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Impact of Fluoridation of Milk on Manufacturing and Properties of Yoghurt

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ABSTRACT

Fluoridation (F) of yoghurt milk (YM) was done by adding sodium fluoride to YM before (treatment A) and after (treatment B) the heat treatment applied on cow's milk . Activity of yoghurt starter culture (YSC) was followed during fermentation by measuring acidity and pH at different intervals up to the complete coagulation. The resultant control (C) and treated yoghurt were analysed when fresh and after 10 days of cold storage (5 ± 1 ^{0} C).The attained results revealed that F had no pronounced impact on YSC, while the differences in acidity, pH, TS, fat and protein contents of the resultant yoghurt due to the applied treatments were slight. Curd syneresis (CS) of C kept for 10 and 30 min at room temperature (30 ± 1 ^{0} C) was higher than the corresponding treated samples, while after 60 and 90 min the differences in CS were slight in fresh samples. The stored samples showed opposite trend of results. F of YM had no obvious impact on hardness, springiness and gumminess of yoghurt. Adhesiveness was higher in C, while the opposite was noticed for cohesiveness.Organoleptically, the fresh treated yoghurt ranked less scores for appearance and firmness while some improvement was recorded during storage of all samples. No adverse impact of F was noticed on flavour attributes.

***Keywords*:** Milk fluoridation, Quality of Yoghurt.

INTRODUCTION

Dental caries , DC (tooth decay) is the progressive dynamic destruction of the teeth via loosing of minerals by means of acid produced by bacteria (e.g. *streptococcus mutans*) on the surface of teeth (Bryans,2006 ; Oshiro *et al.* 2007). Such problem remains a major public health one even in most high income countries since it was reported that it affecting 60-90% of school children and the vast majority of adults (Petersen, 2003 ; Petersen *et al.* 2005).

Consumption of sugar is one of the main aetiological factor for DC both in terms of the amount and frequency of sugar consumed (WHO,2003). However, some of the earliest investigations reviewed by WHO (2009) concluded that milk improved oral health, while many recent studies reviewed by Hofi (2008) demonstrated that milk contains protective factors against DC. The role of calcium and phosphorus in this respect as factors preventing DC and the mechanism of remineralisation action as well as role of milk fat and protein were given- in details -by Rusoff and Konikoff (1975) and Bowen (2002).

Regarding fluoridation as a useful mean for prevention of DC, it was reported that after the successful introduction of water fluoridation, milk was studied in 1950s as another vehicle for fluoride emerged . This was carried out at the same time in Japan, USA and Switzerland (Banoczy and Rugg-Gunn, 2009). However, by the mid - 1980s there was a growing interest for using fluoridated milk (FM) at a community level and during 1990s the international FM programme began to take shape in Russia , China , Chili and the UK (Woodward,2009) . More details on the manufacture of FM in a variety of different forms (Pasteurized,UHT, Serialized and powdered) were given - in details - by villa (2009).

In the present study, FM was prepared and used in making fluoridated yoghurt (FY) since yoghurt is one of the most popular fermented dairy product in Egypt. Studying impact of fluoridation on processing, composition and quality of yoghurt was the objective of the present work.

MATERIALS AND METHODS

Materials:

Fresh cow's milk used in the present study was purchased from milk processing unit belonging to diary department, faculty of agriculture, Cairo university . Sodium fluoride (SF) was also purchased from private pharmaceutical company located in Cairo. Yoghurt starter culture (YSC) consisting of *S.thermophilus* and *L. delbrueckii* ssp. *bulgaricus* in a freeze dried form was also purchased from MIFAD company , Badr city (the local agency of Hansen's lab. , Copenhagen , Denmark) .

Preparation of cf solution:

This was done by dissolving 0.597 gm. SF in 100 ml preboiled distilled water. This stock solution was stored at 5 ± 1 ^{0} C untile use.

Manufacture of yoghurt:

The procedure of Tamime and Robinson (1999) was mainly used for making yoghurt after heat treatment of 90^0 C / 10 min was carried out. Fluoridation treatments were carried out before heat treatment of milk (treatment A) or after cooling the heated milk to 60 ^{0} C (treatment B),

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whereas part of the heated milk was kept without any treatment and served as a control (C). The fluoridation was done by adding 1 ml of the prepared SF solution to 1 L of milk. The control and treated milk samples were cooled to 42 ^{0} C to be ready for adding YSC and fermentation to pH 4.5-4.6 .

Methods of analysis:

Acidity of YSC during fermentation of the control and the treated samples was tested every 30 min by determination of acidity and pH up to the end of fermentation period.

All the fresh and stored (10 days at 5 ± 1 ^{0} C) yoghurt samples were analysed for TS , fat (Gerber method) , protein (TN x 6.38 , Kjeldhal method) ,titratable acidity and pH (using pH meter model HANNA 8417), as described by Ling (1963) . Curd syneresis was measured as described by Mehanna and Mehanna (1989). Texture profile analysis (TPA) of yoghurt samples was done using a Universal Testing Machine (TMS – Pro) equipped with (250 Ibf) load cell and connected to a computer programmed with Texture Pro TM texture analysis software (program, DEVTPA with hold) (Bourne ,1982).

The organoleptic properties were evaluated by 10 panelists using the recommended scoring card given by El-Shibiny *et al*. (1979).

RESULTS AND DISCUSSION

Table (1) shows acidity, pH and gross chemical composition of cow's milk used in the present study, while

Table 1. Acidity (%), pH and gross chemical composition (%) of cow's milk used in making yoghurt. (Average of 3 replicates)

Property	Milk
Acidity	0.17
pH	6.65
Total solids	11.64
Fat	3.32
Protein	3.10
Lactose	4.64

Table (2) reveals acidity and pH measured continuously during milk transformation into yoghurt. Evolution of acidity and pH during fermentation of the control and treated samples showed gradual increase in acidity and decrease in pH starting from acidity values of 0.17, 0.18 and 0.19 % and pH values of 6.65, 6.54 and 6.46 for control and treatments A and B respectively reaching acidity values of 0.53, 0.46, and 0.55 % and pH values of 5.08, 5.29 and 5.09 at 120 min of fermentation in order. This trend of results was noticed up to the end of fermentation.

These results indicate that milk fluoridation before (treatment A) or after (treatment B) the heat treatment applied did not substantially affect the growth and activity of the used lactic acid bacteria (LAB) and subsequently did not cause adverse great impact on development of acidity and pH profile along the fermentation period . This is quite important since it is well - known that lactic acid and other organic acids are produced by metabolic activity of LAB on lactose causing increase in acidity and decrease in pH and consequently milk coagulation. However, such bacteria maintain only some slight activity even at low temperature causing slight increase in acidity and decrease in pH values during cold storage with formation of more flavour components responsible for a good quality yoghurt. In this respect, Tamime and Robinson (1999) mentioned that yoghurt organisms show limited growth activity around 10 ^{0} C and fast cooling around 5 ^{0} C is one of the popular methods used to control the metabolic activity of such bacteria and their enzymes. In the present study, the recorded acidity values of the fresh control yoghurt was 0.73 %, while those of A and B samples were 0.70 and 0.75 % in order (Table3). The corresponding values in the stored samples were 0.82, 0.79 and 0.80 % respectively. The opposite trend was noticed with pH, while in all cases the differences due to fluoridation were slight.

Table 2. Development of acidity,% (1) and pH (2) of milk as affected by fluoridation treatments . (Average of 3 replicates)

Time	Control		A		B	*
(min)	(1)	(2)	(1)	(2)	(1)	(2)
0.0	0.17	6.68	0.18	6.65	0.18	6.66
30	0.30	6.28	0.22	6.18	0.26	6.13
60	0.39	5.74	0.35	5.84	0.37	5.77
90	0.47	5.43	0.41	5.63	0.49	5.41
120	0.53	5.08	0.46	5.22	0.55	5.09
150	0.59	4.95	0.52	5.13	0.58	4.96
180	0.62	4.83	0.57	5.02	0.63	4.83
210	0.65	4.77	0.63	4.83	0.66	4.75
240	0.69	4.65	0.66	4.71	0.68	4.63

***A and B represent carrying out fluoridation of milk before or after the heat treatment applied respectively.**

Table (3) shows also fluoridation of milk as done in A and B had no impact on TS , fat and protein contents of the resultant yoghurt , while the slight changes on storage could be attributed to loss of some moisture since no heat sealing for lids was carried out . Syneresis was reported by Tamime and Robinson (1999) as the most common defect in yoghurt while high minerals content and low acidity were possible causes for such defect. In the present study, fluoridation was done by adding sodium fluoride, while such treatment had slight effect on the acidity of the prepared yoghurt as shown in Table (3).

Table 3. Acidity (%), pH and gross chemical composition (%) of yoghurt as affected by milk fluoridation. (Average of 3 replicates)*

Property	Control		A		B	
	Fresh	Stored	Fresh	Stored	Fresh	Stored
Acidity	0.73	0.82	0.70	0.79	0.75	0.80
pH	4.51	4.40	4.64	4.57	4.53	4.42
TS	11.81	11.94	11.77	11.89	11.80	11.91
Fat	3.67	3.81	3.70	3.80	3.65	3.80
Protein	3.53	3.59	3.52	3.59	3.55	3.58

*** See legend to Table (2) for details.**

Table (4) shows that less curd syneresis (CS) was noticed in A and B treatments comparing to the control (C) since the CS values as gm/15 gm were 8.39 , 7.87 and 8.94 for fresh C , A and B respectively when samples were kept at room temperature (30 ± 1 ^{0} C) for 10 min . The corresponding values at 90 min were 10.21, 10.39 and 10.11 gm / 15 gm in order. Lower values were recorded in the stored samples, while the treated samples suffered from slightly more syneresis .

Table 4. Curd syneresis (g/15g) of fresh and stored yoghurt as affected by the applied fluoridation treatments. (Average of 3 replicates)*

Treatment	Curd syneresis after			
	10 min	30 min	60 min	90 min
Fresh yoghurt				
Control	8.39	9.26	9.73	10.21
A	7.87	9.08	10.16	10.39
B	6.94	8.85	9.72	10.11
Stored yoghurt				
Control	7.20	7.48	7.97	8.16
A	7.83	8.27	8.85	9.05
B	8.59	8.69	9.31	9.50

*** See legend to Table (2) for details.**

Owing to the texture is one of the most important sensorial properties of set-type yoghurt and different factors in the literature affecting it (Vercet *et al*. 2002; Penna *et al*. 2006; Lee and Lucey, 2010; Sendra *et al*. 2010; Hanif *et al.* 2012) , the present study aimed to reveal impact of fluoridation in this respect.

Table(5) reveals slight differences in hardness values between the fresh control yoghurt and the treated samples since the recorded values were 2.6, 2.3 and 2.4 N for the control and treatments A and B respectively. The corresponding values in the stored samples were 2.5, 2.5 and 2.8 N in order. This suggests that fluoridation of milk had no effect on hardness of the resultant yoghurt, while impact of storage agrees with the resultant given by Hanif *et al.* (2012) who mentioned that the firmness of yoghurt was not significantly affected by storage. Adhesiveness of both fresh and stored yoghurt was higher in control yoghurt, while slight differences were recorded between A and B treatments. The opposite was noticed for cohesiveness of fresh samples since the recorded values were 0.385, 0.535 and 0.635 for C, A and B in order.

Springiness seems to be not affected by the applied treatments or storage period since the recorded values were slightly higher than 11.0 mm in all cases. This was also noticed with respect to gumminess since this property had values slightly higher than 1.10 N in the control or the treated fresh and stored yoghurts. The control yoghurt had less chewiness when fresh (10.52 mJ) or after storage (14.33 mJ) than A and B suggesting impact of milk fluoridation on increasing chewiness of the resultant yoghurt.

Table 5. Rheological attributes of fresh and stored yoghurt as affected by the applied treatments.(Average of 3 replicates)*

Property	Control		A		B	
	Fresh	Stored	Fresh	Stored	Fresh	Stored
Hardness (N)	2.60	2.50	2.30	2.50	2.40	2.80
Adhesiveness (mJ)	1.68	1.75	1.39	1.12	1.26	1.12
Cohesiveness (Ratio)	0.385	0.490	0.535	0.50	0.635	0.440
Springiness(mm)	11.93	11.74	11.98	11.73	11.76	11.69
Gumminess (N)	1.15	1.25	1.25	1.25	1.30	1.25
Chewiness (mJ)	10.52	14.33	15.01	14.71	15.51	14.50

*** See legend to Table (2) for details.**

All fresh and stored yoghurt samples were sensually evaluated and the results are shown in Table (6). The fresh control yoghurt got the maximum score for general appearance and firmness, whereas fluoridation of milk slightly decreased the scoring points of the treated yoghurt. This was accompanied by more wheying - off in the treated samples, while the differences in smoothness score were slight. The instrumental measurement (Table 5) showed more values for hardness of fresh control samples which are in agreement with the sensorial evaluation and may be responsible for the recorded more wheying - off in the treated samples . However, a pronounced improvement was noticed in this respect in the stored treated samples since the corresponding scores for most of the prementioned attributes were more than those given for the fresh treated samples. This means more setting and firmness were occurred by cold storage of the treated samples that agrees with more values given for hardness of them as shown in TPA (Table 5).

It may of benefit to note that fluoridation of milk had no adverse impact (Table 6) on flavour of the prepared yoghurt since more than 9 out of 10 points was given for each of the different flavour attributes including acid , bitterness and flat . On the other hand, the control and treated yoghurt were also free- from foreign, unclean and cooked flavours.

Table 6. Sensory evaluation and scoring points given for the fresh and stored yoghurt as affected by the applied treatments. (Average of 10 panelists)*

Property	Fresh yoghurt			Stored yoghurt		
	Control	A	B	Control	A	B
Appearance (10)	8.71	8.32	8.50	8.85	8.41	8.62
Firmness (10)	9.23	8.38	8.98	9.44	8.52	9.29
Smoothness (10)	9.31	9.55	9.27	9.56	9.75	9.42
Wheying - off (10)	9.25	7.81	8.66	9.00	7.77	8.59
Flavour (60)						
Acid (10)	9.38	9.27	9.35	9.44	9.18	9.25
Bitterness (10)	10	10	10	10	10	10
Flat (10)	9.28	9.35	9.25	9.42	9.50	9.37
Foreign (10)	10	10	10	10	10	10
Cooked (10)	10	10	10	10	10	10
Unclean (10)	10	10	10	10	10	10

*** See legend to Table (2) for details.**
- Scores in parenthesis represent the maximum attainable scores.

In general, Villa (2009) in a comprehensive review demonstrated that sodium fluoride was used as a fluoridating agent in the majority of the going international fluoridated milk schemes in different regions of the world. In conclusion consumption of yoghurt is quite important especially for the early ages since calcium is essential for bone and to a lesser extent teeth from one side and from the other side fluoridation besides calcium and phosphorus in yoghurt are protective factors against teeth decay. Such fluoridation could be carried out by adding sodium fluoride before or after the heat treatment applied for yoghurt milk.

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تأثير فلورة اللبن على تصنيع وخواص اليوجورت

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أهتم هذا البحث بدراسة تأثير فلورة اللبن المعد لصناعة اليوجورت ، حيث تم فلورة اللبن البقري باضافة فلوريد الصوديوم قبل المعامله الحرارية للبن (A) وبعدها (B) وقد تم تتبع نشاط بادئ اليوجورت أثناء عملية التخمر وذلك بقياس الحموضة وال pH علي فترات متتالية حتى تمام التجبن . تم تحليل عينات الكنترول والمعاملات طازجة وبعد التخزين المبرد (5 ± 1 ^{0} C) لمدة 10 ايام . وأشارت نتائج التحليل الي انه لا يوجد تاثير ملحوظ نتيجة اضافة الفلور على نشاط بادئ اليوجورت بينما كان تأثيرالأضافة طفيفا على الحموضة وpH و TSوالدهن والمحتوي البروتينى . وسجلت عينات الكنترول الطازجة قيما أعلي في معدل طرد الشرش من مثيلاتها المعاملة بالفلور بعد 10 و 30 ق على درجة حرارة الغرفة (30 ± 1 ^{0} C) بينما بعد 60 و 90 ق كانت الاختلافات في معدلات طرد الشرش طفيفه وسجلت العينات المخزنة نتائج عكسية . كما لم يظهر تاثير واضح لاضافة الفلور على الصلابة (Hardness) و المرونة (Springiness) والصمغية (Gumminess) لليوجورت الناتج بينما كانت قيم الألتصاق (Adhesiveness) أعلي في عينات الكنترول وسجلت العكس بالنسبة لقيم التماسك (Cohesiveness) وأشارت نتائج التقيم الحسي الي انخفاض درجات المظهر والتماسك في المعاملات الطازجة في اليوجورت بينما أظهرت بعض التحسن في الخواص الحسية في العينات المخزنة كما لم يؤثر الفلور المضاف على طعم ونكهة اليوجورت الناتج .