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Quality Evaluation of Set Yoghurt Produced by Two Factories in Khartoum State, Sudan

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Abstract: This study was carried out to chemically and microbiologically evaluate set yoghurt produced by two factories (F1 and F2) in Khartoum State. Ninety samples (45 from each factory) were collected and chemically and microbiologically analyzed at 1, 5 and 10 day intervals. The results showed that fat and total solids contents and titratable acidity were higher in F2 than in F1, while protein and solids-non-fat contents were higher in F1. *Lacobacillus bulgaricus*, coliform bacteria and yeasts and moulds counts were higher in F1. During storage, fat content increased in F1 and decreased in F2, while protein content increased in F1 and followed an irregular pattern in F2. Total solids and solids-non-fat contents increased till day 5, and then decreased at the end of the storage period in the two factories, while titratable acidity steadily increased towards the end in the two factories. *Lactobacillus bulgaricus* count increased till day 5 then decreased towards the end in both factories, while coliform bacteria and yeasts and moulds counts increased towards the end.

Key words: Set yoghurt; storage period; chemical; microbiological

INTRODUCTION

Fermentation is one of the oldest methods of preservation that contributes to flavour, appearance and texture of food, and the fermented foods are more attractive to consumer than non-fermented ones. Yoghurt is the most popular dairy product consumed all over the world and is obtained by lactic acid fermentation of milk by the action of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* that are responsible for milk acidification and synthesis of aromatic compounds (Sahan *et al*. 2008; Trujillo *et al*. 2009).

In modern dairy industry, yoghurt is classified into set yoghurt and stirred yoghurt. Set yoghurt is produced by fermenting milk after packaging into individual containers before incubation, while stirred yoghurt is produced by fermenting milk in a tank, breaking the curd and then packaging it in individual containers (Horiuchi *et al*. 2009).

Yoghurt is easily digested, having high nutritional value and is a rich source of carbohydrates, protein, fat, vitamins, calcium and phosphorus; and the proteins in yoghurt are partially hydrolyzed becoming more digestible. Some lactic acid bacteria synthesize folic acid and others synthesize the enzyme lactase that reduces lactose content in yoghurt. Yoghurt has a high content of linoleic acid which has immuno-regulatory and anti-carcinogenic properties, and the acidic nature of yoghurt ionizes calcium thus improving calcium uptake into the body (Ayar *et al.* 2006).

Yoghurt production and consumption are rapidly increasing in Sudan, thus it is important that yoghurt quality, storage and transport instruments and temperature should comply with the Sudanese Standards for consumer protection.

The objective of this study was to evaluate the chemical and microbiological quality of plain set yoghurt from two different factories during storage period.

MATERIALS AND METHODS

Collection of samples

This invstigation was carried out during the period June – December, 2007. Ninety samples of set yoghurt (45 samples from each of two factories: F1 and F2) were collected. Factory 1 (F1) was located in Khartoum North and factory 2 (F2) was located in Khartoum. The samples were collected on the day of manufacture (day 1), transported in ice box and kept at refrigeration temperature (7°C) and analysed at 1, 5 and 10 day intervals.

Chemical analyses

Fat, protein and moisture contents were determined by Gerber method, Kjeldahl method and oven drying method (AOAC 2000), respectively. The solids-non-fat content was obtained by subtracting fat from total solids content. Titratable acidity was determined according to AOAC (2000).

Microbiological examination

Samples were serially diluted using distilled water as a diluent. Pour plate technique was used for *Lactobacillus* and coliform counts by transferring 1 ml from appropriate dilutions and plated in duplicate (Christen *et al.* 1992; Frank *et al*. 1992), while surface plating technique was used for yeasts and moulds by transferring 1 ml (0.3, 0.3, 0.4 ml) from appropriate dilutions into three solified Petri dishes (Frank *et al.* 1992). Violet red bile agar medium was used for coliform bacteria, MRS agar medium for *Lactobacillus* and acidified potato dextrose agar medium for yeasts and moulds. Violet red bile agar plates were incubated at 32°C for 24 hours, MRS agar plates at 37°C for 48 hours and acidified potato dextrose agar plates at 25°C for 5 days. After incubation, typical colones in each Petri-dish were counted using a colony counter. Purification and identification, based on cultural, morphological and biochemical characteristics, were carried out according to Barrow and Feltham (1993).

Statistical analyses

The data were subjected to statistical analysis using Statistical Package for Social Sciences (SPSS, ver. 13). Completely randomized design was used for statistical analysis and means were separated by Duncan's multiple range test at $P \leq 0.05$.

RESULTS AND DISCUSSION

Mean values of chemical composition of yoghurt from the two factories are presented in Table 1. Fat and total solids contents and titratable acidity were significantly higher ($P<0.001$) in F2, while SNF content was higher in F1 and protein content was not significantly different in the two factories. Fat content ranged between 4.19% and 4.88%, and these results

are in accordance with those of Gundogdu *et al.* (2009) who reported fat content of 4.72%-4.75% and higher than those reported by Younus *et al.* (2002), Aly *et al.* (2004) and Ayar *et al.* (2006) who recorded mean values ranging from 2.10% to 3.75%. The protein content was 3.75%-3.76% and this result is in line with the findings of Alkali *et al.* (2008a) who reported values of 3.72%-3.75%, and lower than those of Abd El-Khair (2009) and Gundogdu *et al.* (2009). Solids-non-fat content was 9.69%– 10.08%. The high solids-non-fat content may be due to high protein content in F1. The results of this study are in agreement with the findings of Younus *et al.* (2002) and lower than the results of Haj *et al.* (2007).

Table 1. Chemical composition of plain set yoghurt from two factories (F1 and F2) in Khartoum State

Chemical composition (%)	Factory		G.M.	S.L.
	F1	F2		
Total solids	14.27 ^{b}±0.02	14.57 ^{a}±0.10	14.42±0.05	***
Fat	4.19 ^{b}±0.02	4.88 ^{a}±0.07	4.54±0.05	***
Protein	3.76 ^{a}±0.03	3.75 ^{a}±0.03	3.75±0.02	N.S.
Solids-non-fat	10.08 ^{a}±0.02	9.69 ^{b}±0.05	9.89±0.03	***
Titratable acidity	0.97 ^{b}±0.01	1.27 ^{a}±0.01	1.12±0.01	***

Means within each row bearing the same superscripts are not significantly different ($P>0.05$).
*** = $P<0.001$
N.S. = Not significant
S.L. = Significance level
G.M. = Grand mean

Total solids content was 14.27%–14.57%. These results agree with the findings of Kucukoner and Tarakci (2003) who reported total solids content of 14.58% for plain yoghurt and disagree with those of Abd El Khair (2009) who reported 13.40%. However, total solids content of yoghurts made with additives was higher than the values reported in this study, i.e. additives resulted in increased total solids content (Kucukoner

and Tarakci 2003; Ayar *et al*. 2006; Alkali *et al*. 2008a; Chougrani *et al*. 2009). Titratable acidity ranged between 0.97% and 1.27%. These results are similar to those of Ayar *et al.* (2006) and lower than those reported by Gundogdu *et al.* (2009). The increase in titratable acidity in F2 may be due to high solids-non-fat content which enabled lactic acid bacteria to produce more lactic acid from lactose (Ayar *et a*l. 2006).

No significant difference was found between the two factories in all microorganisms tested (Table 2). Coliform bacterial count was Log_{10} 4.17 cfu/g in F1 and Log_{10} 3.56 cfu/g in F2. The high number of coliform bacteria may be attributed to contamination and poor hygienic conditions during manufacture. According to Sudanese standards (SSMO 2007), a maximum count of 10 cfu/g of coliform bacteria is allowable in yoghurt. The present results are in disagreement with the findings of Kucukoner and Tarakci (2003) and El-Baradei *et al.* (2008) who reported coliform count of Log_{10} <2 cfu/g.

Table 2. Microbiological quality of plain set yoghurt from two factories (F1 and F2) in Khartoum State

Microbial group	Microbial count (log_{10} cfu/g)		G.M.	S.L.
	F1	F2		
L. bulgaricus	9.38 [a]±8.97	9.13 [a]±8.76	9.26±8.74	N.S.
Coliform bacteria	4.17 [a]±3.85	3.56 [a]±2.85	3.87±3.55	N.S.
Yeasts and moulds	5.04 [a]±4.50	4.85 [a]±4.41	4.96±4.31	N.S.

Means within each row bearing the same superscripts are not significantly different (P>0.05).
N.S. = Not significant
S.L. = Significance level
G.M. = Grand mean
cfu = Colony forming unit

Lactobacillus bulgaricus count ranged between Log_{10} 9.13 cfu/g and Log_{10} 9.38 cfu/g. These results are in accordance with those of Ashraf (2006) who reported a count of Log_{10} 9.53 cfu/g for recombined mixed

milk yoghurt, and higher than those reported by Karagul-Yuceer *et al*. (2001), Uysal *et al.* (2003) and El-Baradei *et al.* (2008) who reported counts of as high as Log_{10} 8.20 cfu/g.

Yeasts and moulds count was Log_{10} 5.04 cfu/g in F1 and Log_{10} 4.85 cfu/g in F2. This high count suggests poor hygienic standards during manufacture in both factories. These results are in line with those of El-Makki (2006) who reported yeasts and moulds count of up to Log_{10} 5.42 cfu/g in yoghurt. However, many investigators reported counts far below the values in this investigation (Moreira *et al.* 2001; Kucukoner and Tarakci 2003; Alkali *et al.* 2008b).

Table 3 shows the chemical composition of yoghurt from each of the two factories during storage of 10 days. In F1, the fat content gradually decreased towards the end, while protein, total solids (TS) and titratable acidity increased and solids-non-fat increased till day 5 then slightly decreased. In F2, the fat content and titratable acidity increased, while protein and solids-non-fat contents decreased with time and TS content increased at day 5 then decreased towards the end of storage. The decreasing trend of fat content in F1 is similar to the reports of Haj *et al.* (2007) and Gondogdu *et al.* (2009) who found a decreasing trend of fat during storage. The results of TS, solids-non-fat and protein contents are consistent with the findings of Gundogdu *et al.* (2009). The results of titratable acidity are in agreement with those of Kucukoner and Tarakci (2003) and Yeganehzad *et al.* (2007) who reported that titratable acidity increased with time during storage. However, they are in disagreement with the findings of Haj *et al.* (2007) who reported an increase in titratable acidity till day 2 followed by a decrease till day 8 and an increase towards the end. The increasing trend of titratable acidity may be attributed to the action of lactic acid bacteria on lactose resulting in lactic acid (Alkali *et al.* 2008b).

During storage, coliform bacteria and yeasts and moulds counts increased steadily towards the end, while *Lactobacillus bulgaricus* count decreased (Table 4). The results of coliform count is in accordance with those of Aly *et al.* (2004), who reported increasing trend of coliform bacteria during

storage, but they are in disagreement with those of Vahedi *et al.* (2008). The results of *Lactobacillus bulgaricus* count, in this study, are in line with those of Karagul-Yuceer *et al.* (2001) and inconsistent with the findings of Uysal *et al.* (2003). The decreasing trend of *Lactobacillus bulgaricus* may be due to increased production of lactic acid which inhibited the growth, and eventually death, of bacterial cell. The results of yeasts and moulds count are in line with those of Kucukoner and Tarakci (2003) and Alkali *et al.* (2008b) and disagree with the findings of Vahedi *et al.* (2008).

Table 3. Chemical composition of plain set yoghurt from two factories (F1 and F2) in Khartoum State

Storage period (days)	Total solids (%)	Fat (%)	Protein (%)	Solids-non-fat (%)	Titratable acidity (%)
			F1		
1	14.25^{a}±0.04	4.21^{a}±0.03	3.67^{a}±0.05	10.04^{a}±0.04	0.94^{b}±0.01
5	14.34^{a} ±0.02	4.21^{a}±0.03	3.79^{a}±0.05	10.12^{a}±0.03	0.98^{a}±0.01
10	14.22^{b} ±0.05	4.14^{a}±0.03	3.81^{a} ±0.04	10.08^{a}±0.05	1.00^{a}±0.01
G.M.	14.27±0.0	4.19±0.02	3.76±0.04	10.08±0.02	0.97±0.02
S.L.	N.S	N.S.	N.S.	N.S.	***
			F2		
1	14.54^{a}±0.18	4.81^{a}±0.13	3.79^{a}±0.04	9.73^{a}±.07	1.17^{c}±0.02
5	14.66^{a}±0.22	4.93^{a}±0.14	3.72^{a}±0.05	9.74^{a}±0.10	1.28^{b}±0.02
10	14.51^{a}±0.14	4.91^{a}±0.11	3.75^{a}±0.05	9.60^{a}±0.08	1.37^{a}±0.01
G.M.	14.57±0.05	4.88±0.04	3.75±0.02	9.69±0.05	1.27±0.06
S.L.	N.S.	N.S.	N.S.	N.S.	***

Means within each column bearing the same superscripts are not significantly different (P>0.05).
*** = P<0.001
N.S. = Not significant
S.L. = Significance level
G.M. = Grand mean

Table 4. The microbiological quality of plain set yoghurt from two factories (F1 and F2) in Khartoum State

Storage period (days)	*L. bulgaricus* count (log_{10} cfu/g)	Coliform count (log_{10} cfu/g)	Yeasts and moulds count (log_{10} cfu/g)
		F1	
1	9.75 [a] ±9.42	2.35 [b] ±1.37	3.11 [b] ±2.51
5	8.98 [b] ±8.67	2.85 [b] ±1.91	4.08 [b] ±3.61
10	8.85 [b] ±8.82	4.63 [a] ±4.31	5.50 [a] ±4.92
G.M.	9.19±0.28	3.86±0.69	4.23±0.69
S.L.	***	**	***
		F2	
1	8.36 [ab] ±7.84	1.29 [b] ±0.46	3.03 [b] ±2.73
5	9.57 [a] ±9.22	3.03 [b] ±2.39	3.39 [b] ±2.69
10	7.93 [b] ±7.37	4.00 [a] ±3.20	5.32 [a] ±4.85
G.M.	8.62±0.49	2.77±0.79	3.91±0.71
S.L.	***	***	***

Means within each column bearing the same superscripts are not significantly different (P>0.05).
** = P<0.01
*** = P<0.001
S.L. = Significance level
G.M. = Grand mean
cfu = Colony forming unit

CONCLUSION

The variation in the chemical composition of yoghurt is an indication of the use of different types of milk (cow milk, whole milk powder or skim milk powder) by the two factories for the manufacture of yoghurt. The low microbiological quality of yoghurt indicates contamination and/or unhygienic processing conditions. During the storage, the quality of yoghurt microbiologically deteriorated.

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التقويم النوعي للزبادي متماسك الخثرة المنتج من مصنعين بولاية الخرطوم- السودان

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موجز البحث: أجريت هذه الدراسة لتقويم الزبادي متماسك الخثرة المنتج من مصنعين (F1 و F2) بولاية الخرطوم كيميائيا وميكروبيولوجيا. جمعت تسعون عينة (خمس وأربعون من كل مصنع) واخضعت للتحليل الكيميائي والفحص الميكروبي في اليوم الأول والخامس والعاشر من فترة التخزين. أظهرت النتائج أن محتوي الدهون والجوامد الكلية والحموضة العيارية كانت أعلي في المصنع الثاني، بينما كانت البروتينات والجوامد غير الدهنية أعلي في المصنع الأول. البكتيريا من نوع *Lactobacillus bulgaricus* والبكتيريا القولونيه والخمائر والفطريات كانت أعلي في المصنع الأول. أثناء التخزين زادت نسبة الدهون في المصنع الأول ونقصت في المصنع الثاني، بينما زادت البروتينات في المصنع الأول وسلكت مسارا غير منتظم في المصنع الثاني. زادت الجوامد الكلية والجوامد غير الدهنية حتي اليوم الخامس ومن ثم زادت لنهاية الفترة في المصنعين. أظهرت كل الميكروبات زيادة في العدد حتي نهاية الفترة عدا البكتيريا من نوع *Lactobacillus bulgaricus* حيث زادت حتي اليوم الخامس ونقصت بنهاية فترة التخزين.