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EFFECTS OF THE DIFFERENT CONCENTRATIONS OF SUGAR AND PECTIN ON SELECTED PHYSICOCHEMICAL PROPERTIES AND SENSORY EVALUATION OF DRINKING YOGHURT DURING COLD STORAGE

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ABSTRACT

The various types of yogurt are characterized by their structural properties. Drinking yogurt is generally described as stirred yogurt of low viscosity. It, in contrast to regular cup yogurt, is not popular in Iran and a manufacturing protocol is not available. For this, the study aimed to optimize the physicochemical properties and sensory characteristics of drinking yogurt on the basis of Iranian acceptance. Physicochemical properties (titratable acidity, water holding capacity, (WHC) and viscosity) and sensory evaluation, including flavor, texture, appearance, odor and overall acceptability, of drinking yoghurt samples were investigated at regular (7-day) intervals during cold storage. In this research, sugar at concentrations of 0.5, 1 and 1.5% (w/w) and stabilizer pectin at concentrations of 0.01 and 0.02% (w/w) were added to the milk. According to final results, the drinking yoghurt sample containing 0.02% (w/w) pectin and 1% (w/w) sugar was selected as the preference treatment.

Keywords: drinking yoghurt, pectin, sugar, physicochemical properties, Sensory analysis

INTRODUCTION

A wide range of fermented milks are manufactured throughout the world. The reasons for fermenting milk are numerous and, although the primary function is to extend its shelf life, other advantages, such as improving the taste of milk, enhancing the digestibility of the product and the manufacture of a wide range of products shouldn't be overlooked (Tamime, 2006).Yogurt is the result of the lactic acid fermentation of milk by two bacteria, *Lactobacillus bulgaricus* and *Streptococcus thermophilus* and is consumed worldwide (Schonbrun, 2002). Drinking yogurt is categorized as stirred yogurt of low viscosity (Tamime and Robinson, 2000; Uysal-Pala *et al.*, 2006) and this product is consumed as a refreshing drink. The European and North American types of drinking yoghurt are made from a milk base low in fat and milk solids and the manufacture of such products is possible in most types of yoghurt plants (Tamime and Robinson, 2000). Although there are no standardized procedures for making a drinkable yogurt product, most processors agree on a general process. This includes pre-treatment of the milk, heat treatment, homogenization, cooling, starter culture addition and subsequent fermentation and packaging (Schonbrun, 2002). In general, milk alone is normally used for the production of drinking yoghurt but in some instances other food additives may be added to the milk (Tamime and Robinson, 2000). Product ranges in consistency from dilute, low viscosity drinks to thick, viscous product. During the manufacture of yogurt drinks, the gel is broken by high shear and never allowed to reset. Most products are made by such shearing of the yogurt post-fermentation. However, others are made by dilution of yogurt with water or fruit juice. Flavors and other ingredients can also be added immediately prior to the post-fermentation homogenization step (Hugunin *et al.*, 2009).

The sedimentation of the protein in short shelf-life drinking yogurts containing live microorganisms can be prevented by stabilization of product by increasing the viscosity. Helpful ingredients include viscosity-producing cultures (e.g. exopolysaccharides) and hydrocolloid stabilizers such as high-methoxyl pectin. The most common way to overcome the sedimentation of the proteins is by preventing such particles from aggregating together. High ester pectin is one of the stabilizers most commonly used to stabilize acidified milk drinks (Thi and Ipsen, 2009; Tamime, 2006; Leroux *et al*., 2003). Pectin is a well-known food additive which is mainly used for its gelling and stabilizing abilities.

Different types of sugar or sweetener may be added to the milk base before the processing and fermentation. It should be noted that too high concentrations of sugar may negatively influence the growth of the lactic acid bacteria (Tamime, 2006).

The aim of the present research was to use different concentrations of sugar (0.5%, 1% and 1.5% (w/w)) and stabilizer pectin (0.01% and 0.02% (w/w)) in the production of drinking yogurt; then, determine the influence of

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various concentrations of these additives on textural and sensory characteristics of final product; and compare the properties of experimental samples to each other for selecting the preference drinking yogurt sample.

MATERIALS AND METHODS

Additives

The following additives are involved in the production of drinking yoghurt samples:

- Stabilizer: pectin (HM, DEG150, Danisco, Denmark).
- Sugar (Shahdane Company, Iran) .

Starter culture

Commercial yogurt culture (containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*), YC-X_{11}, was obtained from Chr. Hansen, Denmark.

Drinking yogurt production

Drinking yogurt was made according to the method described by Waterhouse *et al.*, (2011). The chemical composition of raw cow milk included 9.76% total solids, 2.5% fat and titratable acidity was 14.6°Dornic. Following water addition, the level of solids-non-fat (SNF) in raw cow milk reduced to around 6%.Then, milk was heated at 60˚C and mixed (Mixer Zass, HM-768, Germany)sugar and pectin (Treatments 1-6,as shown in Table 1). The blend was pasteurized at 90°C for 10 min and cooled to 42°C. Milk was inoculated with 0.002% (w/w) of yogurt culture in a freeze dried direct vat set (DVS)and incubated at 40°C.Fermentation continued up to the pH of 4.4.Following agitating(agitator Sunny, Japan), the samples were packed into 250-g plastic cups and cooled to the storage temperature, 4°C, for 22 days. Drinking yogurt samples were produced in triplicate, and results were the averages of three replicates.

Physicochemical analyses

Drinking yogurt samples were analyzed for solids-non-fat and titratable acidity according to the Iran standard methods. Viscosity of drinking yogurts was measured at 25±1°C using a Brookfield DV-II+Pro viscometer (Brookfield Engineering Laboratories, USA). The Viscometer was operated at 42 rpm with spindle number 62 after 45s (Gonzalez *et al.*, 2011). Water holding capacity was determined by the method of Sodini *et al.* (2006). All analyses were conducted on the 1^{st}, 8^{th}, 15^{th} and 22^{th} day of storage at 4°C.

Sensory evaluation

Sensory evaluation was carried out using a five–point hedonic scale (5=very poor, 1= very good) by 15 trained panelists who were the members of Sinaz Dairy Company for flavor, texture, appearance, odor and overall acceptability of experimental drinking yogurts.

Statistical analysis

Statistical analysis on a completely randomized design was performed for ANOVA using SAS software (version 9.1; Statistical Analysis System Institute Inc., Cary, NC, USA). Duncan's multiple range tests were used to compare means at the significant level of 0.05 ($p < 0.05$). All experiments were replicated three times.

RESULTS AND DISCUSSION

Physicochemical properties of drinking yogurt samples

Acidity changes in drinking yogurt during cold storage

Values of lactic acid production at 7-day intervals during cold storage are shown in Table 2. During storage, the titratable acidity increased in all treatments. No significant differences in lactic acid concentration were found between the treatments on any specific day of incubation. Increasing acidity during cold storage could be due to activity of starter cultures; especially, acid production by *Lactobacillus delbrueck* subsp. *bulgaricus* (Antunes *et al.*, 2005).

It should be noted that increasing sugar content decreased acidity of T1-T3 and T4-T6 from day of 1 to 8 . This variation could be attributed to negative influence of sugar addition on the growth of the lactic acid bacteria (Tamime, 2006). However, at the end of cold storage time, this trend was not observed.

Table 1. Treatments used in the study.

Pectin (%w/w)	Sugar (%w/w)	Treatment
0.01	0.5	T1
0.01	1	T2
0.01	1.5	T3
0.02	0.5	T4
0.02	1	T5
0.02	1.5	T6

Table 2. Acidity (°Dornic) of drinking yogurt samples during storage*

Sample \ Days --	1	8	15	22
T1	72.5 ± 3.53	84 ± 1.41	110 ± 31.11	111 ± 26.87
T2	69.5 ± 4.94	82.5 ± 3.53	109 ± 33.94	112 ± 24.74
T3	65 ± 7.07	81.5 ± 2.12	110 ± 32.52	113 ± 26.87
T4	71 ± 1.41	83 ± 1.41	107 ± 38.89	111 ± 26.87
T5	67 ± 8.48	83 ± 1.41	108 ± 37.47	115 ± 32.52
T6	69 ± 1.41	80 ± 0.00	111 ± 38.18	114 ± 32.52

* Mean ± SD values in a column are not significantly different at $P < 0.05$ from each other.

Table 3. Water Holding Capacity of drinking yogurt samples during storage*

Sample \ Days ---	1	8	15	22
T1	76.3 ± 1.83	74.5 ± 6.36	75 ± 3.53	67.2 ± 12.97
T2	78 ± 0.70	72.95 ± 7.70	75.62 ± 4.27	66.6 ± 13.15
T3	73.75 ± 1.76	73.67 ± 6.96	75.67 ± 3.42	63.62 ± 13.82
T4	77.62 ± 1.59	74.3 ± 2.54	74.3 ± 5.44	63.92 ± 16.15
T5	77.55 ± 1.69	76.92 ± 2.72	76.82 ± 1.37	67.65 ± 10.53
T6	76.2 ± 1.69	76.7 ± 2.40	75.67 ± 2.36	67.05 ± 14.77

* Mean ± SD values in a column are not significantly different at $P < 0.05$ from each other.

Table 4. Viscosity (cp) of drinking yogurt samples during storage*

Sample \ Days --	1	8	15	22
T1	3.04 ± 0.20	4.87 ± 1.18	2.31 ± 0.88	2.28 ± 0.12
T2	2.69 ± 0.96	4.75 ± 2.41	2.36 ± 0.38	3.38 ± 0.10
T3	2.48 ± 0.44	3.58 ± 2.76	1.70 ± 0.70	2.15 ± 0.82
T4	6.61 ± 1.01	7.22 ± 2.85	4.08 ± 2.99	4.19 ± 2.83
T5	6.79 ± 2.63	8.58 ± 0.48	4.12 ± 2.29	4.67 ± 2.98
T6	5.82 ± 2.74	7.56 ± 1.93	4.62 ± 1.61	6.04 ± 0.52

* Mean ± SD values in a column are not significantly different at $P < 0.05$ from each other.

Changes in Water holding capacity (WHC) in drinking yogurt during cold storage

WHC in T2, T4 and T5 was recorded the highest value on day of 1, then a down ward tendency was observed in all treatments, except T6, during storage time, from day of 1 to 8 (Table 3). Seven days later, WHC in T1,T2 and T3 increased; in T4 and T5 was not changed and in T6 decreased. From day of 15 to 22, WHC in all of treatments has declined. However, it should be noted that there were no significant differences between experimental treatments (p>0.05).

Table 5. Flavor of drinking yogurt samples during storage*

Sample \ Days --	1	8	15	22
T1	3.04 ± 0.20	4.87 ± 1.18	2.31 ± 0.88	2.28 ± 0.12
T2	2.69 ± 0.96	4.75 ± 2.41	2.36 ± 0.38	3.38 ± 0.10
T3	2.48 ± 0.44	3.58 ± 2.76	1.70 ± 0.70	2.15 ± 0.82
T4	6.61 ± 1.01	7.22 ± 2.85	4.08 ± 2.99	4.19 ± 2.83
T5	6.79 ± 2.63	8.58 ± 0.48	4.12 ± 2.29	4.67 ± 2.98
T6	5.82 ± 2.74	7.56 ± 1.93	4.62 ± 1.61	6.04 ± 0.52

* Mean ± SD values in a column are not significantly different at $P < 0.05$ from each other.

Table 6. Texture of drinking yogurt samples during storage*

Sample \ Days --	1	8	15	22
T1	1.5 ± 0.57	1.96 ± 0.92	3.3 ± 0.83	4.33 ± 0.47
T2	1.6 ± 10.80	2.13 ± 0.97	3.26 ± 0.94	4.4 ± 0.62
T3	1.56 ± 0.77	2.26 ± 0.86	3.4 ± 0.93	4.43 ± 0.67
T4	1.48 ± 0.57	1.9 ± 0.84	3.06 ± 0.82	4.26 ± 0.58
T5	1.63 ± 0.71	2.16 ± 0.98	3.06 ± 0.86	4.43 ± 0.67
T6	1.5 ± 0.62	2.13 ± 1.19	3.06 ± 1.01	4.46 ± 0.51

* Mean ± SD values in a column are not significantly different at $P < 0.05$ from each other.

Table 7. Appearance of drinking yogurt samples during storage*

Sample \ Days ---	1	8	15	22
T1	1.63 ± 0.61	1.96 ± 0.85	2.9 ± 0.92	3.66 ± 0.80
T2	1.45 ± 0.67	2.06 ± 0.86	2.8 ± 10	3.76 ± 0.81
T3	1.46 ± 0.68	1.96 ± 0.92	2.86 ± 0.86	3.8 ± 0.84
T4	1.34 ± 0.48	1.7 ± 0.74	2.66 ± 0.84	3.66 ± 0.80
T5	1.56 ± 0.67	1.76 ± 0.85	2.6 ± 0.77	3.6 ± 0.62
T6	1.36 ± 0.49	2.1 ± 0.95	2.9 ± 0.95	3.63 ± 0.76

* Mean ± SD values in a column are not significantly different at $P < 0.05$ from each other.

It is of interest to note that the aggregated proteins due to acidification are heavy and have the tendency to sedimentation and cause syneresis or wheying off. High ester pectin is negatively charged, so the pectin coats the casein molecules when at pH 4, and confers charge repulsion on these particles. Thus, it protects the proteins during the heating process and to prevent sedimentation (Tamime, 2006; Hugunin *et al.*, 2009).

Viscosity changes in drinking yogurt during cold storage

The viscosity changes during cold storage of experimental samples are shown in Table 4. Treatments T4, T5 and T6, containing the highest pectin concentration, showed higher viscosity values than the other treatments during storage (P < 0.05). Stabilizers bind water and limit syneresis (Duboc and Mollet, 2001). The high viscosity content of the drinking yogurt samples was reflected in the high pectin values for those samples. In all treatments, viscosity increased on the 8^{th} and 22^{th} days of storage. However, it declined during the second week of storage.

Sensory evaluation of drinking yogurt during cold storage

Panelists did not differentiate flavor, texture, appearance (phase separation), odor and overall acceptability between the treatments (Tables 5-9) and the scores recorded for all of sensory properties decreased non-significantly (P < 0.05) during storage time.

Increasing acidity in final product during storage led to sourness flavor .Thus, scores of flavor and odor reduced.

The results indicated that decreasing water holding capacity, in turn; increasing syneresis was the most important factor in recording low scores of texture during cold storage.

Increasing syneresis and phase separation reduced scores recorded in related to product appearance during storage. In all treatments, phase separation on the 22th of storage was high and no acceptable for panelists.

In general, decreasing scores of flavor, texture, appearance and odor during cold storage resulted decline overall acceptability. It should be noted that the samples on 22th day of storage were no acceptable by the panelists.

Table 8. Odor of drinking yogurt samples during storage*

Sample \ Days ---	1	8	15	22
T1	1.7 ± 0.79	1.86 ± 0.81	2.56 ± 0.85	3.53 ± 0.77
T2	1.77 ± 0.95	2.06 ± 0.86	2.8 ± 1.12	3.5 ± 0.77
T3	1.56 ± 0.67	1.76 ± 0.81	2.66 ± 0.84	3.5 ± 0.90
T4	1.44 ± 0.63	1.73 ± 0.82	2.53 ± 0.86	3.43 ± 0.67
T5	1.5 ± 0.57	1.76 ± 0.93	2.56 ± 0.85	3.46 ± 0.86
T6	1.46 ± 0.73	1.93 ± 0.82	2.8 ± 1.06	3.36 ± 0.99

* Mean ± SD values in a column are not significantly different at $P < 0.05$ from each other.

Table 9. Overall acceptability of drinking yogurt samples during storage*

Sample \ Days ---	1	8	15	22
T1	1.96 ± 0.61	2.36 ± 0.76	3.23 ± 0.56	4.03 ± 0.66
T2	2.09 ± 0.83	2.43 ± 0.93	3.26 ± 0.63	4.23 ± 0.5
T3	2.0 ± 0.58	2.26 ± 0.82	3.23 ± 0.77	4.1 ± 0.71
T4	1.89 ± 0.67	2.06 ± 0.73	3.3 ± 0.59	3.93 ± 0.58
T5	1.93 ± 0.58	2.23 ± 0.85	3.16 ± 0.64	4.0 ± 0.69
T6	1.86 ± 0.68	2.26 ± 0.94	3.3 ± 0.65	3.93 ± 0.73

* Mean ± SD values in a column are not significantly different at $P < 0.05$ from each other.

Conclusion

Drinking yogurt is a new fermented dairy beverage in Iran. It is generally described as stirred yogurt of low viscosity. The current study investigated physicochemical properties and sensory characteristics of drinking yogurt samples containing different concentrations of sugar (0.5, 1 and 1.5% w/w) and pectin (0.01 and 0.02% w/w) on the basis of Iranian acceptance. Keeping in mind the importance of viscosity and syneresis features, in addition to sensory analysis, for the choice of preference treatment, the drinking yoghurt sample containing 0.02% (w/w) pectin and 1% (w/w)sugar (T5) was selected as the preference sample.

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