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PREPARATION AND PROPERTIES OF PROBIOTIC FROZEN YOGHURT MADE WITH SWEET POTATO AND PUMPKIN

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ABSTRACT

Low-fat frozen yoghurt was made by using commercial probiotic (*Lactobacillus acidophilus*, *Streptococcus thermophilus* & bifidobacteria) and traditional (*Lactobacillus delbrueckii* ssp. *bulgaricus* & *Streptococcus thermophilus*) starters; as well as; roasted red sweet potato and pumpkin for enhancing nutritional and functional values of this products. The preparing mixes and resulting frozen yoghurt stored at -20ºC for 8 weeks were evaluated for physicochemical, bacteriological and organoleptic properties. The results revealed that, there was significant differences ($p<0.05$) in all properties studied among the mixes and resulting frozen yoghurt. Frozen yoghurt mixes made with traditional yoghurt starter and sweet potato had higher specific gravity, weight per gallon, freezing point and apparent viscosity, but lower in pH values than the mixes made with probiotic starter. Also, resulting frozen yoghurt prepared with traditional starter and sweet potato had higher specific gravity, weight per gallon, freezing time, melting resistance and acetaldehyde content, but lower in overrun % and diacetyl content than that made with probiotic starter. Counts of *Lb. delbrueckii* ssp. *bulgaricus*, *Str. thermophilus* (traditional starter) and *Lb. acidophilus* were the most numerous in pumpkin frozen yoghurt, followed by sweet potato frozen yoghurt. On the other hand, sweet potato frozen yoghurt had higher *Str. thermophilus* & bifidobacteria (probiotic starter) counts, than the other treatments. However, frozen storage for 8 wk was slightly effected on the viable bacterial counts determined of different frozen yoghurt treatments, and bifidobacteria counts were still higher along the storage period than the recommended minimum levels. Also, frozen yoghurt manufactured with probiotic starter; especially with sweet potato; had the highest total organoleptic scores. Therefore, low-fat frozen yoghurt with improved nutritional and functional values, and also good organoleptic properties could be made by traditional yoghurt and probiotic starters; as well as roasted red sweet potato and pumpkin.

Keywords: Probiotic frozen yoghurt; Sweet potato; Pumpkin; Physicochemical properties; Bacteriological properties; Organoleptic properties

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INTRODUCTION

Recently, people have become concerned about the relationship between their health and diet. Lactic acid bacteria (LAB) are attractive to such people because of their potential therapeutic effects **(Inoue *et al* 1998)**. Fermented milks containing probiotic microorganisms are generally considered as functional foods. Their consumption has the potential to improve lactose digestion **(Lourens-Hattingh & Viljoen, 2001)** as well as to modulate immune function and enteric flora. This leads to prevention of some intestinal disorders in humans such as rotavirus gastroenteritis and antibiotic-associated, traveler's and radiation-induced diarrhea. In order to provide health benefits, fermented milks should contain a minimum level of living probiotic bacteria at the use-by date **(Lucas *et al* 2004)**. Assuming a daily consumption of fermented milk equal to 100 g per, a minimum level for probiotic bacteria of 10^6 cfu /g can be suggested in these products according to the daily efficient doses (10^8 cfu) reported by **Vanderhoof & Young (1998)**.

In recent years, consumption of frozen yoghurt has increased drastically because many consumers associate yoghurt with good health **(Hekmat & McMahon, 1992).** Frozen yoghurt, a non-standardized product quite similar to ice cream that is low in fat (4 %). The apparent reason that frozen yoghurt has been preferred over the similarly comprised and prepared ice cream product is that the yoghurt bacteria (*Lactobacillus delbrueckii* ssp. *bulgaricus* and *Streptococcus thermophilus*) are thought by many people to assist in digestion of lactose and to have other health-promoting properties (probiotic effects) **(Marshall *et al* 2003)**.In addition to low-fat formulation, frozen yoghurt supplement with probiotic bacteria, such as *Lactobacillus acidophilus* and *Bifidobacterium longum*, provides additional health benefits. Very limited information has been reported on the effects of probiotic cultures in frozen yoghurt and sensory quality of the product **(Davidson *et al* 2000)**. Frozen yoghurt can serve as an excellent vehicle for dietary incorporation of probiotic bacteria **(Modler *et al* 1990)**.Attempts to provide high numbers of probiotic bacteria, including the genus *Bifidobacterium,* are hampered by the susceptibility of the organisms to low pH and destruction during freezing **(Laroia & Martin, 1991; Hekmat & McMahon, 1992; Ali *et al* 1996**; **Hagen & Narvhus, 1999; Davidson *et al* 2000; Kebary *et al* 2004** and **Taha *et al* 2005).**

Many fruits, vegetable, grains and legumes rich in phytochemicals might be considered "functional" **(Berner & O'Donnell, 1998)**. The sweet potato are recognized as an important dietary supply for human and livestock in various parts of the world, chiefly because of their high carbohydrate; as a good source of energy for the human body (glucose); and an inexpensive source of carotene, ascorbic acid, niacin and thiamin as well as protein **(Edmond & Ammerman, 1971)**. A 130-gm serving provides 320 % of the daily minimum requirements (DMR) for vitamin A, 70 % of the vitamin C and appreciable quantities of thiamine, riboflavin, niacin, phosphorus, iron and calcium. On the other hand, different *Cucurbita* species are known by the same common name, and different names, such as squash and pumpkin, have been used for the same species. *C. pepo* is a highly polymorphic species and grown throughout the world. Fruits of most cucurbits have high moisture content and little nutritional value. Cucurbit fruits with orange or yellow flesh generally have high concentrations of carotenes (e.g. ß–carotene), some of which are the precursors of vitamin A **(Robinson & Decker-Walters, 1997)**. In Egypt, sweet potato and pumpkin are important for local marked and export. The yields are harvested during short period and the price are very low. Frozen yoghurt may contain any of numerous flavouring agents, but it is most often flavoured with fruits **(Marshall *et al* 2003)**. Incorporation of sweet potatoes during the manufacturing of frozen yoghurt **(Ibrahim *et al* 1992)** or ice cream **(Metwally, 1994**) and pumpkin **(Hassan, 2005)** may offer for many benefits such as; to improve the nutritional and functional values as well as organoleptic properties of the resulting product, and also its considerable a cheap source of total solids and sugar.

Therefore, the purposes of the present study were: (a) to attempt to prepare a new type of low-fat frozen yoghurt made with roasted sweet potato or pumpkin and traditional yoghurt starter for enhancing nutritional and functional values of this products, and (b) to evaluate the feasibility of incorporating probiotic starter into these frozen yoghurt in sufficient numbers.

MATERIAL AND METHODS

I. Materials

A. Ingredients

Fresh raw buffaloes' milk was obtained from the herd of the Fac. Agric., Ain Shams Univ., Cairo, Egypt. Milk was skimmed into fresh skim milk and cream for preparation frozen yoghurt mixes. Low heat skimmed cows' milk powder made in Holland and carboxy methyl cellulose (CMC) as a stabilizer were used. Also, raw vanilla, commercial grade cane sugar (sucrose), red sweet potato (*Ipomoea batatas*) (variety, Abeese) and pumpkin (*Cucurbita pepo*) were purchased. Characteristics of the ingredients used in the manufacturing of frozen yoghurt with sweet potato, pumpkin and probiotic starter are presented in **Table (1)**.

B. Source of bacterial starters

Two commercial freeze-dried DVS bacterial starters of B-3 (containing of *Lactobacillus delbrueckii* ssp. *bulgaricus* and *Streptococcus thermophilus*) and ABT-2 (containing of *Lactobacillus acidophilus*, *Streptococcus thermophilus* and bifidobacteria) (Chr. Hansen Laboratory Copenhagen, Denmark) were used in this study. Commercial freeze-dried bacterial starters was prepared as the mother cultures, individually, in autoclaved (121 ºC for 15 min) fresh skim milk (9.6 % TS) before 24 h from using.

II. Methods

A. Preparation of roasted red sweet potato and pumpkin puree

Red sweet potato and pumpkin were washed by a tap water before roasted in the gas stove oven at 180ºC for 45-60 min. The roasted ingredients; individually; were manually peeled, mixed well using a kitchen machine (National, Japan) and stored at -20ºC until used. Characteristics of the roasted red sweet potato and pumpkin puree used in frozen yoghurt manufacture are shown in **Table (1)**.

B. Frozen yoghurt manufacture

Frozen yoghurt mixes were manufactured according to **Gooda *et al* (1993)** and **Marshall *et al* (2003)**. Mixes composition and formulations are shown in **Tables (2) and (3)**, respectively. The mixes were divided into 3 parts; the first part was served as a control (vanilla as flavouring agent). Roasted red sweet potato and pumpkin puree were added, individually, to the other two parts. The ingredients of 3 mixes were divided into 2 portions (A and B), sucrose was added to the first portion (A). Each mix was extensively homogenized at 55-60°C using X 520, UAC 30-R, Chicago II 6064 (30000 rpm/min^{-1}) homogenizer. Mixes were heated to 85ºC for 15 min, then portions (A) rapidly cooled and aged at 5 ±1 ºC for 24 h. On the other hand, the second portions (B) (without sucrose) were cooled to 42 or 39 ±1ºC for inoculating with 3 % of B-3 or ABT-2 starter cultures, respectively, then incubated until clotting (~ 4 h) and cooled at 5 ºC. The fermented portions (B) were combined and mixed well with the aged portions (A), individually, before frozen in the horizontal batch freezer Taylor Co., USA and freezing time min was recorded. Also, vanilla was added to the control mixes. The frozen fermented products were packaged into 120 cc plastic cups and hardened at - 20ºC for 8 wk.

C. Frozen yoghurt sampling

Frozen yoghurt mixes samples were taken after combined portions (A) with (B) and before frozen to determine the different properties. The resulting frozen yoghurt samples were assessed for chemical, bacteriological and organoleptic properties after 24 h from the hardening. Also, samples of frozen yoghurt were evaluated after 2, 4, 6 and 8 wk of hardening for bacteriological analysis.

D. Analysis of roasted red sweet potato and pumpkin puree

Roasted red sweet potato and pumpkin puree were chemically analyzed for pH values (using Beckman pH meter type 7010), total solids, total nitrogen (using micro-Kjeldahal method), ash, carbohydrate and fiber contents according to the methods described by **Nielsen (1998)**.

E. Physicochemical analysis of frozen yoghurt

The total solids, total nitrogen (using micro-Kjeldahal method), ash, carbohydrate and fat (using Gerber method) contents; as well as pH values (using Beckman pH meter type 7010) in fresh skim milk and cream were determined according to the methods of **AOAC (1990)**. Also, the pH values of all frozen yoghurt mixes were measured. Specific gravity and weight per gallon (Kg) **(Arbuckle, 1986)** were examined in the mixes and resulting frozen yoghurt. Also, freezing points (ºC) in mixes was determined **(Ling, 1963 & Nielsen 1998)**.Viscosity of mixes using the coaxial rotational viscometer (Rheotest, type RV2, Medingen, Germany) was measured at shear rates ranging from 1.000 to 437.40 s^{-1}. Shear stress values were done using device (S2) and samples adjusted to 20 ±1ºC before loading in the viscometer device. Apparent viscosity (Cp) was calculated at shear

Table1. Characteristics[1] (%) of ingredients used in frozen yoghurt manufacture

Ingredients	Total solids	Fat	Protein	Ash	Carbohydrate	Fiber	pH
Fresh skim milk	9.60 ± 0.10	0.10 ± 0.06	4.22[2] ± 0.08	0.85 ± 0.05	4.90 ± 0.10	ND	6.60 ± 0.05
Fresh cream	55.40 ± 0.25	50.00 ± 0.08	1.88[2] ± 0.03	0.39 ± 0.02	2.31 ± 0.03	ND	6.60 ± 0.05
Skim milk powder	96.00 ± 0.05	0.99 ± 0.02	37.13[2] ± 0.06	7.89 ± 0.10	47.43 ± 0.81	ND	6.40 ± 0.06
Roasted sweet potato puree	31.19 ± 0.50	ND[3]	1.90[4] ± 0.11	1.20 ± 0.12	25.94 ± 0.55	1.01 ± 0.05	5.70 ± 0.10
Roasted pumpkin puree	10.33 ± 0.31	ND	1.21[4] ± 0.10	0.56 ± 0.11	6.93 ± 0.40	1.55 ± 0.10	5.00 ± 0.20

[1]: Values are means of triplicate determinations.
[2]: Protein % = N × 6.38.
[3]: ND: Not determined.
[4]: Protein % = N × 4.38.

Table 2. Frozen yoghurt mixes composition (%)

Mixes composition	Control mix	Sweet potato mix	Pumpkin mix
Milk solids not fat	11.0	8.0	8.0
Milk fat	4.0	4.0	4.0
Sucrose	16.0	12.0	16.0
Carboxy methyl cellulose	0.2	0.2	0.2
Starter	3.0	3.0	3.0
Vanilla	0.01	-	-
Roasted sweet potato puree	-	25.0	-
Roasted pumpkin puree	-	-	25.0
Total solids	31.28± 0.50	32.04 ± 0.20	30.83 ± 0.80

Table 3. Frozen yoghurt mix formulations (g / 5 Kg mix)

Ingredients	Control mix	Sweet potato mix	Pumpkin mix
Fresh skim milk	3445.0	2454.0	2231.5
Fresh cream	400.0	400.0	400.0
Skim milk powder	194.5	136.0	158.5
Sucrose	800.0	600.0	800.0
Carboxy methyl cellulose	10.0	10.0	10.0
Starter	150.0	150.0	150.0
Vanilla	0.5	-	-
Roasted sweet potato puree	-	1250.0	-
Roasted pumpkin puree	-	-	1250.0
Total	5000.0	5000.0	5000.0

rate of 437.40 s^{-1}. Also, the resulting frozen yoghurt were analyzed for overrun and meltdown test (loss % at 23 ± 1ºC after 30, 60 and 90 min) **(Elhami *et al* 1977** & **Arbuckle, 1986)**. Acetaldehyde and diacetyl (µmol/ml) contents were determined in the resulting frozen yoghurt according to **Lees & Jago (1969) and (1970),** respectively.

F. Bacteriological analysis of frozen yoghurt

Samples of all frozen yoghurt were prepared for bacteriological analysis according to the method described in the Standard Methods for the Examination of Dairy Products **(Wehr & Frank, 2004)**.Viable counts of *Lactobacillus delbrueckii* ssp. *bulgaricus* on MRS agar (pH 5.2) (Anaerobic incubation at 45 ºC for 72 h), *Lactobacillus acidophilus* on MRS-sorbitol agar (Anaerobic incubation at 37 ºC for 72 h), *Streptococcus thermophilus* on ST agar (Aerobic incubation at 37 ºC for 24 h) and bifidobacteria on MRS agar (Oxoid) supplemented with L-cystein and lithium chloride (Sigma Chemical CO.,USA) (Anaerobic incubation at 37 ºC for 72 h) were enumerated. The plates were incubated in an anaerobic environment (BBL Gas Pak, Becton Dickinson Microbiology Systems).The enumeration protocols the same as those reported by **Dave and Shah (1996)**. The results expressed as $\log_{10}$ colony forming unit (cfu)/ml.

G. Organoleptic assessment of frozen yoghurt

The organoleptic properties of frozen yoghurt made with sweet potatoes, pumpkin and probiotic starter were evaluated by 10 staff members of the Food Sci. Dept., Fac. Agric., Ain Shams Univ., according to the score card of **Marshall *et al* (2003)**. The organoleptic score card used consisted of flavour (50 points), body & texture (30 points), melting property (10 points) and colour & appearance (10 points).

H. Statistical analysis

The experimental data were analyzed using the general linear models procedure of the Statistical Analysis System **(SAS, 1996)**. Significance of differences was defined at $p < 0.05$.

RESULTS AND DISCUSSION

Physicochemical properties of frozen yoghurt mixes

Physicochemical properties of frozen yoghurt mixes made with probiotic and traditional starters, as well as sweet potato and pumpkin are presented in **Table (4)**. There were significant differences ($p<0.05$) in the physicochemical properties between mixes manufactured with probiotic (ABT-2) or traditional (B-3) starters in side, and vanilla (control), sweet potato or pumpkin on the other side. The results revealed that, frozen yoghurt mixes made with traditional starter (*Lb. delbrueckii* ssp. *bulgaricus* & *Str. thermophilus*) had higher specific gravity , weight per gallon, freezing point and apparent viscosity, but lower pH values, than that made with probiotic starter (*Lb. acidophilus*, *Str. thermophilus* & bifidobacteria). This differences in these values between probiotic and traditional mixes, could be due to the difference in starter used. On the other hand, mixes prepared with sweet potato had the highest values of specific gravity, weight per gallon, freezing point and apparent viscosity, followed by pumpkin and control mixes, respectively. The higher values of the sweet potato mixes, might be due to sweet potato used. Pumpkin mixes showed the lowest pH values. Also, it could be noticed that the specific gravity of all mixes was closely related to their weight per gallon **(Hussein &Yasin, 2005)**.

These results agree with those reported by **Mostafa *et al* (2001)** and **El-Kholy *et al* (2004)**, who mentioned that the acidity, specific gravity and weight per gallon of frozen yoghurt mixes made with the traditional starter were slightly increased as fruits solids increased in the mix or using low pH culture. Also, they noticed that the viscosity was increased when using low pH culture, this could be due to attributed to the high water holding capacity of yoghurt culture at low pH, which bound some free water and accordingly increase the mix viscosity. **Ali *et al* (1996)** reported that the pH value and freezing point were lower, while specific gravity was higher of frozen yoghurt mix made with yoghurt starter than the other fermented mixes made with single or mixed starter cultures of *Lb. acidophilus*, *Lb. casei*, *Str. thermophilus* & *Bif. bifidum*. Moreover, **El-Nagar & Kuri, (2001)** found that the viscosity was increased in the low fat frozen yoghurt mixes made with various concentrations of soluble fibers (inulin), may be due to the interactions of the fiber and liquid components in the mixes. In supplementary, **Arbuckle, (1986)** mentioned that the freezing point of an ice cream mix is highly dependent on the kind of sweetener added to the mix, and the low molecular weight glucose and fructose decrease the freezing point more than sucrose. Sweet potato roots are containing

Table 4. Physicochemical properties[1] of frozen yoghurt mixes made with probiotic and traditional starters, as well as sweet potato and pumpkin

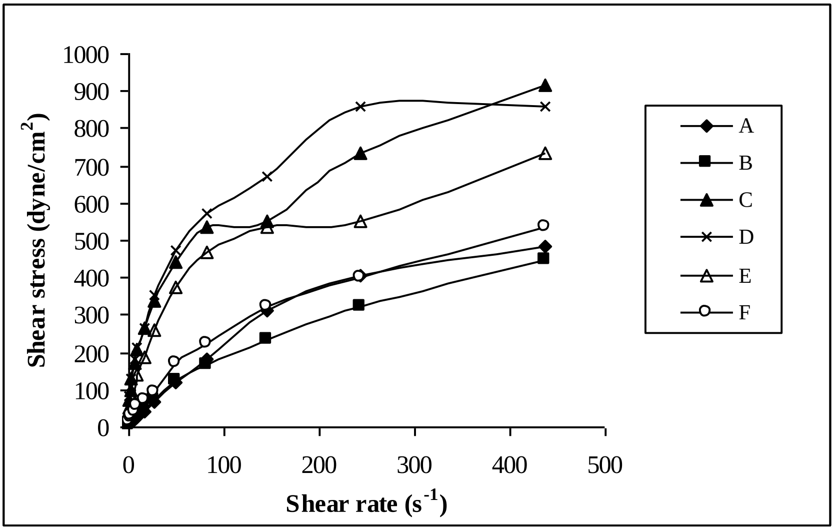
Frozen yoghurt mixes properties	Control mixes		Sweet potato mixes		Pumpkin mixes	
	B-3 [2]	ABT-2 [3]	B-3	ABT-2	B-3	ABT-2
pH values	4.80	5.35	4.70	5.00	4.60	4.90
Specific gravity	1.0759	1.0557	1.1614	1.1190	1.1259	1.0680
Weight per gallon (Kg)	4.0721	3.9961	4.3961	4.2089	4.2618	4.0426
Freezing point (ºC)	- 2.7	-2.6	- 3.1	- 3.0	- 2.9	- 2.8
Apparent viscosity (Cp)	110.73	102.10	209.88	195.88	167.90	122.23

[1]: Values are means of triplicate determinations.
[2]: Bacterial starter containing of *Lb. delbrueckii* ssp. *bulgaricus* & *Str. thermophilus*.
[3]: Bacterial starter containing of *Lb. acidophilus, Str. thermophilus* & bifidobacteria.

of abundant quantities of glucose **(Edmond & Ammerman, 1971)**. On the other hand, reducing sugars (e.g. glucose and fructose) are primarily produced in young pumpkin fruits, with the percentage of sucrose produced increasing with fruit maturity **(Robinson & Decker-Walters, 1997). Marshall *et al* (2003)** reported that low pH leads to high viscosity of mix and an ice cream mix viscosity is greatly influenced by the mix composition. However, **Ibrahim *et al* (1992), Metwally, (1994)** and **Hassan (2005)** mentioned that the addition of sweet potato or pumpkin to ice cream mixes, increased its acidity, specific gravity, weight per gallon, freezing point and apparent viscosity.

Flow behaviour of frozen yoghurt mixes

Flow behaviour (shear stress / shear rate curve) of frozen yoghurt mixes made with probiotic and traditional starters, as well as sweet potato and pumpkin is illustrated in **Fig. (1)**. There were significant differences ($p<0.05$) in the flow behaviour among probiotic or traditional starters mixes in side, and vanilla (control), sweet potato or pumpkin mixes on the other side. It could be seen, that the relationship between shear stress and shear rate was non-liner in all mixes. Also, a strong relationship among the flow behaviour and both type of starter in site and type of ingredient used in the other site. Preparation of frozen yoghurt mixes with probiotic starter resulting in the downward shifting of the flow curve as compared with traditional starter mixes. This decrease in flow curve indicated that there was decrease in viscosity of mixes prepared with probiotic starter **(Hussein &Yasin, 2005)**.On the other hand, the sweet potato mixes showed the highest upward shifting of the flow curve, followed by pumpkin and control mixes. **Ali *et al* (1996)** reported that the hysteretic



A: Frozen yoghurt made with traditional starter (Control).
B: Frozen yoghurt made with probiotic starter (Control).
C: Frozen yoghurt made with traditional starter and sweet potato.
D: Frozen yoghurt made with probiotic starter and sweet potato.
E: Frozen yoghurt made with traditional starter and pumpkin.
F: Frozen yoghurt made with probiotic starter and pumpkin.

Fig. 1. Flow behaviour of frozen yoghurt mixes made with probiotic and traditional starters, as well as sweet potato and pumpkin

behaviour of mixes made with cultures (1:1:1) of *Lb. acidophilus*, *Str. thermophilus* and *Bif. bifidum* seemed to be non-Newtonian dilatants fluids.

Properties of frozen yoghurt

The specific gravity, weight per gallon, overrun %, freezing time, meltdown %, acetaldehyde and diacetyl contents of frozen yoghurt made with probiotic and traditional starters, as well as sweet potato and pumpkin are shown in **Table (5)**. Significant differences ($p<0.05$) in these properties were found among resulting frozen yoghurt made with probiotic (*Lb. acidophilus*, *Str. thermophilus* & bifidobacteria) and traditional (*Lb. delbrueckii* ssp. *bulgaricus* & *Str. thermophilus*) starters, as well as sweet potato and pumpkin. Frozen yoghurt made with traditional starter (B-3) had higher specific gravity, weight per gallon, freezing time, melting resistance (low melting ability) and acetaldehyde content, but lower overrun % and diacetyl content than that made

Table 5. Properties[1] of frozen yoghurt made with probiotic and traditional starters, as well as sweet potato and pumpkin

Frozen yoghurt properties	Control		Sweet potato		Pumpkin	
	B-3[2]	ABT-2[3]	B-3	ABT-2	B-3	ABT-2
Specific gravity	0.7969	0.7706	0.9519	0.9024	0.8661	0.8090
Weight per gallon (Kg)	3.0164	2.9169	3.6034	3.3943	3.2783	3.0626
Overrun (%)	35.02	37.05	22.13	24.05	30.10	32.00
Freezing time(min)	13.0	12.8	15.5	15.0	13.8	13.5
Melting resistance						
Loss % after : 30 min	23.25	25.00	18.55	20.85	22.00	22.35
60 min	48.20	50.50	33.95	38.60	47.55	47.95
90 min	28.10	24.00	45.59	38.58	29.35	29.00
Acetaldehyde (μmol/ml)	164.27	121.37	257.70	124.29	251.07	162.69
Diacety (μmol/ml)	8.199	13.363	9.097	15.817	9.148	13.808

[1]: Values are means of triplicate determinations.
[2]: Bacterial starter containing of *Lb. delbrueckii* ssp. *bulgaricus* & *Str. thermophilus*.
[3]: Bacterial starter containing of *Lb. acidophilus, Str. thermophilus* & bifidobacteria.

with probiotic starter. On the other side, frozen yoghurt prepared with sweet potato had the highest values of specific gravity, weight per gallon, freezing time and melting resistance, followed by pumpkin and control frozen yoghurt, respectively. Moreover, the overrun % of the frozen yoghurt made with sweet potato were the lowest. The acetaldehyde and diacetyl contents of sweet potato frozen yoghurt were the highest, when manufactured by traditional and probiotic starters, respectively. This increase in freezing time could be due to the decrease in the freezing point of the traditional starter and sweet potato mixes **(Hussein &Yasin, 2005)**. Also, the specific gravity, weight per gallon and freezing time depend on the formula compounds; as well as the ability to hold air pulps in the resulting frozen yoghurt. However, the differences in melting resistance are mainly due to the differences in the freezing points of the mixes.

The highest overrun and least melting resistance was recorded for the frozen yoghurt containing mixed cultures (1:1:1) of *Lb. acidophilus*, *Str. thermophilus* and *Bif. bifidum* **(Ali *et al* 1996)**. Also, in general, as the viscosity increases, the resistance to melting and the smoothness of texture increase, but the whipping decrease. The freezing time preceded, the overrun of mix decreased **(Marshall *et al* 2003).** However, a high acidity contributes to excess mix viscosity and decreased the overrun **(Arbuckle, 1986)**. **EL-Sadek *et al* (1972)** mentioned that the different species of lactobacilli studied were able to produce variable amounts of acetaldehyde; which is an important flavour component in Zabady; but not diacetyl**.** Also, *Lb. delbrueckii* ssp. *bulgaricus* gave distinctly higher values than *Str. thermophilus***. El-Kholy *et al* (2004)** reported that decreasing the pH of yoghurt culture improved the melting resistance of the resultant frozen yoghurt**.** Also, **El-Nagar & Kuri (2001)** found that preparation frozen yoghurt with soluble fibers (inulin) resulted in reduced melting rates, this effect may be due to formed stable gel networks and act as a stabilizer for binding water. However, **Ibrahim *et al* (1992), Metwally (1994**) and **Hassan (2005)** mentioned that the addition of sweet potato or pumpkin to ice cream mixes, increased the specific gravity, weight per gallon, improved viscosity but decreased whipping ability as compared with control.

Bacteriological properties of frozen yoghurt

Viable bacterial counts (log_{10}cfu / ml) of frozen yoghurt made with probiotic and traditional starters, as well as sweet potato and pumpkin during storage at -20ºC for 8 wk are shown in **Table (6)**. Significant differences (p<0.05) in log bacterial counts were found among resulting frozen yoghurt made with probiotic (ABT-2, *Lb. acidophilus*, *Str. thermophilus* & bifidobacteria) and traditional (B-3, *Lb. delbrueckii* ssp. *bulgaricus* & *Str. thermophilus*) starters, as well as sweet potato and pumpkin. Initial log counts of *Lb. delbrueckii* ssp. *bulgaricus* and *Str. thermophilus* (traditional starter) were the most numerous in pumpkin frozen yoghurt, followed by sweet potato and control frozen yoghurt. On the other hand, pumpkin frozen yoghurt made with probiotic starter had the highest initial log counts of *Lb. acidophilus*. But, sweet potato frozen yoghurt had higher initial log *Str. thermophilus* & bifidobacteria (probiotic starter) counts, than the other treatments. High log counts of bacterial determined in sweet potato and pumpkin frozen yoghurt, could be due to its stimulation effects of glucose and fructose from sweet potato and pumpkin on the growth of these bacteria **(El-Kholy *et al* 2004)**. However, frozen storage for 8 wk was slightly effected on the viable bacterial counts determined of different frozen yoghurt treatments. Results also indicated that the viable counts of bifidobacteria in all treatments were still higher along the storage period than the recommended minimum levels (10^6 cfu /ml).

Lourens-Hattingh & Viljoen (2001) mentioned that the streptococci are inhibited at pH values of 4.2-4.4,whereas lactobacilli tolerate pH values in the range of 3.5-3.8. After ~3 h of fermentation, the numbers of the two organisms should be equal. With longer fermentation, the growth rate of *Str. thermophilus* declines while *Lb. delbrueckii* ssp. *bulgaricus* continues to reduce the pH by producing excessive amounts of lactic acid. Also, *Lb. acidophilus* survived well at pH 3.0 or above and the viable counts remained above 10^7 cfu/ml after 3 h incubation. Overall, most strains of bifidobacteria are sensitive to pH values below 4.6.This can be prevented by using ABT-yoghurt starter cultures. Moreover, **Thompson & Mistry, (1994)** found that no significant decrease in *Lb. delbrueckii* ssp. *bulgaricus* and *Str. thermophilus* numbers of frozen yoghurt, when stored 3 mo at -18ºC. **Lopez *et al* (1998)** observed only

Table 6. Bacteriological properties of frozen yoghurt made with probiotic and traditional starters, as well as sweet potato and pumpkin during storage at -20ºC for 8 weeks

Frozen yoghurt	Viable counts (log_{10} cfu[1]/ml) Storage period (weeks) 0	2	4	6	8
B-3[2]	*Lb. delbrueckii* ssp. *bulgaricus*				
Control	7.09	7.00	7.00	6.95	6.95
Sweet potato	8.10	7.90	7.95	7.90	7.83
Pumpkin	8.53	8.35	8.30	8.30	8.35
	Streptococcus thermophilus				
Control	6.98	6.98	6.95	6.91	6.90
Sweet potato	7.35	7.40	7.40	7.30	7.25
Pumpkin	7.87	7.80	7.75	7.70	7.70
ABT-2[3]	*Lactobacilus acidophilus*				
Control	8.37	8.75	8.73	8.70	8.71
Sweet potato	8.55	8.85	8.80	8.75	8.70
Pumpkin	8.83	8.89	8.88	8.85	8.80
	Streptococcus thermophilus				
Control	7.85	7.83	7.82	7.82	7.80
Sweet potato	8.65	8.65	8.55	8.33	8.75
Pumpkin	8.33	8.55	8.58	8.03	8.00
	Bifidobacteria				
Control	7.05	6.90	6.93	6.907.	6.85
Sweet potato	7.89	7.85	7.85	80	7.78
Pumpkin	7.27	7.23	7.15	7.01	7.00

[1]: Colony forming unit.
[2]: Bacterial starter containing of *Lb. delbrueckii* ssp. *bulgaricus* & *Str. thermophilus*.
[3]: Bacterial starter containing of *Lb. acidophilus*, *Str. thermophilus* & bifidobacteria.

a slight decline in lactic acid bacteria in three batches (pH = 4.32, 5.09 and 5.53) of commercial frozen yoghurt stored at -23ºC for 1 yr, and the total LAB in the three batches was $>10^7$ cfu/g. Also, **Baig & Prasad (1995)** reported in frozen yoghurt, a 1 $\log_{10}$ cfu/ml reduction in *Str. thermophilus*, *Lb. delbrueckii* ssp. *bulgaricus* and *Bif. bifidum* during a 90-d storage period at -20ºC. However, **Hekmat & McMahon (1992)** found that *Lb. acidophilus*, inoculated in a standard ice cream mix and allowed to ferment, exhibited a 2 $\log_{10}$ cfu/ml decrease, and also a 1 $\log_{10}$ cfu/ml loss in *Bif. longum* cells in strawberry-flavoured frozen yoghurt when stored at -29ºC for 17 wk. Moreover, **Modler *et al* (1990)** found that approximately 90 % survival of bifidobacteria in frozen yoghurt during the 70 d storage period. **Holcomb *et al* (1991)** observed no evidence of freeze injury to *Lb. acidophilus* and *Bif. longum* in frozen yoghurt when exposed to -5ºC for 6 h. Also, **Laroia & Martin (1991)** reported that numbers in the millions per ml in frozen fermented dairy desserts with pH 5.6-5.8 of both *Bif. bifidum* and *Lb. acidophilus* survived even after 8 wk of frozen storage. However, **Ordonez *et al* (2000)** mentioned that the *Lb. acidophilus*, *Bif. bifidum* and a mixed yogurt culture were stable in frozen yogurt made with ultrafiltered milk during six weeks of frozen storage.

Organoleptic properties of frozen yoghurt

Sensory evaluations of frozen yoghurt made with sweet probiotic and traditional starters, as well as sweet potato and pumpkin are presented in **Table (7)**. The sensory panel found differences ($p<0.05$) for among the treatments when scoring the samples for flavour, body & texture, melting property and colour & appearance. The results indicated that the frozen yoghurt made with probiotic (*Lb. acidophilus*, *Str. thermophilus* & bifidobacteria) starter ranked superior in the total score, than with traditional (*Lb. delbrueckii* ssp. *bulgaricus* & *Str. thermophilus*) starter. Frozen yoghurt manufactured with traditional starter (control) had the lowest total organoleptic scores, due to pronounce acidity taste. On the other hand, frozen yoghurt prepared with sweet potato and probiotic starter had the highest total organoleptic scores. Also, smooth texture was found in frozen yoghurt prepared with sweet potato. Minor stickiness in the texture and light golden yellow in the colour was found of frozen yoghurt prepared with sweet potato. Pumpkin frozen yoghurt prepared with probiotic starter had higher melting property, than the sweet potato frozen yoghurt. In contrast, the colour & appearance of frozen yoghurt made with pumpkin were the lowest, due to slightly dull colour.

Our results are in agreement with those obtained by **Marshall *et al* (2003),** who reported that the high acidity leads to smoothness of texture and off-flavours. Also, **Hekmat & McMahon (1992)**, **Gooda *et al* (1993), Inoue *et al* (1998)** and **El-Kholy *et al* (2004)** reported that a good organoleptic properties of plain, flavoured or probiotic frozen yoghurt was attained by fermenting the standardized milk to pH 5.5-6.0. However, **Speck & Hansen (1983)** found that the highest overall quality evaluation were obtained in frozen yoghurt with a final pH of 5.17. Moreover, the balance of flavouring systems may be significantly affected by

Table 7. Organoleptic properties of frozen yoghurt made with sweet probiotic and traditional starters, as well as sweet potato and pumpkin

Frozen yoghurt properties	Control mixes		Sweet potato mixes		Pumpkin mixes	
	B-3[1]	ABT-2[2]	B-3	ABT-2	B-3	ABT-2
Flavour (50)	43.7	49.7	48.0	49.5	46.3	49.7
Body & texture (30)	27.5	29.1	28.3	29.3	28.1	29.1
Melting property (10)	9.0	9.5	8.7	9.0	9.1	9.5
Colour & appearance (10)	9.0	9.0	9.0	9.5	8.5	8.5
Total score (100)	89.2	97.3	94.0	97.3	92.0	96.8

[1]: Bacterial starter containing of *Lb. delbrueckii* ssp. *bulgaricus* & *Str. thermophilus*.
[2]: Bacterial starter containing of *Lb. acidophilus*, *Str. thermophilus* & bifidobacteria.

varying levels of organic compounds **(Davidson *et al* 2000).** Milder flavour and aroma found in yoghurt with bifidobacteria **(Laroia & Martin 1991).** Also, the preferred was that made with a starter culture containing *Lb. acidophilus, Str. thermophilus* and *Bif. bifidum* **(Ali *et al* 1996)**. **Ordonez *et al* (2000)** mentioned that a good flavor and textural quality of frozen yogurt made with ultrafiltered milk fermented with *Lb. acidophilus, Bif. bifidum* and a mixed yogurt culture. **Ibrahim *et al* (1992)**, **Metwally, (1994)** and **Hassan (2005)** mentioned that the addition of sweet potato or pumpkin to ice cream mixes, improved the texture.

Finally, one can say that, low-fat frozen yoghurt with improved nutritional and functional values, and also acceptable organoleptic properties could be made by traditional and probiotic starters; as well as roasted red sweet potato and pumpkin.

REFRENCES

Ali, A.A.; A.I. Metwally and Nayra S. Mehanna (1996). Manufacture of frozen fermented dairy products containing probiotic bacteria. ***Pro.2nd Int. Conf. on Food Sci. & Tech., 17-19 September,*** **pp. 169-186.** ***Cairo.***

AOAC, (1990). ***Official Methods of Analysis*** **(15th Ed.), pp. 840-850**. Association Official Analytical Chemists. Arlington VA, USA.

Arbuckle, W.S. (ed.) (1986). In: ***Ice Cream*****. (4th Ed.), pp. 20-369.** The AVI Pub. Co., Inc., Westport, USA.

Baig, M.I. and V. Prasad (1995). Biochemical characteristics and stability of *Bifidobacterium bifidum* in frozen yoghurt supplemented with condensed cheese whey. ***J. Dairy Foods Home Sci., 15: 99-108.***

Berner, L.A. and J.A. O'Donnell (1998). Functional foods and health claims legislation: Applications to dairy foods. ***Int. Dairy J.*** **8: 355-362.**

Dave, R.I. and N.P. Shah (1996). Evaluation of media for selective enumeration of *Streptococcus thermophilus*, *Lactobacillus delbrueckii* spp. *bulgaricus*, *Lactobacillus acidophilus* and bifidobacteria**.** ***J. Dairy Sci.,*** **79(9): 1529-1536.**

Davidson, R.H.; S.E. Duncan; C.R. Hackney; W.N. Eigel and J.W. Boling (2000). Probiotic culture survival and implications in fermented frozen yoghurt characteristics. ***J. Dairy Sci.*** **83(4):666-673.**

Edmond, J.B. and G.R. Ammerman (eds.) (1971). In: ***Sweet Potatoes: Production, Processing, Marketing. Major Feed and Food Crops in Agriculture and Food Series.*****pp. 33-40 & 264**. The AVI Publishing Company, INC., Westport, Connecticut.

Elhami, M.; M.Y. Khalifa; M.S. El-Safty and A.A. Nofal (1977). Use of margarine in ice cream making. ***Egyptian J. Dairy Sci.*** **5(2): 143-150.**

El-Kholy, Amira M.; A. Gouda; A.A. Mohamed and Waffaa A.G. Ali (2004). Technological aspects to improve frozen yoghurt quality. ***Egyptian J. Dairy Sci.*** **32(1): 99-110.**

El-Nagar, G.F. and V. Kuri (2001). Rheological quality and stability of yog-ice cream with added fibers. ***Pro. 8th Egyptian Conf. for Dairy Sci. & Tech., 3-5 November, Cairo, pp.*** **525-536.**

EL-Sadek, G.M.; K. Naguib and A. Negm (1972). Acetaldehyde and diacetyl production in Zabady and Zabady cultures. **Milchwissenschaft 27(12): 756-758.**

Gooda, E.; I.A. Attia; S.A. Salem and M.S. Kamar (1993). Studies on frozen yoghurt.1.Manufacturing method. ***Egyptian J. Food Sci.*** **2(1): 157-66.**

Hagen, M. and J.A. Narvhus (1999). Production of ice cream containing probiotic bacteria. **Milchwissenschaft 54(5): 265-268.**

Hassan, Z.M.R. (2005). Potential healthy functional ice cream manufacture with pumpkin fruit *Cucurbita pepo***.** ***Annals Agric. Sci., Ain Shams Univ., Cairo*** **50(1): 161-168.**

Hekmat, S. and D.J. McMahon (1992). Survival of *Lactobacillus acidophilus* and *Bifidobacterium bifidum* in ice cream for use as a probiotic food. ***J. Dairy Sci.*** **75 (6): 1415-1422.**

Holcomb, J.E.; J.F. Frank and J.U. McGregor (1991). Viability of *Lactobacillus acidophilus* and *Bifidobacterium bifidum* in soft-serve frozen yoghurt. ***Cult. Dairy Prod. J.*** **26(4): 4-5.**

Hussein, Gehan A.M. and Nessrien M.N. Yasin (2005). Characteristics of extracted peanut oil and impact of its use in partial replacement of milk fat on the quality of ice cream. ***Egyptian J. Dairy Sci.,*** **33(2): 279-293.**

Ibrahim, M.K.E.; M.M. El-Abd; A.M. Mehriz and F.A.M. Ramadan (1992). Effect of some stabilizers and sweetening materials on the properties of a new ice cream like yoghurt. ***Egyptian J. Dairy Sci.,*** **20(1): 67-81.**

Inoue, K.; K. Shiota and T. Ito (1998). Preparation and properties of ice cream type frozen yoghurt. ***Int. J. Dairy Technol.,*** **51(2): 44-50.**

Kebary, K.M.K.; A.I. Hamed; O.M. Salem and E.T.A. Yousef (2004). Impact of frozen yoghurt ingredients on its quality and survival of bifidobacteria.1.Effect of sweeteners. ***Pro. 9th Egyptian Conf. for Dairy Sci. & Tech. "Milk and Dairy Products for a Healthy Future"*****, pp. 165-180.** ***9-11 October, Cairo*****.**

Laroia, S. and J.H. Martin (1991). Effect of pH on survival of *Bifidobacterium bifidum* and *Lactobacillus acidophilus* in frozen fermented dairy desserts. ***Cult. Dairy Prod. J.*** **26(4): 13-21.**

Lees, G.J. and G.B. Jago (1969). Methods for the estimation of acetaldehyde in cultured dairy products. ***Aust. J. Dairy Technol.*** **24: 181-185**.

Lees, G.J. and G.B. Jago (1970). The estimation of diacetyl in the presence of the carbonyl compounds. ***J. Dairy Res.*** **37: 129- 132.**

Ling, E.F. (ed.) (1963). ***A Text Book of Dairy Chemistry.*** **Vol. 2, Practical, (3rd Ed.), pp. 94-102.** Chapman and Hall Ltd., London.

Lopez, M.C.; L.M. Medina and R. Jordano (1998). Survival of lactic acid bacteria in commercial frozen yoghurt. ***J. Food Sci.,*** **63(4): 706-708.**

Lourens-Hattingh, A. and B.C. Viljoen (2001). Yoghurt as probiotic carrier food. Review. ***Int. Dairy J.*** **1:11-17.**

Lucas, A.; I. Sodini; C. Monnet; P. Jolivet and G. Corrieu (2004). Probiotic cell counts and acidification in fermented milks supplemented with milk protein hydrolysates. ***Int. Dairy J.*** **14: 47-53.**

Marshall, R.T.; H.D. Goff and R.W. Hartel (eds.) (2003). In: ***Ice Cream*****. (6th Ed.), pp. 11-355.** Kluwer Academic/ Plenum Publishers, London, USA.

Metwally, A.I. (1994). The use of red sweet potato in ice cream manufacture. ***Egyptian J. Dairy Sci.,*** **22(1): 59-66.**

Modler, H.W.; R.C. McKeller; H.D. Goff and D.A. Mackie (1990). Using ice cream as a mechanism to incorporate bifidobacteria and fructooligosaccharides into the human diet. ***Cult. Dairy Prod. J.*** **25: 4-6 & 8-9.**

Mostafa, M.B.M.; F.A. Abd El-Malek and A.I. Okasha (2001). Utilization of some dairy by-products in the manufacture of reduced cholesterol froze yoghurt. ***Pro.8th Egyptian Conf. for Dairy Sci. & Tech.,*** **pp.551-560*.3-5 November, Cairo*.**

Nielsen, Suzanne S. (ed.) (1998). In: ***Food Analysis.*** **(2nd Ed.), pp. 71-82 & 99-249.** Aspen Publishers, Inc., Maryland.

Ordonez, G.A.; I.J. Jeon and H.A. Roberts (2000). Manufacture of frozen yogurt with ultrafiltered milk and probiotic lactic acid bacteria. ***J. Food Process. & Preserv.,*** **24(2):163-176**.

Robinson, R.W. and D.S. Decker-Walters (eds.) (1997). In: ***Cucurbits.*** **pp. 37-38 & 71**. CAB International, UK.

SAS (1996). ***Statistical Analysis System.*** SAS User's Guide: Statistics, Release 6.12 Education. SAS Inst. Inc. Cary. NC. ,USA.

Speck, M.L. and A. Hansen (1983). Properties of frozen non-fruit yoghurt. ***Cult. Dairy Prod. J.*** **18: 6-9.**

Taha, Soad H.; A.M. Abd El-Fattah; Sofie Y. El-Dairy and Neamah R. Attalla (2005). Probiotic ice cream : manufacture, properties and survival of added probiotic microorganisms. ***Egyptian J. Dairy Sci.*** **33(1):105-113.**

Thompson, L.D. and A.N. Mistry (1994). Compositional changes in frozen yoghurt during fermentation, frozen storage and soft serve freezing. ***Cult. Dairy Prod. J.*** **29(3): 12-17.**

Vanderhoof, J.A. and R.J. Young (1998). Use of probiotics in childhood gastrointestinal disorders. ***J. Pediatric Gastroenterology and Nutrition*** **27(3): 323-332.**

Wehr, H.M. and J.F. Frank (eds.) (2004). In: ***Standard Methods for the Examination of Dairy Products.*** **(17th Ed.), pp.85-87&263-264.** American Public Health Association, Washington, DC.

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تحضير وخواص يوجهورت مجمد حيوي مصنع بالبطاطا والقرع العسلي [43]

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تم صناعة يوجهورت مجمد منخفض في الدهن باستخدام بادئات تجارية حيوية (*Lb. acidophilus, Str. thermophilus* & bifidobacteria) وتقليدية (*Lb. delbrueckii* ssp. *bulgaricus* & *Str. thermophilus*) بالإضافة إلى استخدام البطاطا والقرع العسلي المشوي لزيادة القيمة الغذائية والوظيفية لهذا المنتج ،ولقد قيمت كلا من مخاليط اليوجهورت المجمد ، اليوجهورت المجمد الناتج المخزن على - 20 °م لمدة 8 أسابيع للخواص الكيماوية والطبيعية والبكتيريولوجية والحسية.

ولقد أظهرت النتائج إلى وجود فروق معنوية ($p<0.05$) في كل الخواص التي تمت دراستها بين مخاليط اليوجهورت المصنعة ، وأيضا بين اليوجهورت المجمد الناتج. حيث تميزت مخاليط اليوجهورت المجمد المصنعة ببادئ الزبادى التقليدى و البطاطا بارتفاع في الوزن النوعي ووزن الجالون ونقطة التجمد واللزوجة الظاهرية ، وانخفاض في رقم الأس الهيدروجيني مقارنة بالمخاليط المصنعة ببادئ حيوي. وعلى الجانب الآخر تميز اليوجهورت المجمد الناتج المصنع ببادىء تقليدى وبالبطاطا بارتفاع في الوزن النوعي ووزن الجالون ووقت التجمد والمقاومة للانصهار والمحتوى من الاسيتالدهيد مقارنة بالمصنعة ببادئ حيوي. كذلك تميز اليوجهورت المجمد المصنع بالقرع العسلي بارتفاع في أعداد *Lb. delbrueckii* ssp. *bulgaricus* & *Str. thermophilus* (بادئ تقليدى) & *Lb. acidophilus* ، تلاه اليوجهورت المجمد المصنع بالبطاطا. وعلى الجانب الآخر تميز اليوجهورت المجمد المصنع بالبطاطا بارتفاع في أعداد *Str. thermophilus* & bifidobacteria (بادئ حيوي) مقارنة بالمعاملات الأخرى. كذلك وجد أن التخزين المجمد لمدة 8 أسابيع اثر قليلا على أعداد البكتيريا الحية المقدرة في كل معاملات اليوجهورت المجمد ، حيث وجد أن أعداد الـ bifidobacteria مازالت عالية طوال التخزين بالمقارنة بالحد الأدنى الموصى به. وكذلك تميز اليوجهورت المجمد المصنع ببادئ حيوي وخاصا المصنع بالبطاطا بأعلى درجات في التحكيم الحسي. لذلك يمكن إنتاج يوجهورت مجمد منخفض في الدهن باستخدام بادئات حيوية وتقليدية بالإضافة إلى استخدام البطاطا والقرع العسلي المشوي لزيادة القيمة الغذائية والوظيفية وذو خواص حسية جيدة .

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