Quality Evaluation of Stirred Yoghurt Flavoured with Guddaim (*Grewia tenax*) Fruit

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ABSTRACT-- ***This investigation was conducted to evaluate the quality of stirred yoghurt manufactured with Guddaim fruit. Cow milk was filtered and Guar gum was added as a stabilizer (2% w/v), followed by pasteurizing the mixture at 90ºC for15 min. After inoculation with 3% (w/v) of Lactobacillus bulgaricus and Streptococcus thermophilus, incubation was carried out at 45 ºC for 3 hr, followed by breaking the curd and addition of fruit puree [5% v/v (T1), 7% v/v (T2) and 10% v/v (T3)], in addition to plain yoghurt (T)). Yoghurt was stored at 4 ºC for 10 days and chemical, microbiological and sensory characteristics were carried out at 1, 3, 7 and 10-day intervals. Results indicated that addition of Guddaim did not increase the physic-chemical properties of yoghurt in comparison to control. During the storage period the fat and TA increased while protein and TS contents fluctuated and the ash content decreased to a minimum at day 3 then increased thereafter. TVB and Staphylococcus aureus counts were high in control, while coliform bacteria count was high in T1 and yeasts and moulds count was high in T2. During the storage period, TVB and yeasts and moulds counts increased while coliform bacteria and S. aureus counts fluctuated. The colour, consistency, taste and overall acceptability were best in control as judged by the panelists, while T1 scored best in flavour. All sensory characteristics deteriorated during storage period.***
Keywords-- Chemical, fruit puree, Guddaim, microbiological, sensory

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1. INTRODUCTION

Yoghurt is defined as a coagulated milk product obtained by the fermentation of lactose into lactic acid through the action of *Lactoacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus* from milk with or without additions (Trachoo, 2002).

Yoghurt is a valuable health food for infants and elderly people, and the nutritional constituents of yoghurt are derived from the milk used in the manufacture, in addition to those synthesized by the lactic acid bacteria and those added by the manufacturers (Ayar *et al.*, 2006).

The consumption of yoghurt has been associated with health benefits which include protection against gastrointestinal upsets, enhancing lactose digestion by maldigesters, decreasing risk of cancer, lowering blood cholesterol, improving immune response, helping the body to assimilate protein, calcium and iron, longevity, diarrhea protection and control as well as maintenance of gastrointestinal microflora (Aly *et al.*, 2004; Foda *et al.*, 2007; Iwalokun and Shittu, 2007; Vahed *et al.*, 2008; Andronoiu *et al*,. 2011). The benefits of yogurt consumption to gastrointestinal function are most likely due to effects mediated through gut microflora, bowel transit, enhancement of gastrointestinal innate and adaptive immune responses (Adolfsso *et al.*, 2004).

Physical properties of yoghurt are influenced by heat treatment applied to milk, protein content, acidity, culture, additives, homogenization, mechanical handling of coagulum and presence of stabilizers (Küçüköner and Tarakçi, 2003). For the acceptance of yoghurt by the consumers, flavourings and sweeteners have been added to improve the flavour balance (Yaman *et al.*, 2006).

Consumers, especially children, demand novel yoghurt formulations more than traditional ones like plain yoghurt. Introduction of various fruit-flavoured yoghurts has significantly contributed to the consumption of yoghurt from all ages. A variety of different flavouring ingredients (fruits, natural flavours or synthetic flavours) are currently added to

yoghurt. The types of flavouring materials used are fruits, fruit preserves, canned fruits, frozen fruits and miscellaneous fruit products (Küçüköner and Tarakçi, 2003). Most common fruits used in yoghurt formulae are peach, cherry, orange, lemons, purple plum, boysenberry, spiced apple, apricot, pineapple, strawberry, raspberry and blueberry (Cinbas and Yazici, 2008).

Grewia tenax (Forssk.) Fiori (locally known as Guddaim) is a fruit producing deciduous shrub or small tree of widespread occurrence in the semi-arid and sub-humid tropical zones of the Sudan (Gebauer *et al.*, 2007). The fruit pulp represents only 40-50% of the whole fruit, and contains 10-15% moisture, 20% crude fibre, 5.2% ash, 0.4% fat, 66% carbohydrates, 13.8% reducing sugar and 44.4% starch. The fruit is rich in iron (20.8 mg/100 gm), potassium (817 mg/100 gm), sulphur, phosphorus, magnesium, calcium and sodium, and a good source of amino acids (aspartic acid, threonine, serine, glutamic acid, proline glycine, alanin, valine, cysteine, methionine, isoleucine, leucine, tyrosine, phenylalanine, lysine, histidine and arginine). The fruit is low in tannin (1.13%) and high in pectic substances (6.26%), and is traditionally used for the treatment of anaemia (Gebauer *et al.*, 2007; Mohammed Elhassan and Yagi, 2010).

The objective of this study is to use *Grewia tenax* fruit for the manufacture of stirred flavoured yoghurt and evaluate the resultant product chemically, microbiologically and organoleptically.

2. MATERIALS AND METHODS

2.1 Source of materials

Raw cow milk was obtained from the University of Khartoum dairy farm, while Guddaim fruits (dark red in colour) and powdered Guar Gum were obtained from the local market. The starter culture was obtained from Chris Hansens Company, Denmark.

2.2 Preparation of fruit purees

The fruits were prepared into fruit purees as follows: the whole ripe fruits were cleaned, washed with tap water and soaked in water (2x fruit volume) for 3 hr, then blended into paste using a blender followed by filtering. Sucrose (5% w/v) was added to improve the sweetness of the purees before they were heated to 100ºC for 10 min. The fruit purees were cooled to 45ºC and cold stored until used. Three different concentrations were used [5% v/v (T1), 7% v/v (T2) and 10% v/v (T3)].

2.3 Manufacture of yoghurt

Stirred yoghurt was manufactured as follows: milk was filtered with cheese cloth to clean from debris and foreign materials, and guar gum was added as a stabilizer (0.2% w/v). The mixture was pasteurized at 90ºC for 15 min followed by cooling rapidly in iced water to 45ºC, and then inoculated with 3% (v/v) yoghurt culture of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* (1:1 ratio). After incubation (45ºC for 3 hr), the curd was stirred to break, and the fruit purees were added (in fruit yoghurt only) to give three treatments (T1, T2, T3), in addition to the control (T0). Yoghurt was stored at 4ºC for 10 days, and physicochemical, microbiological and sensory evaluation was carried out at 1, 3, 7 and 10-day intervals.

2.4 Physico-chemical analyses

Milk and yoghurt were analyzed for fat, protein, total solids (TS), ash and titratable acidity (TA) according to AOAC (2000).

2.5 Microbiological examination

Samples were diluted in a ratio of 1:10 (v/v) and used for total viable bacteria (TVB), coliform bacteria, *S. aureus* and yeasts and moulds counts. Plate count agar medium was used for TVB count and plates were incubated at 32ºC for 48 hr (Houghtby *et al.*, 1992). MacConkey agar medium was used for coliform bacteria count and plates were incubated at 32ºC for 48 hr (Christen *et al.*, 1992). Mannitol salt agar medium was used for *S. aureus* count and the plates were incubated at 32ºC for 48 hr (Flowers *et al.*, 1992). Potato dextrose agar medium was used for yeasts and moulds counts and the plates were incubated at 25ºC for 5 days (Frank *et al.*, 1992). Biochemical tests were carried out for identification according to Barrow and Feltham (1993).

2.6 Sensory evaluation

The quality of the coded yoghurt samples (colour, flavour, consistency, taste, overall acceptability) was organoleptically determined. This involved the use of 10 untrained panelists to examine the attributes of yoghurt products that were blinded by coding. Evaluation was based on 5 point hedonic scale with very poor (score = 1) and excellent (score = 5) as extremes.

2.7 Statistical analyses

The data were analyzed using Statistical Analysis Systems (SAS, ver. 9). Data on physicochemical, microbiological and sensory profiles were analyzed by one-way analysis of variance (ANOVA). Mean separation was done by Duncan multiple range test at $P \leq 0.05$.

3. RESULTS AND DISCUSSION

3.1 Chemical composition of yoghurt

From the results in Table 1 it is obvious that the addition of Guddaim did not increase the physico-chemical properties of yoghurt in comparison to control (T0), except for TA which increased. The lowest fat and TS contents were in T3 and lowest protein and ash contents were in T1. These findings are in disagreement with Andronoiu *et al.* (2011) who reported an increase in the physico-chemical properties of yoghurt with the addition of walnuts and strawberries jam.

The decrease in fat content was in agreement with the results of Tarakci (2010) who found a decreasing trend of fat as the concentration of the added marmalade increased from 0% to 20%, and Kucukoner and Tarakci (2003), Ayar *et al.* (2006) and Cinbas and Yazici (2008) who found that the fat content of yoghurt decreased with the addition of different fruit purees.

Although Guddaim fruit has a protein content of 6.3% -8.7% (Gebauer *et al*., 2007; Mohammed Elhassan and Yagi, 2010), the protein content of yoghurt decreased with the addition of Guddaim to yoghurt. The findings of this study are in line with those of Kucukoner and Tarakci (2003) and Ginbas and Yazici (2008).

TS content was expected to increase with the addition of Guddaim, but its content decreased. Aly *et al*. (2004) and Cinbas and Yazici (2008) reported a decreasing trend of TS of yoghurt made with different concentrations of carrot juice and strawberry respectively. However, the results of this investigation disagree with those of Kucukoner and Tarakci (2003), Tarakci and Kucukoner (2003), Ayar *et al*. (2006) and Tarakci (2010).

All treatments had lower ash content compared to control. These results are in line with Iwalokun and Shittu (2007) and Andronoiu *et al.* (2011), and disagree with Kucukoner and Tarakci (2003), Cinbas and Yazici (2008) and Tarakci (2010). The increasing pattern of TA is in line with the findings of Kucukoner and Tarakci (2003) and Dlamini and Silaula (2009), and in disagreement with Ayar *et al.* (2006).

During the storage period of 10 days, the fat content and TA increased towards the end of storage period, while protein and TS contents decreased at day 7 then increased at the end. The ash content decreased at day 3 before increasing (Table 2). Tarakci (2010) and Tarakci and Kucukoner (2003) reported an increasing trend of TA in fruit yoghurt during storage.

3.2 Microbiological quality of yoghurt

TVBC ranged from Log 7.59 cfu/gm in T2 to Log 8.20 cfu/gm in T0, and during storage period the count increased from Log 7.71 cfu/gm in day 1 to Log 7.88 cfu/gm in day 10 (Tables 3 and 4). The presence of the organisms in this high number could be due to poor handling, inadequate heat treatment and environmental conditions during preparation and storage (Okoye and Animalu, 2009). This result is in agreement with Vahedi *et al.* (2008) and Mbaeyi and Anayanwu (2010). However, Tarakci and Kucukoner (2003) reported lower initial bacterial count in fruit-flavoured yoghurt.

Coliform bacteria count ranged between Log 3.15 cfu/gm in T0 and Log 3.69 cfu/gm in T1, and the count showed a decrease in day 7 (Log 3.06 cfu/gm) before increasing to the end (Tables 3 and 4). This result is in line with Aly *et al*. (2004), and in disagreement with Vahedi *et al.* (2003) who reported a decreasing trend of coliform bacteria during storage. No growth of coliform bacteria during preparation and storage of yoghurt was reported by some investigators (Okoye and Animalu, 2009; Mbaeyi and Anyanwu, 2010).

S. aureus count was Log 3.70 cfu/gm in T3 and Log 4.44 in T0. The count increased during storage from Log 4.07 cfu/gm at day 1 to Log 4.16 cfu/gm at day 10 with a slight decrease in day 7 (Log 3.90 cfu/gm) (Tables 3 and 4). The environmental contamination and heat treatment during preparation of yoghurt might be the reason. Belickonva *et al.* (2001) reported lower count of *S. aureus* (Log 0.70 – Log 2.0 cfu/ml) in yoghurt milk with strawberry flavor.

Yeasts and moulds count ranged from Log 3.69 cfu/gm in T0 to Log 4.12 cfu/gm in T2, showing an increasing trend during storage period (Tables 3 and 4). Tarakci and Kucukoner (2003) found initial yeasts and moulds count not exceeding Log 2.89 cfu/gm. Okoye and Animalu (2009) reported no fungal growth in yoghurt stabilized with sweet potato.

3.3 Sensory evaluation of yoghurt

Table 5 presents the results of sensory evaluation of yoghurt made with different concentrations of Guddaim by untrained panelists on a scale of 5. High mean values were obtained for T0 in all sensory attributes compared to T1, T2 and T3 except for flavour which was lowest in T0. During the storage period all sensory characteristics were deteriorated towards the end of storage (Table 6). Similar results were reported by Iwalokun and Shittu (2007) in sabdariffa and non-sabdariffa yoghurts, Cinbas and Yazici (2008) in strawberry yoghurt and Tarakci (2010) in kiwi yoghurt.

4. CONCLUSIONS

Although non-cultivated *Grewia tenax* fruit is rich in many nutritional compounds and traditionally used for the treatment of anaemia, yoghurt made from this fruit was not better than the plain yoghurt in terms of chemical and sensory characteristics probably because of the concentrations used (5%, 7%, 10%). For commercial production of fruit yoghurt from *Grewia tenax*, it is recommended that higher concentration be used in order to produce yoghurt with higher nutritional qualities as well as acceptable sensory characteristics to the consumer.

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Table 1: Physico-chemical characteristics (%) of yoghurt formulation manufactured with *Grewia tenax* fruit

Parameters (%)	Treatments				S.E.	S.L.
	T0	T1	T2	T3		
Fat	4.19[a]	3.70[b]	3.79[b]	3.67[b]	0.283	**
Protein	5.47[a]	4.09[b]	4.44[b]	4.48[b]	0.534	***
Total solids	18.60[a]	16.14[bc]	16.36[b]	15.17[c]	1.083	***
Ash	0.54[a]	0.51[a]	0.51[a]	0.53[a]	0.037	N.S
Titratable acidity	0.96[b]	0.96[b]	0.97[b]	1.049[a]	0.066	*

Means in the same row bearing the same superscripts are not significantly different (P>0.05).
* = P<0.05
** = P<0.01
*** = P<0.001
N.S = Not significant
S.L. = Significance level
S.E. = Standard error of means

Table 2: Effect of storage period on physic-chemical characteristics of yoghurt made with Grewia tenax fruit

Storage period (days)	Fat (%)	Protein (%)	Total solids (%)	Ash (%)	Titratable acidity (% lactic acid)
1	3.79[a]	5.37[a]	17.09[a]	0.53[a]	0.85[c]
3	3.73[a]	4.76[b]	16.80[ab]	0.49[b]	0.88[c]
7	3.92[a]	3.92[c]	15.68[b]	0.55[a]	1.049[b]
10	3.93[a]	4.42[bc]	16.69[ab]	0.52[ab]	1.16[a]
S.E.	0.283	0.534	1.083	0.037	0.066
S.L.	N.S	***	*	**	***

Means in the same column bearing the same superscripts are not significantly different (P>0.05).
* = P<0.05
** = P<0.01
*** = P<0.001
N.S = Not significant
S.L. = Significance level
S.E. = Standard error of means

Table 3: Microbiological quality (Log10 cfu/gm) of yoghurt formulation manufactured with Grewia tenax fruit

Parameters	Treatments				S.E.	S.L.
	T0	T1	T2	T3		
Total viable bacteria	8.20[a]	7.64[b]	7.59[b]	7.75[b]	0.442	*
Coliform bacteria	3.15[b]	3.69[a]	3.62[a]	3.34[ab]	0.402	*
S. aureus	4.44[a]	4.00[b]	4.14[b]	3.70[c]	0.296	***
Yeasts and moulds	3.69[b]	3.94[ab]	4.12[a]	3.74[ab]	0.377	*

Means in the same row bearing the same superscripts are not significantly different (P>0.05).
* = P<0.05
*** = P<0.001
S.L. = Significance level
S.E. = Standard error of means

Table 4: Effect of storage period on the microbiological quality (Log10 cfu/gm) of yoghurt made with Grewia tenax fruit

Storage period (days)	Total viable bacteria	Coliform bacteria	*S. aureus*	Yeasts and moulds
1	7.71^{a}	3.46^{b}	4.07^{a}	3.31^{c}
3	7.71^{a}	3.91^{a}	4.15^{a}	3.26^{c}
7	7.89^{a}	3.06^{b}	3.90^{a}	4.23^{b}
10	7.88^{a}	3.37^{b}	4.16^{a}	4.69^{a}
S.E.	0.442	0.402	0.296	0.377
S.L.	N.S	**	N.S	***

Means in the same column bearing the same superscripts are not significantly different (P>0.05).
** = P<0.01
*** = P<0.001
N.S = Not significant
S.L. = Significance level
S.E. = Standard error of means

Table 5: Sensory characteristics of yoghurt formulation manufactured with Grewia tenax fruit

Parameters	Treatments				S.E.	S.L.
	T0	T1	T2	T3		
Colour	3.55^{a}	3.09^{b}	3.15^{b}	2.70^{c}	0.714	***
Flavour	2.63^{b}	2.73^{ab}	2.66^{ab}	2.91^{a}	0.569	*
Consistency	2.88^{a}	2.58^{b}	2.50^{b}	2.67^{ab}	0.555	*
Taste	3.55^{a}	3.23^{b}	3.07^{b}	2.48^{c}	0.664	***
Overall acceptability	3.55^{a}	3.15^{b}	3.02^{b}	2.46^{c}	0.659	***

Means in the same row bearing the same superscripts are not significantly different (P>0.05).
* = P<0.05
*** = P<0.001
S.L. = Significance level
S.E. = Standard error of means

Table 6: Effect of storage period on the sensory characteristics of yoghurt made with *Grewia tenax* fruit

Storage period (days)	Colour	Flavour	Consistency	Taste	Overall acceptability
1	3.33^{a}	2.85^{a}	2.93^{a}	3.40^{a}	3.38^{a}
3	3.27^{a}	2.64^{a}	2.53^{bc}	3.24^{a}	3.13^{a}
7	3.23^{a}	2.68^{a}	2.77^{ab}	3.18^{a}	3.13^{a}
10	2.67^{b}	2.74^{a}	2.40^{c}	2.51^{b}	2.53^{b}
S.E.	0.714	0.569	0.555	0.664	0.659
S.L.	***	N.S	***	***	***

Means in the same column bearing the same superscripts are not significantly different (P>0.05).
*** = P<0.001
N.S = Not significant
S.L. = Significance level
S.E. = Standard error of means