced Indian group. The later group includes many varieties such as Alphonso, Abusamaka, Dibsha and Gulb El-Tour. Due to the shift of consumer preference to fruit yoghurt and difficulty of importing fruit concentrates, it is necessary to use local fruits. This study was conducted to manufacture stirred yoghurt using mango pulp and to carry out the chemical and organoleptic evaluation of the resultant product.

MATERIALS AND METHODS

Materials: Fresh milk of sheep was obtained from a local dairy farm, while mangoes (variety Abusamaka), sugar and stabilizer (gum arabic) were obtained from the local market. The starter culture (1:1 combination of *Streptococcus thermophilus* and *Lactobacillus bulgaricus*) was obtained from Chris Hansen's Company, Denmark and the plastic cups (250 mL size) were obtained from the local market.

Preparation of mangoes: Fully riped mangoes fruits free from injured and deteriorated parts were carefully washed with tap water for 3-5 min and peeled with sterile stainless steel knives. The fruits were divided into two parts: One part was cut into slices of 3-4 mm thickness, while for the other part mangoes were blended with electrical blender to obtain a concentrated juice. Sugar was added to the slices and concentrated juice in the ratio of 1:2.7 (sugar: mango) and kept at 4.4°C for 12-24 h.

Preparation of yoghurt: Whole milk was heated at 82.2°C for 30 min, followed by cooling to 45°C. The starter culture (1:1 combination of *Streptococcus thermophilus* and *Lactobacillus bulgaricus*) was added at 3% (w/w). The mixture was thoroughly mixed by agitation and incubated at 45°C for 4 h, followed by cooling to 10°C. Mangoes (slices or concentrate) were sterilized and added to yoghurt at the rate of 15% (w/w), followed by addition of 0.35% (w/w) gum arabic as stabilizer. The curd was broken, filled into clean sterile plastic cups and stored at 4.4°C for 10 days. Plain yoghurt (control) was prepared in the same procedure

without addition of fruit. Chemical and organoleptic evaluation was carried out at 1, 3, 7 and 10 days intervals.

Physicochemical analysis of yoghurt: Physicochemical analysis was carried out according to methods described in AOAC[10]. Fat content was determined by Gerber method, while the protein content was determined by Kjeldahl method and the total solids content was determined by forced-draft oven method. The ash content was determined by incineration of the total solids in the muffle furnace at 550°C for 2 h, cooled in a desiccator and weighed. The solids-non-fat content was determined by subtracting the fat content from the total solids content and the titratable acidity was determined by the titration of yoghurt against 0.1 N NaOH to the end point.

Sensory evaluation: Samples were subjected to descriptive sensory analysis using the 5 point hedonic scale[11], where 5 = like very much, 4 = like moderately, 3 = neither like nor dislike, 2 = dislike moderately and 1 = dislike very much. Ten untrained panelists were selected to evaluate yoghurt samples for colour, taste, flavour, consistency and overall acceptability.

Statistical analysis: The data were analyzed using Statistical Analysis Systems, version 9 (SAS Institute, Inc., Cary NC, USA). Factorial arrangement (3×4) was used to determine the effect of treatment and storage period on the chemical composition and sensory characteristics of yoghurt. Mean separation was carried out by Duncan multiple range test ($p \leq 0.05$).

RESULTS AND DISCUSSION

Physicochemical characteristics of yoghurt: Table 1 presents the effect of addition of mangoes on physicochemical characteristics of yoghurt. The results of fat content in plain yoghurt (4.29%) was higher than that reported by El Zubeir *et al.*[12] and Younus *et al.*[3] who found fat content to be 2.94% and Aly *et al.*[13] who reported a fat content of 3.75%. The fat content in plain yoghurt was higher than that in mango yoghurt samples and could be attributed to addition of mango that lead to lower fat content causing a noticeable decrease in fat. There were no significant differences in fat content of mango yoghurt. The protein content was not significantly affected by addition of mango, although the maximum content (4.17%) was in the control sample, probably due to the fact that it was not diluted by the addition of mangoes. This result was in accordance with Duttschaever *et al.*[14] who stated that, plain yoghurt was higher in protein content due to the absence of dilution effect. These results agreed with the findings of Hossain *et al.*[15] who concluded that the protein content of fruit yoghurt decreased compared to plain/control yoghurt because mango contained lower protein. The maximum content of total solids, solids-non-fat and ash ($p<0.001$) were obtained from mango juice yoghurt, while the minimum contents were obtained from control. These results were in agreement with the study of Kroger and Weaver[16] who stated that in fruit yoghurt the total solids content is strongly depended on the fruit addition and also agreed with the study of Duttchaever *et al.*[14] who reported that high solids fruit preparations would raise the total solids of fruit yoghurt. Aly *et al.*[13], El Zubeir *et al.*[12] and El Bakri and El Zubeir[17] reported average total solids content of 9.3±2.5% for yoghurt in Sudan. Similar results of solids-non-fat content were reported by Musaiger *et al.*[18], while Karagozlu *et al.*[19] reported lower results. The ash content was highest (0.73%) in control compared to other preparations. This result is in accordance with the findings of Hossain *et al.*[15] who reported that the ash content of fruit yoghurt decreased compared to plain/control yoghurt

Table 1: Physicochemical characteristics of mango yoghurt compared to the control

Physicochemical characteristics (%)	Treatments				
	Control	MSY	MJY	SE	SL
Fat	4.29[a]	3.48[b]	3.26[b]	0.1617	***
Protein	4.17[a]	3.98[a]	4.08[a]	0.1194	NS
Total solids	16.37[c]	18.76[b]	19.78[a]	0.2203	***
Solids-non-fat	12.08[c]	15.28[b]	16.51[a]	0.1677	***
Ash	0.73[a]	0.61[b]	0.60[b]	0.0189	***
Titratable acidity	1.11[a]	0.86[b]	0.89[b]	0.0254	***

Means in the same row bearing similar superscripts are not significantly different ($p>0.05$), ***: $p<0.001$, NS: Not significant, SE: Standard error of means, SL: Significance level, MSY: Mango slices yoghurt, MJY: Mango juice yoghurt

because mango contained lower ash. The acidity was significantly ($p<0.001$) highest in plain/control yoghurt (1.11%), while the lowest value (0.86%) was in mango slices yoghurt. This might be due to low total solids and solids-non-fat contents in control (plain) sample compared to high total solids in mango juice. Nilufar[20] observed an increase in titratable acidity of yoghurt supplemented with mango juice and Humphreys and Plunkett[21] concluded that an increase in the total solids results in an increase in titratable acidity due to the buffering action of milk constituents.

The data in Table 2 represent the physicochemical characteristics of yoghurt as affected by the storage period. The storage period did no significantly affect fat, total solids and solids- non- fat contents, although a decreasing trend was observed during the storage period for all components. El-Shibiny *et al.*[22,23] reported that total solids content of yoghurt decreased proportionally during the storage period with increasing glucose and galactose concentrations. Humphrey and Plunkett[21] stated that decreasing the total solids content may also be attributed to the interaction of basic amino groups with lactose. The maximum protein ($p<0.05$) and ash ($p<0.001$) contents were obtained in 1 day (4.33 and 0.66%, respectively) and the minimum in 10 days (3.87 and 0.59%, respectively). This is largely attributable to the microbial action on fat and protein[24]. Hidiroglou and Proulx[25] reported that milk Ca, P and Mg content were all highest during the first day of storage, decreasing sharply at 2nd day and then dropping gradually when storage progressed. The acidity showed a significant ($p<0.05$) gradual increase reaching a maximum at day 10 (1.00%). *Lactobacillus bulgaricus* and *Streptococcus thermophilus* are responsible for the post acidification of yogurt during storage by converting lactose into lactic acid[26]. This result is in agreement with the study of Toba *et al.*[27], who reported a slight increase in titratable acidity during storage period and with the study of Kosikowski and Mistry[28], who stated that standard commercial yoghurt generally increased in titratable acidity from 0.9 to 1.7% after manufacture and storage. Although there was no significant effect of storage period on the total solids and SNF contents of yoghurt, these values decreased with progressing storage period and this may be due to a great correlation between the free amino acids and lactose[21].

Sensory characteristics of yoghurt: Table 3 shows the sensory characteristics of mango yoghurt. There was a significant difference between the three mango treatments in taste ($p<0.001$), flavour ($p<0.01$) and overall acceptability ($p<0.001$). However, there was no significant effect on colour and consistency of yoghurt ($p<0.01$). While the control sample was preferred in taste and consistency, mango slices yoghurt was preferred in colour and mango juice yoghurt in flavour and overall acceptability. The preference in flavour was obtained in yoghurt made with mango juice. The

Table 2: Effect of storage period on the physicochemical characteristics of yoghurt

	Storage period (days)					
Physicochemical characteristics (%)	1	3	7	10	SE	SL
Fat	384^{a}	3.89^{a}	3.41^{a}	3.58^{a}	0.1868	NS
Protein	4.33^{a}	4.04^{ab}	4.07^{ab}	3.87^{b}	0.1379	*
Total solids	18.63^{a}	18.27^{a}	18.11^{a}	18.20^{a}	0.2544	NS
Solids-non-fat	14.78^{a}	14.38^{a}	14.70^{a}	14.63^{a}	0.1937	NS
Ash	0.66^{b}	0.61^{bc}	0.73^{a}	0.59^{c}	0.0218	***
Titratable acidity	0.90^{b}	0.96^{ab}	0.96^{ab}	1.00^{a}	0.0294	*

Means in the same row bearing similar superscripts are not significantly different ($p>0.05$), ***: $p<0.001$, *: $p<0.05$, NS: Not significant , SE: Standard error of means, SL: Significance level

Table 3: Sensory characteristics of mango yoghurt compared to the control

	Treatments				
Sensory characteristics	Control	MSY	MJY	SE	SL
Colour	4.30^{a}	4.38^{a}	4.28^{a}	0.0992	NS
Taste	3.74^{a}	3.21^{b}	3.06^{b}	0.0763	***
Flavour	3.34^{b}	3.38^{b}	3.73^{a}	0.0871	**
Consistency	2.88^{a}	2.58^{b}	2.83^{ab}	0.0994	NS
Overall acceptability	4.14^{b}	4.38^{b}	4.73^{a}	0.0879	***

Means in the same row bearing similar superscripts are not significantly different ($p>0.05$), ***: $p<0.001$, **: $p<0.01$, NS: Not significant , SE: Standard error of means, SL: Significance level, MSY: Mango slices yoghurt , MJY: Mango juice yoghurt

Table 4: Effect of storage period on the sensory characteristics of yoghurt

	Storage period (days)					
Sensory characteristics	1	3	7	10	SE	SL
Colour	4.50[a]	4.07[b]	4.37[ab]	4.33[ab]	0.1146	*
Taste	3.38[a]	3.23[a]	3.37[a]	3.37[a]	0.0881	NS
Flavour	3.45[a]	3.55[a]	3.42[a]	3.50[a]	0.1006	NS
Consistency	2.53[b]	3.02[a]	2.70[ab]	2.78[ab]	0.1148	*
Overall acceptability	4.65[a]	4.25[b]	4.33[b]	3.42[ab]	0.1015	*

Means in the same row bearing similar superscripts are not significantly different (p>0.05), *: p<0.05, NS: Not significant , SE: Standard error of means, SL: Significance level

preference of flavour in mango juice is in agreement with Lee *et al.*[29], who reported that milk-based yoghurt was preferred by the sensory panelists with respect to flavour. This flavour preference may be due to the fact that mango juice had a high flavour concentration compared to the two treatments. The significantly ($p<0.05$) high preference in colour and overall acceptability of yoghurt were obtained in 1 day and the less preference in 3 days, while consistency and flavour were preferred in day 3 (Table 4). The results in Table 4 show the preference in colour, flavour and overall acceptability of yoghurt slightly increased towards the end of the storage period. The increase in preference of the flavour with time may be due to development of acetaldehyde produced by microbial action on lactose, breakdown of protein to flavour compounds and breakdown of fat to volatile fatty acids[30,31]. The results in this study are in accordance with Nosawa[32], who reported variations between individual panel members in their evaluations for colour, smell and taste. The deterioration in the preference in consistency during storage period may be a result of high starter level in yoghurt. This is in accordance with the findings of Hrabova and Hylmar[33], who found that at 3-5% starter level, the consistency was adversely affected (coarse texture) and whey separation increased.

CONCLUSION

Mangoes are more suitable to use as flavouring materials in yoghurt manufacture. Although mango juice yoghurt scored the highest in overall acceptability, mango slices yoghurt was also acceptable by panelists and secured the best results in flavour, total solids, SNF and ash. All the yoghurt types retained their colour, flavour and general acceptability, unchanged for ten days at 5°C. This study will help the researchers to uncover the critical areas of utilization of mango as natural flavour in yoghurt that many researchers were not able to explore. Thus a new theory on use of other kinds of fruits as natural flavour in yoghurt may be arrived at.

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