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Effect of replacement of Sucrose with Date Syrup on physiochemical, bacteriological and sensory properties of frozen yogurt

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ABSTRACT

The aim of this research to study the effect of replacing sucrose with different ratios of date syrup on physiochemical, bacteriological and sensory properties of frozen traditional yogurt made with starter culture (*Lactobacillus delbrueeckii spp. Bulgaricus and Streptococcus Thermophilus)* and probiotic starter (*Lactobacillus acidophilus, Streptococcus Thermophilus* and bifidobacteria). Liquid Date syrup was used to replace 30, 40 and 50% of sucrose in frozen yogurt mixes. The resultant traditional and probiotic frozen yogurt were stored at -20 ^{0}C for 8 weeks. There were significant differences ($p \leq 0.05$) in all properties studied among the mixes and resultant probiotic frozen yogurt. The specific gravity, weight per gallon, freezing points and dynamic viscosity values of probiotic frozen yogurt mixes prepared with yogurt starter and substitute sucrose with date syrup were considerably more than that prepared with probiotic starter and (control), but less pH values. Also, values of specific gravity, weight per gallon, freezing time, melting resistance and acetaldehyde of resultant probiotic frozen yogurt prepared by yogurt starter and replacement sucrose with date syrup were higher, but lower diacetyl as compared with that prepared by probiotic starter and control. The probiotic frozen yogurt prepared by 30% date syrup had characterized with the highest overrun% followed by control. On the other hand, *Str. thermoohilus* cells were shown the best survival rates in the resultant probiotic frozen yogurt either made with yogurt starter or probiotic starter, followed by *Lb. delbrueckii spp. bulgaricus*. Viable cell counts of *Lb. acidophilus* were higher than bifidobacteria in probiotic frozen yogurt prepared with probiotic starter. *Lactobacillus acidophilus* and bifidobacteria cell counts in all probiotic frozen yogurt samples were still higher along the storage. The sensory evaluation of probiotic frozen yogurt prepared with 30% and 40% date syrup had the highest organoleptic total score especially when using probiotic starter. Therefore, probiotic frozen yogurt with good properties could be made by 30% and 40% date syrup instead of sucrose and fermented by yogurt or probiotic starter.

Key words: Date syrup, probiotic frozen yogurt, physiochemical properties, bacteriological properties, organoleptic evaluation.

Introduction

Frozen yogurt dessert is a complex fermented frozen dairy dessert that combines the physical characteristics of ice cream with the sensory and nutritional properties of fermented milk products. Frozen yogurt dessert could be considered a healthy alternative to ice cream for people with obesity, cardiovascular diseases and lactose intolerance due to its low fat and lactose content (Marshall *et al.,* 2003).

Date syrup is considered to have functional properties such as the ability to act as a sugar replacer. Most of the carbohydrates in dates are in the form of fructose and glucose, which are easily absorbed by the human body (Al-Farsi *et al.,* 2005). Date syrup contains in addition to sugar, macro and micro elements especially potassium and iron which may play important role of considering the date syrup as rich nourishment (Al-Hooti *et al.,* 2002).

The dates and the date syrup are used for human consumption, in bakery and ice-cream products, and for the production of caramel color, ethanol, vinegar and single cell protein. Because of the high

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concentration of sugars in date, it is important to develop new and more attractive uses of these sugars (Roukas and Kotzekidou, 1997).

The aim of this study was to investigate the effect of using different ratios of date syrup instead of sucrose on physiochemical, bacteriological and sensory evaluation of probiotic frozen yogurt.

Materials and Methods

Materials

Fresh raw buffalo's milk was obtained from Almarai Company, Jeddah, Kingdom Saudi Arabia. Date syrup was purchased from a local market in Jeddah, Kingdom of Saudi Arabia.
Milk was skimmed into fresh skim milk and cream for preparation of probiotic frozen yogurt mixes.

Low heat skim cow milk powder were obtained from Dairy America, USA and carboxy methyl cellulose (CMC) from Danisco Ingredients, Copenhagen, Denmark as a stabilizer were used.

Commercial grade cane sugar (sucrose) were purchased from the local market .

Traditional yogurt starter containing (*Lactobacillus delbrueeckii spp. Bulgaricus and Streptococcus Thermophilus)* and probiotic starter containing (*Lactobacillus acidophilus, Streptococcus Thermophilus* and bifidobacteria) were obtained from Chr. Hansen Laboratory (Copenhagen, Denmark).

Mother cultures were prepared 24h before their use from these starters by inoculating sterilized (121 ^{0}C / 10 min) fresh skim milk with 0.02 % (w /v) inoculums. The inoculated milk were incubated at 40 ^{0}C until complete coagulation and cooled to 5± 1 ^{0}C.

Methods

Manufacture of probiotic frozen yogurt:

Frozen yogurt mixes were prepared according to Hussein and Aumara (2006). Mixes composition are shown in Table (1). The mixes were divided into four parts the first part was prepared by sucrose (control). The other three parts were prepared by replacing sucrose with 30, 40 and 50 % date syrup.

The ingredient of four mixes were divided into two portions (1 and 2) each mix was extensively homogenize d at 55 – 60 ^{0}C using X 520 UAC 30-R, Chicago II 6064 (30000 rpm /min^{-1}) homogenizer. Mixes were heat treated to 85 ^{0}C / 15 min, then portion 1 rapidly cooled and aged at 5 ^{0}C for 24 h. On the other hand, the second portions (2) (without sweeteners) were cooled to 40 ^{0}C for inoculating with 3% of yogurt starter or probiotic starter, then incubated until clotting and cooled at 5 ^{0}C .

The fermented portions (2) were combined and mixed well with the aged portions (1), individually. Also, vanilla was added to each mixes, before freezing in the horizontal batch freezer (Taylor Co., USA) and freezing time (min) was recorded. The probiotic frozen yogurt were packaged into 120 cc plastic cups and hardened at -20 ˚C for 8 weeks.

Table 1: Composition of probiotic frozen yogurt

Mix composition	Control 100% Sucrose	Replacement of sucrose with date syrup %		
		30%	40%	50%
Milk solid non fat	11.0	11.0	11.0	11.0
Milk fat	4.0	4.0	4.0	4.0
Sucrose	16.0	11.2	9.6	8.0
CMC	0.20	0.20	0.20	0.20
Starter	3.0	3.0	3.0	3.0
Vanilla	0.01	0.01	0.01	0.01
Date syrup	100	4.80	6.40	8.0
Total solids	34.21	34.21	34.21	34.21

Total solids, protein, fat and ash contents of frozen yogurt were analyzed according to methods as described by Association of Official Analytical Chemists (AOAC, 2005).

The pH was measured using a digital pH meter. The titratable acidity of frozen yogurt mixes was determined according to standard of the International Dairy Federation (1992).

Specific gravity and weight per gallon (kg) (Arbuckle, 1986). Were examined in the date syrup mixes and resultant probiotic frozen yogurt according to Arbuckle (1986).

Freezing point ˚C in mixes was also determined by Nielson (1998).

Viscosity of mixes was measured using the coaxial rotation viscometer (Rheotest, type RV2, Michigan, Germany) at shear rate ranging from 1.000 to 437.40 s^{-1} using device (S2). Shear stress values (dyne/cm^2) were recorded at 23 ±1 °C before loading in the viscometer device. Dynamic viscosity (poise) (p) was calculated at a constant shear rate of 81.0 s^{-1}.

The resultant probiotic frozen yogurts were analyzed for meltdown test (loss % at 23±1 °C after 30, 60 and 90 min) (Arbuckle 1986).

Acetaldehyde and diacetyl (µmol/ml) contents were determined in the resultant probiotic frozen yogurt according to Lee and Jado (1969) and (1970) respectively.

Over-run was measured according to the method described by Marshall *et al.* (2003) with a comparison of the weight of frozen yogurts mixture before and after freezing. The formula for over-run is as follows:-

Over-run% = weight of frozen yogurt mix - weight of frozen yogurt X 100 / weight of frozen yogurt

Bacteriological counts of resultant probiotic frozen yogurt

Samples of all probiotic frozen yogurt were prepared for bacteriological analysis according to the method described in standard methods for the Examination of Dairy products (Wehr and Frank 2004). Viable cells count of *Lb. delbrueckii spp. bulgaricus* on MRS agar (pH 5.20) (Anaerobic incubation at 45 ^{0}C for 72h), *Lb. acidophilus* on MRS sorbitol agar (Anaerobic incubation at 37 ^{0}C for 72h), *Str. thermophillus* on ST agar(Aerobic incubation at 37 ^{0}C C for 24 h.) and bifidobacteria on MRS agar (Oxoid) supplemented with L-cystein and lithium chloride (Sigma Chemical Co., USA) (Anaerobic incubation at 37 ^{0}C for 72h) were enumerated as described by Dave and Shah (1996). The plates were incubated in anaerobic environment (BBL Gas Pak, Becton Dickinson Microbiology System).The results expressed as log colony forming unit (log_{10} cfu) /ml of sample.

Organoleptic evaluation of resultant probiotic frozen yogurt.

Organoleptic evaluation was carried out according to the scheme of Clark *et al.* (2009).

Statistical analysis

Statistical analysis of the data was carried out by ANOVA using SAS statistical software (SAS, 1998). The significant differences among means were assessed by Duncan's multiple range tests (Duncan, 1955).

Results and Discussion

Physiochemical properties of date syrup (dibis).

Chemical constituents of date syrup are presented in Table (2). It could be noticed that, date syrup contained 16% moisture content, 6.8% ash, 1.98% fat, 0.83% protein, and 79.70% total sugars. On the other hand, total solids, total soluble solids, total titratable acidity and pH values were 84%, 80%, 0.18% and 6.11 in date syrup. While ascorbic acid, sodium, potassium, magnesium and calcium in date syrup were 3.2, 13.0, 202.8, 7.8,143 and 338mg/100g respectively. These results are agreement with Al-Farsi *et al.* (2005) and Ardali and Akbarian (2014).

Table 2: Chemical contents of resultant date syrup

Components	(%)	Components	Mg/100mg
Moisture	16	Ascorbic acid	3.20
Fat	1.98	Sodium	13
Protein	0.83	Potassium	202.80
Ash	6.80	Iron	2.8
Total solids	84	Magnesium	143
T.S.S	80	Calcium	338
Total Sugars	79.70		
pH values	6.11		
Acidity	0.18		

Physicochemical properties of probiotic frozen yogurt mixes:

Results presented in Table (3) indicated that there are significant differences in mixes physicochemical properties due to either type of culture or level of date syrup. Concerning pH values it could be observed that mixes fermented with probiotic culture showed significant high pH values than fermented with yogurt starter. However replacing of sucrose with date syrup showed significant lower pH values in compare with control and this was associated with the level of added date syrup. On other hand it could be noticed that mixes containing date syrup showed significant higher specific gravity, weight per gallon and viscosity than the control one. However mixes containing date syrup showed significant lower freezing point than control one.

These results agree with those reported by Ali *et al.* (1996) , who noticed that, the pH values and freezing point were lower, while specific gravity was higher in frozen yogurt mix made with yogurt starter than culture contained of *Lb. acidophilus, Lb. casei, Str. Thermophillus* and *B. bifidum*. Also,(EL- Kholy *et al.,* 2004), found that the viscosity of frozen yogurt mixes made with traditional starter was increased when using low pH culture. This could be due to the higher water holding capacity of yogurt culture at low pH, which bound some free water and accordingly increase the mix viscosity. (Marshall *et al.,* 2003), reported that low pH leads to high viscosity of ice cream mix, and mix viscosity is greatly influenced by the mix composition. 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. Moreover, the use of different sugars in the ice cream production significantly affected pH of the ice cream samples (Ozdemir *et al.,* 2008).

Flow behavior of probiotic frozen yogurt

Flow behavior (shear stress / shear rate) of mixes prepared with different levels of date syrup instead of sucrose and fermented by yogurt or probiotic starter are presented in fig (1) and fig (2). There was significant differences $p \leq 0.05$ in the flow behavior among mixes made with probiotic and yogurt starter in side, and the ratio of date syrup replacement. It could be seen, that the relation between shear stress and shear rate was non-liner in all mixes. Also, using probiotic starter in made of probiotic frozen yogurt mixes was resulted in the downward shifting of the flow curve as compared with that made by yogurt starter. This decrease in flow curve indicated that, there was decrease in the viscosity of probiotic frozen yogurt mixes prepared with probiotic starter (Hussein and Aumara 2006). On the other hand, the control mixes prepared with sucrose only had characterized with downward shifting of the flow curve, as compared with that made by different ratios of date syrup instead of sucrose. These increases in the flow curve of the mixes made by date syrup were proportional to the rate of substitution. (Ozdmir *et al.,* 2008), mentioned when honey (contained of fructose and glucose) together with sucrose was added to ice cream mixture, the viscosity was increased. Also, (Ali *et al.,* 1996), reported that the hysteretic behavior of mixes made with cultures contained of Lb. acidophilus, *Str. thermophillus* and *B. bifidum* seemed to be non-Newtonian dilatants fluids.

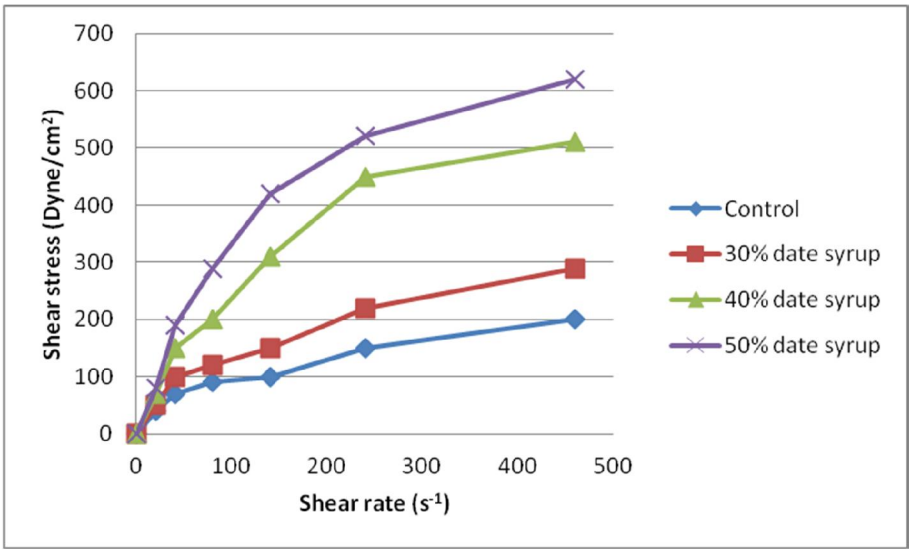

Fig. 1: Flow behavior of probiotic frozen yogurt prepared with different ratios of date syrup and fermented with yogurt starter.

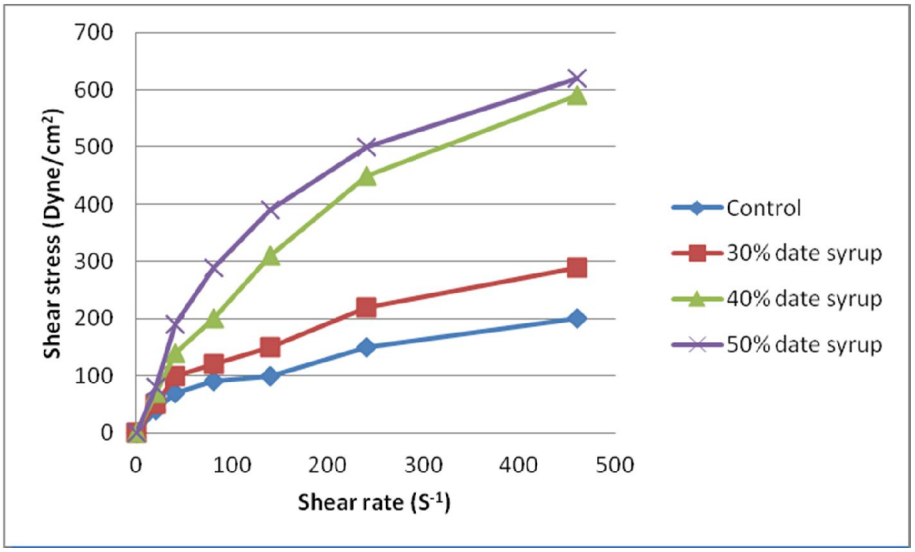

Fig. 2: Flow behavior of probiotic frozen yogurt prepared with different ratios of date syrup and fermented with probiotic starter.

Properties of the resultant probiotic frozen yogurt

The specific gravity, weight per gallon, overrun% freezing time, meltdown, acetaldehyde% and diacetyl content of the resultant probiotic frozen yogurt prepared with different ratios of date syrup instead of sucrose and fermented by yogurt starter and probiotic starter are shown in Table (4). Significantly differences in these properties were found among the resultant probiotic frozen yogurt made with probiotic or yogurt starter in side, and the ratios of replacement sucrose with date syrup. On the other hand, the frozen yogurt made with yogurt starter had characterized with higher specific gravity, weight per gallon, freezing time, milting resistance (low melting ability) and acetaldehyde content, but lower overrun% and diacetyl content than probiotic frozen yogurt which made with probiotic starter. On the other side, probiotic frozen yogurt prepared by replacement sucrose with date syrup showed higher values of specific gravity, weight per gallon, freezing time, melting resistance, acetaldehyde% and diacetyl compared with control. When the ratios of date syrup instead of sucrose

increased from 30 to 50% these values were significantly increased. The increasing in freezing time could be due to the decrease in freezing point of probiotic frozen yogurt mixes made with yogurt starter and replacement sucrose with date syrup. Moreover, probiotic frozen yogurt made by substitute of sucrose with 30% date syrup had characterized with the highest overrun%, followed by control but substitute with 50% date syrup resulted in the lowest overrun%.

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 resultant has frozen yogurt (Hussein and Aumara 2006). Also, they mentioned that the differences in melting resistance are mainly due to the differences in the freezing points of the mixes. (Ali *et al.,* 1996), recorded the highest overrun and least melting resistance in the resultant frozen yogurt contained of *Lb. acidophilus, Str. thermophillus* and *B. bifidum*. In general, as the viscosity increases the resistance to melting and the smoothness of texture increase. (El-Kholy *et al.,* 2004), found that the decreasing in pH values of yogurt culture improved the melting resistance of the resultant frozen yogurt. However, the lowest melting ratio was determined in samples containing glucose syrup instead of sucrose in the ice cream production, as well as decreased the overrun values (Ozdemir *et al.,* 2008).

Table 4: The effect of adding different ratios of date syrup on properties of resultant probiotic frozen yogurt

Properties	Control		% Date syrup instead of sucrose					
			30%		40%		50%	
	A	B	A	B	A	B	A	B
Specific gravity	0.7680c	0.7340d	0.7710c	0.7360d	0.8650a	0.8430b	0.8790a	0.8610a
Overrun %	42.50c	44.20b	43.21c	44.36b	44.52b	45.63a	27.31d	28.60d
Weight per gallon Kg	2.8870c	2.8390d	2.8930c	2.8510c	3.3520b	3.2530b	3.4300a	3.3890a
Freezing time(min	11.0c	9.0d	11.5c	10.0c	12.50b	12.0b	14.0a	13.0a
M.R.L.% after 30min	22.50b	24.30a	21.00c	22.00b	20.80c	21.20c	19.50d	20.10d
60min	45.20c	49.42a	44.32c	47.20b	41.80d	43.62c	33.62f	35.14e
90min	33.00d	29.20e	35.12c	33.46d	42.73b	41.52b	45.30a	42.93b
Diacetyl (µmol/ml)	7.920e	12.220c	8.630d	12.750c	8.940d	13.460b	9.420d	14.710a
Acetaldehyde (µmol/ml)	150.80d	112.90e	172.50c	134.30d	210.40b	170.50c	240.30a	180.90c

M.R.L. = Melting resistance Loss
Values with different letters in the same raw are significantly different at P<0.05.
A-containing yogurt starter B- containing probiotic starter

Bacterial counts of the resultant probiotic frozen yogurt

Viable bacterial counts (log10 cfu/ml) of bacterial starter strain in the resultant probiotic frozen yogurt prepared with different ratios of date syrup instead of sucrose and fermented by yogurt or probiotic starters during storage period for 8 weeks at – 20 C are shown in Table (5).

Significantly differences in log bacterial counts were found among the resultant probiotic frozen yogurt prepared with yogurt starter (Lb. *delbrueckii bulgaricus and Str. thermophilus*) or probiotic starter (Lb. *acidophilus, Str. thermophillus and bifidobacteria*) as well as the ratios of replacement sucrose with date syrup. Counts of *Lb. delbryeckii bulgaricus and Str. thermophillus* were most numerous in the different samples of the resultant probiotic frozen yogurt. Str. thermophillus was shown to survive the best in probiotic frozen yogurt either fermented with yogurt starter or probiotic starter. Also viable counts of *Lb. acidophilus* in probiotic frozen yogurt fermented with probiotic starter were higher than bifidobacteria. On the other side, probiotic frozen yogurt prepared by replacement sucrose with date syrup showed higher counts of viable bacterial cells than control samples. Also, when the ratios of date syrup instead sucrose increased from 30 to 50%, the cell counts were increased. On other words, probiotic frozen yogurt prepared with 50% date syrup had characterized with the highest count of bacterial cells. Moreover, a gradual decrease in viable bacterial counts could be observed in all probiotic frozen yogurt samples upon extended period of storage for 8 weeks at -20 C. Furthermore, survival of *Lb. delbrueckii bulgaricus , Str. thermophillus Lb. acidophilus,. and bifidobacteria*, cells during storage in all probiotic frozen yogurt samples could be considered satisfactory. Results also indicated that the viable counts of *Lb. acidophilus* and

bifidobacteria in all probiotic frozen yogurt treatments were maintained at an acceptable level to be considered as functional foods until the 8th week of storage. Alamprese *et al.* (2002) and Nousia *et al.* (2011), showed that the freezing process caused a significant decrease in the viability of *Lb. acidophilus* culture, but no significant change in the viable counts during frozen storage. It should be emphasized that studies on frozen yogurt and ice cream have established that the medium possesses cryoprotection properties, due to the presence of casein, sucrose and lactose (Godward & Kailasapathy 2003 and Turgut *et al.* 2009), found at the end of storage demonstrated that the counts of *Lb. acidophilus* and *B. bifidum* contained to decrease during the storage for 90 days at -20 ^{0}C, but remained above 1 x 10^6 cfu / g and maintained probiotic properties during storage. However, Akin *et al.* (2007) found that Str. thermophillus was most stable in all samples of probiotic ice cream with >10^7 cfu /g throughout the storage period.

Table 5: The effect of different ratios of date syrup on viable counts (log_{10} cfu /ml) of bacterial starter in probiotic frozen yogurt during storage at -20C for 8 weeks.

Type of starter	Storage period (weeks)	Control	% Date syrup		
			30%	40%	50%
A- Yogurt starter *Lb. bulgaricus*	0	7.90	8.0	8.10	8.15
	2	7.80	7.90	7.94	8.00
	4	7.80	7.85	7.90	7.96
	6	7.75	7.81	7.86	7.92
	8	7.70	7.75	7.80	7.85
Str. thermophilus	0	7.94	8.33	8.50	8.77
	2	7.88	7.97	8.30	8.65
	4	7.85	7.92	8.20	8.44
	6	7.80	7.90	8.10	8.33
	8	7.76	7.82	7.95	8.18
B- Probiotic starter	0	7.95	8.10	8.20	8.24
Str. thermophillus	2	7.90	8.06	8.14	8.19
	4	7.86	8.00	8.07	8.12
	6	7.80	7.95	8.00	8.06
	8	7.77	7.90	7.96	8.00
Lb. acidophilus	0	8.13	8.21	8.29	8.32
	2	8.07	8.16	8.22	8.26
	4	8.00	8.10	8.16	8.20
	6	7.96	8.04	8.10	8.17
	8	7.92	7.98	8.06	8.11
Bifidobacteria	0	7.96	8.00	8.12	8.20
	2	7.90	7.95	8.06	8.13
	4	7.85	7.96	8.08	8.11
	6	7.80	7.86	7.92	7.97
	8	7.75	7.80	7.87	7.92

Sensory attributes of the resultant probiotic frozen yogurt

Sensory properties of the resultant probiotic frozen yogurt prepared with different ratios date syrup instead of sucrose and fermented by yogurt or probiotic starters are presented in Table (6). The sensory panel found differences among the treatments when scoring the samples for flavor, body& texture, melting property and color & appearance depending on the type starter cultures and ratio of replacement sucrose with date syrup. The probiotic frozen yogurt prepared with probiotic starter ranked superior in the total score than with prepared with yogurt starter. The decline in total score of probiotic frozen yogurt prepared with yogurt starter may be due to interact between mildly acid and sweet taste. The probiotic frozen yogurt prepared with 30 and 40% date syrup instead of sucrose had characterized with the highest organoleptic total score especially when using probiotic starter followed by control. On the other hand, the substituted sucrose with 50% date syrup had lowest of

organoleptic total score, this is due to high sweetness flavor, gummy body and texture and low melting property.

Finally, it could be concluded that, probiotic frozen yogurt with good physicochemical, bacteriological and organoleptic properties could be made replace sucrose with 30 to 40% date syrup and fermented by probiotic starter culture.

Table 6: Sensory evaluation of probiotic frozen yogurt prepared with different ratios of date syrup.

Properties		Control	% Date syrup		
			30%	40%	50%
Frozen yogurt with yogurt starter					
Flavor	1–10 point	9.40a	9.50a	9.60a	7.00b
Body & texture	1–5 point	4.60a	4.80a	4.90a	4.00b
Melting property	1–5 point	4.80a	4.90a	4.90a	4.10b
Color & appearance	1–5 point	5.00a	5.00a	4.90a	3.60b
Total score	25)	23.80a	24.20a	24.30a	18.70b
Frozen yogurt with probiotic starter					
Flavor	1–10 point	10.00a	10.00a	10.00a	7.00b
Body & texture	1–5 point	4.700a	4.90a	5.00a	4.00b
Melting property	1–5 point	5.00a	5.00a	4.90a	4.10b
Color & appearance	1–5 point	4.80a	4.80a	4.70a	3.20b
Total score	25	24.50a	24.70a	24.60a	18.30b

Values with different letters in the same raw are significantly different at P<0.05.

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