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Quality characteristics and consumer acceptance of yogurt fortified with date fiber

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ABSTRACT

Yogurt is considered a healthy food and incorporating dietary fiber will make it even healthier. Date fiber (DF), a by-product of date syrup production, is a good source of dietary fiber. The effect of fortification with DF on fresh yogurt quality was investigated. Acidity, pH, color [L* (lightness), a* (redness), and b* (yellowness) values], texture profile, sensory properties, and consumer acceptance were studied. Control yogurt (without fiber), yogurt fortified with 1.5, 3.0, and 4.5% DF, and yogurt with 1.5% wheat bran (WB) were prepared. Fortification with DF did not cause significant changes in yogurt acidity, although pH was increased. Yogurts fortified with DF had firmer texture (higher hardness values) and darker color (lower L* and higher a*) compared with control or WB yogurts. Consumer test results indicated that the appearance, color, and flavor ratings were significantly affected by fiber fortification. Yogurt fortified with up to 3% DF had similar sourness, sweetness, firmness, smoothness, and overall acceptance ratings as the control yogurt. Sensory ratings and acceptability of yogurt decreased significantly when increasing DF to 4.5% or using 1.5% WB. Flavoring yogurt fortified with 4.5% DF with vanilla did not improve flavor or overall acceptance ratings. Thus, fortifying yogurt with 3% DF produced acceptable yogurt with beneficial health effects.
Key words: yogurt, date fiber, sensory quality, acceptability

INTRODUCTION

Yogurt is an important dairy product, particularly for consumers with lactose intolerance. Yogurt is considered a healthy food because it contains viable bacteria that are considered probiotics. Milk and dairy products do not contain fiber. Fiber is found in the cell wall of fruits, vegetables, and cereals (Trowell et al., 1976; Lunn and Buttriss, 2007). Fiber of different sources is added to products to increase cooking yield and water-holding capacity, reduce lipid retention, improve textural properties and structure, or reduce caloric content by acting as a bulking agent (Larrauri, 1999). Consumption of foods containing fiber may prevent or decrease gastrointestinal disorders (Elia and Cummings, 2007), hypertension, hypercholesterolemia, obesity (Van Dam and Seidell, 2007), diabetes (Anderson et al., 2004; Schulze et al., 2004; Venn and Mann, 2004), coronary heart disease (Pereira et al., 2004; Mann, 2007), and cancer (Bingham et al., 2003; Buttriss and Stokes, 2008).

Several researchers have studied the effect of dietary fiber on yogurt quality. Addition of 1.32% oat fiber improved the body and texture of unsweetened yogurt and decreased the overall flavor quality (Fernández-García et al., 1998). The effect of wheat bran (natural and toasted) and flavor (pineapple and piña colada) on yogurt quality were studied by Aportela-Palacios et al. (2005). The pH increased and syneresis decreased with increasing fiber (1.5, 3.0, and 4.5% by weight). Natural bran had a greater effect on consistency than did toasted bran, and yogurt flavored with piña colada had higher viscosity than yogurt flavored with pineapple. Staffolo et al. (2004) studied the effects of commercial fibers from apple, wheat, bamboo, or inulin on sensory and rheological properties of yogurt. Although some rheological characteristics were modified, the supplemented yogurts were acceptable to consumers. Yogurt fortified with apple fiber had a different color compared with unfortified yogurt. García-Pérez et al. (2005) reported that yogurt containing 1% orange fiber had a lighter, more red and more yellow color [lower lightness (**L***), higher redness (**a***) and yellowness (**b***) values] in addition to having lower syneresis than control and yogurt containing 0.6 and 0.8% orange fiber. Fermented milk enriched with citrus fiber (orange and lemon) had good acceptability (Sendra et al., 2008). Addition of 0.5% barley β-glucan or inulin and guar gum (>2%) were effective in improving serum retention and viscoelastic properties of low-fat yogurt (Brennan and Tudorica, 2008). Incorporation of fiber obtained from asparagus

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shoots increased yogurt consistency and imparted a yellow-greenish color to the yogurt (Sanz et al., 2008).

Dates are a good source of dietary fiber (Myhara et al., 1999; Al-Farsi et al., 2007; Elleuch et al., 2008). The dietary fiber content of dates ranges from 4.4 to 11.4% depending on date variety and ripening stage (Spiller, 1993; El-Zoghbi, 1994; Al-Hooti et al., 1995; Al-Shahib and Marshall, 2002). A serving of dates (5 to 6 fruits) can provide 14% of the recommended daily intake of dietary fiber (Spiller, 1993).

The United Arab Emirates (**UAE**) is the fourth leading country worldwide for date production, producing 755,000 tonnes of dates annually, representing 12% of the world's production (FAO, 2008). The dates, one of the most important fruit crops in the UAE, are processed to produce date syrup. Date fiber (**DF**), a by-product remaining after date syrup extraction, contains 51.57% total dietary fiber (Hashim, 2008). The aim of this study was to determine the amount of DF that could be incorporated into yogurt without affecting sensory quality and acceptability. The effect of DF fortification on fresh yogurt quality was estimated based on measurement of acidity, pH, color, texture profile, sensory properties, and consumer acceptance.

MATERIALS AND METHODS

Fresh pasteurized cow's milk and vanilla were purchased from a local supermarket. Milk solid nonfat, commercial stabilizer (Grindsted ES255 Emulsifier and Stabilizer system, Danisco Ingredients, Braband, Denmark), and commercial yogurt culture (YO-FAST-88, Chr. Hansen, Hørsholm, Denmark) were provided by a local dairy company (Al Ain Dairy, Al Ain, UAE). Date fiber was provided by a local date processing factory (Emirates Date Factory, Al Ain, UAE).

Yogurt Making

Yogurt samples were prepared from fresh cow milk in the Food Preparation Laboratory of the Food Sciences Department, United Arab Emirates University, following the procedure used at a local dairy company (Al Ain Dairy). Yogurt was made by dissolving milk solid nonfat (2.5%) and stabilizer (0.6%) in milk. The fiber was added according to the composition of the samples (0, 1.5, 3.0, and 4.5%). The mixture was heated in a water bath at 85°C for 30 min, cooled to approximately 42°C, inoculated with commercial yogurt culture, transferred to plastic cups, incubated at 43°C for 4 h, and stored at 4°C overnight before testing. Control yogurt without date fiber and yogurt containing 1.5% wheat bran (**WB**) were also prepared. Preliminary studies indicated that yogurt containing a high level of DF had a different flavor. Yogurt with the highest DF level was flavored with vanilla (**FDF**) to mask the flavor that might arise from the high level of addition of DF.

pH and Titratable Acidity

The pH of the samples was determined using a digital pH meter (Thermo Orion pH meter, model 420, Waltham, MA). The measurements were done in triplicate.

Titratable acidity, expressed as percentage of lactic acid, was determined by mixing 10 g of yogurt with 20 mL of distilled water and titrating with 0.1 *N* NaOH using phenolphthalein as an indicator to an end-point of faint pink color. The measurements were done in triplicate.

Texture Profile

Texture profile analysis of the yogurt samples was measured using QTS 20 texture analyzer (model QTS20, Brookfield Instruments, Harlow, UK) equipped with a 5-kg load cell. Texture profile analysis was carried out by a compression test that generated plot of force (g) versus time (s). A 25-mm-diameter perplex cylindrical probe was used to measure textural profile of the yogurt samples at 10 ± 0.5°C. In the first stage, the samples were compressed to 10 mm depth and the speed of the probe was fixed at 30 mm/min during the pre-test, compression, and relaxation of the samples. The typical textural profile (force–time) curve was obtained with one complete run. Hardness, gumminess, adhesiveness, cohesiveness, and springiness of yogurt samples were calculated by the software program (TexturePro software, Brookfield Instruments). The data presented are average of 5 replications.

Color

The color parameters L*, a*, b* values were measured by using a colorimeter (ColorFlex, HunterLab, Reston, VA). A white tile was used for standardization. Three replications were conducted.

Sensory Evaluation

Thirty-three panelists consisting of students and staff of the university were recruited and instructed on how to perform sensory evaluation. The evaluation was conducted in partitioned sensory evaluation booths at the Department of Food Science (UAE University, United Arab Emirates). Yogurt samples were presented in white plastic cups under fluorescent light. All samples were marked with 3-digit codes, and the order of pre-

Table 1. Acidity, pH, and color of yogurt fortified with date fiber (means ± SD)

Treatment[1]	Acidity, % lactic acid	pH	Color[2]		
			L*	a*	b*
Control	1.04 ± 1.0[a]	4.47 ± 0.06[b]	95.5 ± 0.3[a]	−0.8 ± 0.6[d]	9.1 ± 0.4[c]
1.5% WB	1.08 ± 1.8[a]	4.64 ± 0.03[a]	89.3 ± 0.3[b]	0.8 ± 0.7[c]	11.1 ± 0.2[b]
1.5% DF	1.08 ± 1.8[a]	4.61 ± 0.02[a]	84.8 ± 1.1[c]	2.7 ± 0.4[b]	9.7 ± 0.4[c]
3.0% DF	1.08 ± 1.8[a]	4.63 ± 0.04[a]	80.1 ± 1.2[d]	4.1 ± 0.6[a]	11.0 ± 0.3[b]
4.5% DF	1.07 ± 1.8[a]	4.65 ± 0.02[a]	75.4 ± 0.9[e]	4.9 ± 0.8[a]	12.4 ± 0.3[a]
4.5% FDF	1.05 ± 1.8[a]	4.67 ± 0.02[a]	75.5 ± 1.1[e]	5.0 ± 0.4[a]	12.2 ± 0.4[a]

[a–e]Means within a column followed by different superscript letters differ ($P \leq 0.05$).

[1]WB = yogurt made with wheat bran; DF = yogurt made with date fiber; FDF = yogurt made with date fiber and flavored with vanilla.

[2]L* = lightness; a* = redness (+) and blueness (–); b* = yellowness.

sentation of samples was randomized for each panelist. The panelists rated appearance, color, firmness (texture or body), smoothness, sweetness, sourness, flavor, and overall acceptance using a 9-point hedonic scale (1 = dislike extremely and 9 = like extremely).

Statistical Analysis

Data analysis was conducted using SPSS Statistical Software (version 13.5, SPSS Inc., Chicago, IL). Sensory data were statistically tested using ANOVA to determine if a statistical difference existed ($P \leq 0.05$) and the least significance difference was used for means comparison.

RESULTS AND DISCUSSION

Table 1 shows acidity, pH, and color values of fresh yogurt fortified with fiber. Yogurts fortified with DF or WB had similar acidity (1.07–1.08) as control yogurt (1.04). Similar results were reported for yogurt fortified with oat fiber (Fernández-García et al., 1998) and natural or toasted wheat bran (Aportela-Palacios et al., 2005). Yogurt fortified with 4.5% DF and flavored with vanilla had similar acidity (1.05) as the control and unflavored DF yogurts. Aportela-Palacios et al. (2005) reported that yogurts fortified with natural or toasted wheat bran and flavored with pineapple or piña colada had similar acidity. Acidity of yogurt was not significantly affected by fiber (DF and WB) and flavor addition.

The pH of yogurts fortified with DF ranged from 4.61 to 4.67, which is similar to the pH of yogurt fortified with WB (4.64). Increasing the DF level had no effect on yogurt pH. Yogurts fortified with DF or WB had significantly higher pH compared with that of control yogurt (4.47). Although addition of fiber had no effect on yogurt acidity and lactobacilli counts, it increased the pH. A similar result was reported for yogurt fortified with 1.32% oat fiber. Oat fiber yogurt had a significantly higher pH (4.31) compared with control yogurt (4.17; Fernández-García et al., 1998), whereas Staffolo et al. (2004) reported that addition of commercial apple, wheat, bamboo, or inulin fibers had no effect on yogurt pH. We have no explanation for this effect other than to attribute it to the type of fiber. Flavoring yogurt fortified with 4.5% DF with vanilla had no effect on pH. Flavored and unflavored yogurts fortified with 4.5% DF had similar pH.

Yogurt color was affected by the addition of DF or WB. The date fiber had a brownish color, whereas the wheat bran had a yellowish color. Yogurts fortified with DF or WB had significantly higher a* and b* values and lower L* values compared with the control yogurt. Increasing the DF level increased a* and b* values and decreased L* values significantly. Yogurts fortified with DF had significantly lower L* values and higher a* values compared with WB yogurt. Yellowness of the yogurt depends on the level of DF. Yogurt fortified with 3% DF had similar b* values as WB yogurt. Yogurt fortified with 1.5% DF had significantly lower b* values compared with WB yogurt, whereas yogurt fortified with 4.6% had significantly higher b* values. Similar results were reported for yogurts fortified with commercial apple fiber (Staffolo et al., 2004), orange fiber (García-Pérez et al., 2005), and asparagus fiber (Sanz et al., 2008). Yogurt fortified with DF had a brownish color, whereas yogurt fortified with orange fiber or apple fiber had a yellowish color and that fortified with asparagus fiber had a yellow-greenish color. Staffolo et al. (2004) reported that fortification with commercial wheat, bamboo, or inulin fibers had no effect on yogurt color. This indicated that yogurt color is dependent on the color of the fiber source. Flavoring 4.5% DF yogurt with vanilla had no effect on yogurt color. Flavored and unflavored yogurts fortified with 4.5% DF had similar color values.

Texture properties of yogurt fortified with fiber are presented in Table 2. Yogurt fortified with 1.5% DF

Table 2. Texture properties (means ± SD) of yogurt fortified with date fiber

Treatment[1]	Hardness, g	Gumminess, g	Adhesiveness, g·s	Cohesiveness	Springiness, mm
Control	37.5 ± 3.1[c]	20.8 ± 1.8[c]	−76.1 ± 13.5[a]	0.56 ± 0.01[a]	7.4 ± 0.09[b]
1.5% WB	47.6 ± 1.9[b]	25.6 ± 1.4[b]	−101.2 ± 10.8[b]	0.54 ± 0.01[ab]	7.7 ± 0.16[a]
1.5% DF	36.5 ± 3.5[c]	20.9 ± 1.9[c]	−64.0 ± 11.9[a]	0.55 ± 0.01[ab]	7.3 ± 0.26[b]
3.0% DF	55.0 ± 5.4[a]	29.0 ± 2.6[a]	−175.7 ± 39.2[c]	0.53 ± 0.02[b]	7.6 ± 0.16[a]
4.5% DF	57.0 ± 5.0[a]	30.4 ± 2.5[a]	−180.4 ± 29.1[c]	0.53 ± 0.01[b]	7.7 ± 0.18[a]
4.5% FDF	49.2 ± 4.3[b]	26.4 ± 2.7[ab]	−134.4 ± 16.0[b]	0.54 ± 0.01[ab]	7.6 ± 0.17[a]

[a–c]Means within a column followed by different superscript letters differ ($P \leq 0.05$).

[1]WB = yogurt made with wheat bran; DF = yogurt made with date fiber; FDF = yogurt made with date fiber and flavored with vanilla.

had similar textural properties (hardness, gumminess, adhesiveness, cohesiveness, and springiness) as control yogurts. Although the addition of 1.5% DF had no effect on yogurt texture, 1.5% WB yogurt had significantly higher hardness, gumminess, and springiness values and a significantly lower adhesiveness value compared with the control. Fortifying yogurt with 3.0% DF had significant effect on the textural properties. Hardness, gumminess, and springiness increased and adhesiveness and cohesiveness decreased significantly. Increasing the hardness may be related to DF absorbing more moisture because of its higher water-holding capacity. Yogurt fortified with 3 or 4.5% DF had similar textural properties showing that increasing DF level to 4.5% had no significant effect on yogurt texture. The use of a 1:1 ratio of inulin to galactomannan produced yogurt with the highest curd tension (Hassan et al., 1999), and addition of β-glucan (0.5%), partially hydrolyzed guar gum, and inulin (2%) improved the texture and rheological properties of low-fat yogurt (Brennan and Tudorica, 2008). Flavoring 4.5% DF yogurt with vanilla (to improve yogurt flavor) decreased the hardness and increased adhesiveness significantly without affecting gumminess, cohesiveness, or springiness; we have no explanation for this effect. Aportela-Palacios et al. (2005) reported that yogurt flavored with piña colada was more viscous than that flavored with pineapple.

Table 3 presents sensory quality and consumer acceptance of yogurt fortified with fiber. Fortifying yogurt with DF had a significant effect on all sensory properties except sweetness. Yogurt fortified with DF had significantly lower ratings for appearance, color, and flavor. Firmness, smoothness, sourness, and overall acceptance ratings depended on the level of fortification. Yogurt fortified with up to 3% DF had similar firmness, smoothness, sourness, and overall acceptance ratings as control yogurt. Increasing DF fortification level to 4.5% decreased firmness, smoothness, sourness, and overall acceptance ratings significantly compared with control yogurt. Yogurt fortified with WB was significantly different compared with control yogurt. Although WB- and DF-fortified yogurts had similar ratings for appearance, color, firmness, and smoothness, the WB-fortified yogurts had significantly lower ratings for sweetness, sourness, flavor, and overall acceptance. Fernández-García et al. (1998) reported that fiber addition improved the body and texture of unsweetened yogurt and decreased overall flavor quality. Yogurts fortified with wheat, bamboo, or inulin fibers were acceptable and had similar sensory properties as plain yogurt (Staffolo et al., 2004) and citrus fiber–enriched fermented milk was reported to be acceptable (Sendra et al., 2008).

Flavoring yogurt fortified with 4.5% DF had no effect on sensory quality and acceptability. Flavored and unflavored yogurts fortified with 4.5% DF had similar sensory quality and acceptability ratings.

CONCLUSIONS

Fortifying yogurt or dairy products with fiber is of great interest to improve the functionality and create

Table 3. Sensory quality and acceptability[1] of yogurt fortified with date fiber (n = 33)

Treatment[2]	Appearance	Color	Firmness	Smoothness	Sweetness	Sourness	Flavor	Overall acceptance
Control	8.3 ± 0.7[a]	8.5 ± 0.7[a]	7.6 ± 1.4[a]	7.5 ± 1.2[a]	6.9 ± 1.1[a]	7.4 ± 1.0[a]	7.5 ± 1.2[a]	7.4 ± 1.2[a]
1.5% WB	6.2 ± 2.2[b]	6.2 ± 1.9[b]	6.0 ± 2.2[b]	6.1 ± 1.9[b]	3.4 ± 1.5[b]	4.3 ± 1.8[d]	3.3 ± 1.4[d]	4.2 ± 1.6[d]
1.5% DF	6.2 ± 1.0[b]	6.3 ± 1.3[b]	6.7 ± 1.1[ab]	6.6 ± 1.1[ab]	5.9 ± 1.4[a]	6.5 ± 1.2[ab]	6.1 ± 1.2[b]	6.8 ± 1.0[ab]
3.0% DF	6.4 ± 0.7[b]	6.2 ± 1.1[b]	6.6 ± 1.1[ab]	6.7 ± 1.2[ab]	6.2 ± 1.1[a]	6.5 ± 1.4[ab]	5.9 ± 1.2[bc]	6.8 ± 0.9[ab]
4.5% DF	6.5 ± 0.7[b]	6.2 ± 0.7[b]	5.9 ± 1.0[b]	6.2 ± 1.1[b]	5.9 ± 1.1[a]	5.4 ± 1.2[c]	5.1 ± 1.2[c]	5.8 ± 0.9[bc]
4.5% FDF	6.0 ± 1.3[b]	5.8 ± 1.4[b]	5.9 ± 1.5[b]	6.4 ± 1.2[b]	5.9 ± 1.0[a]	5.4 ± 1.4[c]	5.0 ± 1.4[c]	5.3 ± 1.1[c]

[a–d]Means within a column followed by different superscript letters differ ($P \leq 0.05$).

[1]A 9-point hedonic scale was used where 1 = dislike extremely and 9 = like extremely; mean ± SD.

[2]WB = yogurt made with wheat bran; DF = yogurt made with date fiber; FDF = yogurt made with date fiber and flavored with vanilla.

functional foods with health benefits. The addition of dietary fiber to yogurt would complement its healthy characteristics. This study has shown that fortifying yogurt with 3% DF produced an acceptable product with potential beneficial health effects.

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