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ENHANCEMENT YOGHURT FLAVORED WITH MANGO (*MANGIFERA INDICA L.*) FRUITS JUICE

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ABSTRACT

This study was conducted to enhance and evaluate the physicochemical and sensory characteristics of yoghurt flavoured with mango fruit during the storage period. Yoghurt was manufactured from sheep milk with the addition of 15% (w/v) mango fruit (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-day intervals. The results showed that fat, ash and acidity were significantly ($P<0.001$) higher in control sample (4.29%, 0.73% and 1.11% respecticely), while total solids and solids-non-fat contents were significantly ($P<0.001$) higher in yoghurt made with mango fruit 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-signifcant 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 signficant 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 falvour were not affected.

KEYWORDS: Mango fruit, physicochemical, sensory, stirred yoghurt, storage period.

INTRODUCTION

Yoghurt is one of the most popular fermented dairy products 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 role of these two genera in yoghurt manufacture is the acidification of milk and synthesis of aromatic compounds (Sahan *et al.,* 2008; Serra *et al.,* 2009). Yoghurt is derived from the Turkish word "Jugurt" reserved for any fermented milk with acidic taste (Younus *et al.,* 2002). Some studies using lactic acid bacteria species 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 (Adolfsson *et al.,* 2004).

Consumption of yoghurt has been shown to induce measurable health benefits linked to the presence of live bacteria (Guarnar *et al.,* 2005). 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 (Guarnar *et al.,* 2005).

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 (Chandan, 1999).

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 mangos, kiwi fruit, papaya and guava is about 15% (Vobl and Makarowa, 1984). Mango fruit 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, Alphonse, Dibsha, Zibda, Galbeltor and Shendi. However, the majority of the mango fruit 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 (Elkashif *et al*., 2003). Mango fruit is a drupe, 100- 400 gm 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 mango fruits is very high. Many cultivars of mango fruits are grown in almost all states of the Sudan. Most of mango fruits are consumed locally as fresh fruits in cities and producing areas (Mardi and Awad, 1984).

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 last group includes many varieties such as Alphonso, Abu Samaka, 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 fruit pulp and chemical and organoleptic evaluation of the resultant product.

MATERIALS AND METHODS

Materials

Fresh sheep's milk was obtained from a local dairy farm, while mango fruit (variety Abu Samaka), 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 mango fruit

Fully ripe mango fruits free from injured and deteriorated parts were carefully washed with tap water for 3-5 minutes and peeled with sterile stainless steel knives. The mango fruits were blended with electrical blender to obtain a concentrated juice. Sugar was added to the concentrated juice in the ratio of 1:2.7 (sugar:mango) and kept at 4.4˚C for 12-24 hr.

Preparation of yoghurt

Whole milk was heat treated 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 hr, followed by cooling to 10˚C. Mango fruits (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 (cotrol) was prepared in the same procedure without addition of fruit. Chemical and organoleptic evaluation was carried out at 1, 3, 7 and 10-day intervals.

Physicochemical analysis of yoghurt

Physicochemical characteristics were carried out according to methods described in AOAC (2000). 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 ºC for 2 hr, 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 (Singh-Ackbarali and Maharaj, 2014), where 5=like very much, 4= like moderately, 3=neither like nor dislike, 2=dislike moderately, 1=dislike very much. Ten untrained panelists were chosen to evaluate yoghurt samples for color, taste, flavor, consistency and overall acceptability.

Statistical analysis

The data were analyzed using Statistical Analysis Systems (SAS, ver. 9). Factorial design (3x4) 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 mango fruit on physicochemical characteristics of yoghurt. The results of fat content in plain yoghurt (4.29%) was higher than that reported by Elzubeir *et al* (2005), Younus *et al.* (2002) who found fat content to be 2.94% and Aly *et al.* (2004) who reported a fat content of 3.75%. The fat content in plain yoghurt was higher than that in mango fruit yoghurt samples, and could be attributed to addition of mango fruit that lead to lower fat content causing a noticeable decrease in fat. There were no significant differences in fat content of mango fruit yoghurt. The

protein content was not significantly affected by addition of mango fruit, 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 mango fruits. This result is in accord with Duitschever and Arnott (1972) who stated that, plain yoghurt was higher in protein content due to the absence of dilution effect. These results agree with the findings of Hossain *et al*. (2012) who concluded that the protein content of fruit yoghurt decreased compared to plain/control yoghurt because mango fruit contained lower protein. The maximum content of total solids, solids- non- fat and ash ($p<0.001$) were obtained from mango fruit juice yoghurt, while the minimum contents were obtained from control. These results are in agreement with those of Kroger and Weaver (1973) who stated that in fruit yoghurt the total solids content is strongly depended on the fruit addition, and Duitschaver and Arnott (1972) who concluded that high solids fruit preparations would raise the total solids of fruit yoghurt. Higher results of total solids were reported by Aly *et al.* (2004), Elzubeir *et al.* (2005) and Elbakri and Elzubeir (2009) who 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.* (1998), while Karagozlu *et al*. (2005) reported lower results. The ash content was highest (0.73%) in control compared to other preparations. This result is in accord with the findings of Hossain *et al*. (2012) who concluded that the ash content of fruit yoghurt decreased compared to plain/control yoghurt because mango fruit 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 fruit 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 fruit juice. Nilufar (1999) observed an increase in titratable acidity of yoghurt supplemented with mango juice, and Humphreys and Plunkett (1969) 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*. (1979a,b) reported that total solids content of yoghurt decreased proportionally during the storage period with increasing glucose and galactose concentrations. Humphrey and Plunkett (1969) 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 at day 1 (4.33% and 0.66% respectively) and the minimum at day 10 (3.87% and 0.59% respectively). This is largely attributable to the microbial action on fat and protein (Shanely, 1973). Hidiroglou and Proulx (1982) 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 (Donkor *et al.*, 2006). This is in agreement with Toba *et al*. (1983) who reported a slight increase in titratable acidity during storage period, and Kosikowski (1997) 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 (Humphrey and Plunkett, 1969).

Sensory characteristics of yoghurt

Table 3 shows the sensory characteristics of mango yoghurt. There was a significant difference between the treatments in taste ($p<0.001$, flavor ($p<0.01$) and overall acceptability ($p<0.001$). However, there was no significant effect on color and consistency of yoghurt ($p<0.01$). While the control sample was preferred in taste and consistency, and mango fruit juice yoghurt preferred in flavor and overall acceptability. The preference in flavor was obtained in yoghurt made with mango fruits juice. The preference of flavor in mango fruit juice is in agreement with Lee *et al.* (1990) who reported that milk-based yoghurt was preferred by the sensory panelists with respect to flavor. This flavor preference may be due to the fact that mango fruit juice had a high flavor concentration compared to the control. The significantly ($p<0.05$) high preference in color and overall acceptability of yoghurt were obtained at day 1 and the less preference at day 3, while consistency and flavor were preferred at day 3 (Table 4). The results in Table 4 showed that the preference in color, flavor and overall acceptability of yoghurt slightly increased towards the end of the storage period. The increase in preference of the flavor with time may be due to development of acetaldehyde produced by microbial action on lactose, breakdown of protein to flavor compounds and breakdown of fat to volatile fatty acids (Breslaw and Kleyn, 1973; Tamime and Deeth, 1980). The results in this study are in accord with Nosawa (1973) who reported variations between individual panel members in their evaluations for color, 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 accord with the findings of Hrabova *et al.* (1974) who found that at 3-5% starter level, the consistency was adversely affected (coarse texture) and whey separation increased.

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

	Treatments		SE	SL
	Control	MFJY		
Fat	4.29[a]	3.26[b]	0.1617	***
Protein	4.17[a]	4.08[a]	0.1194	NS
Total solids	16.37[c]	19.78[a]	0.2203	***
Solids-non-fat	12.08[c]	16.51[a]	0.1677	***
Ash	0.73[a]	0.60[b]	0.0189	***
Titratable acidity	1.11[a]	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
MFJY = Mango fruit Juice yoghurt

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

Physicochemical characteristics (%)	Storage period (days)				SE	SL
	1	3	7	10		
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]	0.61b[c]	0.73[a]	0.59[c]	0.0218	***
Titrable 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 fruit yoghurt compared to the control.

Sensory characteristics	Treatments		SE	SL
	Control	MFJY		
Color	4.30[a]	4.28[a]	0.0992	NS
Taste	3.74[a]	3.06[b]	0.0763	***
Flavor	3.34[b]	3.73[a]	0.0871	**
Consistency	2.88[a]	2.83[ab]	0.0994	NS
Overall acceptability	4.14[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
MFJY = Mango fruit juice yoghurt

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

Sensory Characteristics	Storage period (days)				SE	SL
	1	3	7	10		
Color	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
Flavor	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

CONCLUSION

Mango fruits are more suitable to use as flavoring materials in yoghurt manufacture. Although mango fruits juice yoghurt scored the highest in overall acceptability, flavor, total solids, SNF and ash. All the yoghurt types retained their color, flavor and general acceptability, unchanged for ten days at 5°C.

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