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THE EFFECT OF THE DIFFERENT CONCENTRATIONS OF WHEAT FIBER AND GELATIN ON SELECTED PHYSICOCHEMICAL, TEXTURAL AND SENSORY PROPERTIES OF FAT-FREE CONCENTRATED FLAVORED YOGURT

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ABSTRACT

The aim of the present research was to incorporate different concentrations of gelatin (0.025, 0.05 and 0.1, w/w) and wheat fiber (1, 1.5 and 2%, w/w) into free-fat flavored concentrated flavored yogurt and to compare physicochemical (titratable acidity, dry matter, syneresis and viscosity), textural (hardness and adhesiveness) and sensory (mouth feel, texture, stickiness, flavor, odor and overall acceptability) properties of such yogurts prepared to full-fat flavored concentrated yogurt, control, on day 1 of storage. From the overall results of replacement of fat with gelatin and wheat fiber in flavored concentrated yogurt, it could be concluded that gelatin and wheat fiber can improve the texture and sensory properties of fat-free concentrated yogurt and that preferred sample is fat-free flavored concentrated yogurt containing 0.1% gelatin and 1.5% wheat fiber.

Keywords: fat-free concentrated yogurt, gelatin, wheat fiber, physicochemical properties, Sensory analysis

INTRODUCTION

Fat plays an important role in controlling the firmness/viscosity (McCann *et al.*, 2011; Arno *et al.*, 2009; Mandujano *et al.*, 2009; Lobato-Calleros *et al.*,2004) and perceived creaminess of yogurt (Arno *et al.*, 2009; McCann *et al.*, 2011). A poor texture leading to poor quality and/or decreased flavor intensity (Guggisberg *et al.*, 2011; McCann *et al.*, 2011) and higher syneresis (McCann *et al.*, 2011) have been observed due to the low level of fat in yogurt.

The addition of stabilizer to low fat yogurts improves body and texture, appearance (Kumar and Mishra, 2004) and mouth feel (Kumar and Mishra, 2004; Arno *et al.*, 2009) and delays whey separation. Stabilizers have two basic functions in yogurt: the binding of water and improvements in texture (Kumar & Mishra, 2004).

Gelatin is a well-known ingredient in low-fat yogurts, due to its melting behavior at body temperature (Arno *et al.*, 2009). Gelatin has a neutral taste and does not have an E additive number. The results of Fiszman *et al.* (1999) demonstrated the suitability of the use of gelatin to improve the quality of milk products. The addition of gelatin to the milk during preparation of the yogurt changed the microstructure of the product by the formation of flat sheets or surfaces which interacted with the casein matrix, enclosing granules of casein in several zones. The gelatin seemed to connect the granules and chains of milk proteins, and consequently create a continuous, fairly homogeneous double network structure with no free ends. This more interconnected network would retain the aqueous phase more efficiently, reducing the drainage of liquid.

In recent years, dietary fiber has been much attention from researchers and industry due to the possible beneficial effects on the decrement of cardiovascular (Prosky, 2001) and diverticulitis diseases ,blood cholesterol (Borderias *et al.*, 2005; Dubois *et al.*, 2003; Jenkins *et al.*, 2002), diabetes (Panlasigui *et al.*, 2006; Jenkins *et al.*, 2002; Bach Knudsen, 2001), and colon cancer (Hu *et al.*, 2009; Rodrı´guez *et al.*, 2006; Azizah and Yu, 2000). In addition to nutritional effects, dietary fiber has functional properties such as water binding capacity (WBC) and fat binding capacity (FBC). So, addition of dietary fiber to a wide range of products will contribute to the development of value-added foods or functional foods that currently are in high demand (Day *et al.*, 2009; Hu *et al.*, 2009; Shahidi, 2009; Sudha *et al.*, 2007; Parrrado, 2006; Pacheco de Delahaye *et al.*, 2005; Quershi *et al.*, 2002); also, it can give these functional properties to the foods.

The objective of this work was to use different concentrations of wheat fiber (1, 1.5 and 2%, w/w) and gelatin (0.025, 0.05 and 0.1%, w/w)) along with milk protein concentrate (2.5%, w/w) and pectin (0.05%, w/w) in the production of fat-free concentrated flavored yogurt; then, to determine the influence of various concentrations of

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these additives on physicochemical, textural and sensory characteristics of final product and compare the properties of experimental samples to each other and the control, full-fat concentrated flavored yogurt, for selecting the preference sample.

MATERIALS AND METHODS

Additives

The following additives are involved in the production of fat-free concentrated yogurt samples:

- Pectin (HM, Powdery, Danisco, Denmark).
- Milk protein concentrate (MPC), 70% (IDAHOO, Powdery, IDAHOO MILK PRODUCTS, USA).
- Wheat fiber (VITACELL, Powdery, JRS, Germany).
- Gelatin (Powdery, JELITA, Brazil).
- Vegetables (Grandis, flaked, Lale Bahare Hamedan, Iran).
- Salt (Pousan, Powdery, Pars namake Kaveh, Iran).
- Garlic (Grandis, Granular, Lale Bahare Hamedan, Iran).

Starter culture:

Commercial yogurt culture (containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*), L811-381, was obtained from Chr.Hansen, Denmark.

Preparation of fat-free concentrated flavored yogurt samples

The following steps are involved in the production of concentrated yogurt samples:

- Standardization of the fat and solids-non-fat contents to 1.5% and 8.73%, respectively. It was noted that standardization of the milk fat content in the control sample was conducted to 3.5%.
- Homogenization (180bar/50 °C).
- Cooling to 2-5 °C.
- adding gelatin, MPC, pectin (Table 1).
- Mixing (2-5 °C, 5 min; Mixer Seven, 5000 rpm, Turkey).
- Hydration (2-5 °C, 1 h).
- Heat treatment at 50-72°C for 15 min, and then; at 90 °C for 5 minutes.
- Cooling to 44 °C.
- Inoculation with 2% (w/w) of yogurt culture in a freeze dried direct vat set (DVS).
- Incubation at 44 °C for 4 h, to pH 4.2.
- Cooling to the storage temperature, 5 °C.
- Adding vegetables and garlic (0.5%, w/w), salt (0.5%, w/w) and wheat fiber (Table 1).
- Mixing.
- Packing into 500-g plastic cups.

Flavored concentrated yogurt samples were produced in triplicate, and results were the averages of three replicates.

Table 1. Treatments used in the study.

Treatments	Pectin (% w/w)	Gelatin (% w/w)	Milk Protein concentration (% w/w)	Wheat fibre (% w/w)
T1	0.05	0.025	2.5	1
T2	0.05	0.025	2.5	1.5
T3	0.05	0.025	2.5	2
T4	0.05	0.05	2.5	1
T5	0.05	0.05	2.5	1.5
T6	0.05	0.05	2.5	2
T7	0.05	0.1	2.5	1
T8	0.05	0.1	2.5	1.5
T9	0.05	0.1	2.5	2
TC (control)	--	--	4	--

Physicochemical analyses

Concentrated flavored yogurt samples were analyzed for titratable acidity and dry matter according to Standard AOAC, 2002 and 1995, respectively. Viscosity of concentrated yogurts was measured at 4°C using a Brookfield DV-II + Pro viscometer (Brookfield Engineering Laboratories, USA). The Viscometer was operated at 20 rpm with spindle number 4 after 30s (Cinbas andYazici, 2008). Syneresis was determined by the method of AL-Kadamani *et al.* (2003). All analyses were replicated thrice, on the 1^{st} day of storage at 5°C.

Textural analyses

Textural properties were measured with a Texture Analyzer (M350-10CT, ROCHDAL ENGLAND, England). Hardness and adhesiveness were evaluated by Yazici and Akgun (2003) method. The measurements were performed three times, on the 1^{st} day of storage at 5°C.

Sensory evaluation

Sensory evaluation was carried out using a five–point hedonic scale (1= very poor, 5= very good) by 5 trained panelists who were the experts of Food & Drug Laboratory (Qom province, Iran) for texture, stickiness, flavor, odor, mouth feel and overall acceptability of experimental concentrated yogurts.

Statistical analysis

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

RESULTS AND DISCUSSION

Physicochemical properties of fat-free concentrated flavored yogurt samples

Acidity of fat-free concentrated flavored yogurt samples:

Values of lactic acid production in samples produced are shown in Table 2. In all treatments, adding fiber and increasing its content led to decline acidity ($p<0.05$). It could be due to high absorption of water by fiber and the water becomes unavailable for starter cultures. This may probably the reason for reduction of the starter activity (Tamime and Robinson, 1999) and lactic acid production. Gelatin at a concentration of 5% decreased acidity; however, higher level of gelatin increased it ($p<0.05$). These observations are in line with those of Pradyuman and Mishra (2003), who reported that stabilizer addition increased partially acidity of soy fortified set yogurt.

The lowest and highest acidity were observed in T4 and the control, respectively. High acidity in the control could be attributed to positive influence of dry matter on the growth of the lactic acid bacteria, as well as, high protein content in comparison to other samples. It was in concordance with the findings of Yazici and Akgun (2003), who demonstrated using some protein based fat replacers in stirred yogurt led to increasing acidity, and Oliveria *et al*. (2001), who found that hydrolyzed casein increased acid production of starter bacteria. This is in contrast to the result obtained by Dello Staffoloa *et al*., (2004), who found that pH of Yogurt fortified with wheat fiber was stable with storage time. In contrast to our findings, Fernandez-Garcia and McGregor (1997) found an acceleration in the acidification rate of yogurts containing soy I and II, sugar beet and rice fibers compared with control. They reported that some fibers can have supplied nutrients or growth stimulant factors for the starter culture.

Dry matter of fat-free concentrated flavored yogurt samples:

Adding fat replacers and increasing their content led to raise dry matter. The lowest and highest dry matter were observed in T1 and T9, respectively (Table 2). This result is in agreement with results obtained by Pradyuman and Mishra (2003), who observed type and rate of stabilizer affected significantly dry matter; and Yazici and Akgun (2003), who found that some protein based fat replacers in low fat yogurt led to an increase in dry matter.

Syneresis of fat-free concentrated flavored yogurt samples:

As shown in Table 2, the syneresis decreases with increasing fat replacers concentration and it reaches the highest and the lowest value at 59/790± 4/567and 4/050±4/786 for the control and T9, respectively. This finding was similar to that of Dello Staffoloa *et al*.,(2004), who observed no syneresis in yogurt samples enriched with commercial fibers, such as wheat fiber.

Viscosity of concentrated flavored yogurt samples:

As the fat replacers content in yogurt increased, viscosity values increased (Table 2). Increased viscosity in the fat-free samples containing fat replacers can be explained by the binding of water and improvement in texture (Kumar and Mishra, 2004). Also, the viscosity increase has been attributed to interactions between the exogenous hydrocolloids and dairy proteins (Fernandez-Garcia & McGregor, 1997). The control had higher viscosity than the other samples. It is presumably due to the formation of a larger number of smaller fat particles during homogenization when they are stabilized by milk proteins and interact with the protein matrix (McCann *et al.*, 2011; Arno *et al.*, 2009; Mandujano *et al.*, 2009).The increased protein content in the control could be another reason for this. The lowest viscosity was observed in T7. This observation is in line with those of Sendra *et al*. (2010), who reported that viscosity of yogurt increased with increasing orange fibre content.

Textural properties of fat-free concentrated flavored yogurt samples

Hardness values were shown in Table 3. Adding fat replacers and increasing their concentration resulted in increment of hardness ($p<0.05$). This could be related to enhancement of dry matter content. So, the lowest and highest hardness were observed in T1 and T9, respectively. This result is in agreement with results obtained by Radi *et al.* (2009), who found that wheat starch affected positively firmness of low-fat yogurt. Similar results were also observed by Fiszman *et al.,* (1999), who demonstrated positive effect of gelatin on firmness of yogurt and acidified milk, and Pradyuman and Mishra (2003), who demonstrated positive effect of gelatin on soy yogurt.

An increase in the concentration of fat replacers induced a significant decrease in adhesiveness ($p<0.05$). Decreases in adhesiveness appear to be related to the formation of a weak three-dimensional network caused by increasing hydrocolloid concentration. Probably, the high content of fiber was reflected in the low adhesiveness values for those samples and producing yogurt with soft and very low rubbing texture (Table 3). The results revealed a contrary relationship between adhesiveness and hardness. The lowest and highest adhesiveness were observed in T9 and T1, respectively.

Sensory evaluation of concentrated flavored yogurt samples

Table 4 shows the organoleptic evaluation of the different treatments of flavored concentrated yogurt. According to results of ranking tests done by sensory panelists, samples containing higher amounts of fat replacer received the highest scores in mouth feel, texture, stickiness, flavor and odor. Panelists did not differentiate overall acceptability ($p>0.05$) between the control, T8 and T9. The average scores for overall acceptability were 5/00±0.00, 5/00±0.00 and 4.80±0.44, respectively, for control, T8 and T9. It revealed that these fat replacers within the ranges used can play the role of fat in fat-free concentrated yogurt. This is in accordance with other studies, which have shown that sensory analysis did not detect any difference between yogurt fortified with wheat fiber and the control (Dello Staffoloa *et al*., 2004).

Conclusion

The current study showed the beneficial effect of gelatin and wheat fiber on the texture of fat-free concentrated yoghurt. The fat-free concentrated flavored yogurt incorporation with 0.1% gelatin, 1.5% wheat fiber, 2.5% milk protein concentrate and 0.05% pectin was ranked the most preferred by panelists. The results showed that it was possible to make a fat-free concentrated flavored yogurt with physicochemical, textural and sensory attributes similar to those in the control, full-fat concentrated flavored yogurt.

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Table 2. Physicochemical characteristics (mean ± SD) of experimental treatments*

Treatment	T1	T2	T3	T4	T5	T6	T7	T8	T9	TC
Acidity (°Dornic)	122/000±3/60^{bc}	121/000±1/000^{dc}	118/333±1/154de	115/666±1/154^{e}	117/0000±1/732^{e}	116/000±1/732^{e}	125/333±1/527^{b}	124/333±1/527 ^{be}	124/6666±2/081 ^{b}	129/666±2/516 ^{a}
Dry matter (g/100g)	13/500±0/200^{C}	13/626±0/110^{c}	13/766±0/208^{c}	13/566±0/115 ^{c}	13/733±0/057 ^{C}	13/800±0/300 ^{c}	14/233±0/305 ^{b}	14/766±0/115 ^{a}	14/933±0/152 ^{a}	13/550± 0/108^{c}
Syneresis (g/100g)	58/800±1/837	57/390±3/538	53/363±1/803	56/796±5/607	55/280±7/270	51/450±4/952	55/890±6/271	53/173±2/766	49/050±4/786	59/790± 4/567
Viscosity (Pa.s)	7/708±1/692 ^{d}	9/837±3/117 ^{cd}	13/726±4/176 ^{c}	7/248±0/606 ^{d}	7/798±1/425 ^{d}	18/015±4/659 ^{b}	6/478±0/844 ^{d}	7/698±1/182 ^{d}	8/988±0/121 ^{d}	29/044±0/349 ^{a}

*Means within the same row with different superscript letters differ significantly (P<0.05).

Table **3**. Rheological characteristics (mean ± SD) of experimental treatments*

Treatment	T1	T2	T3	T4	T5	T6	T7	T8	T9	TC
Hardness (N)	0/173±0/004^{f}	0/185±0/009^{f}	0/316±0/009^{cd}	0/288±0/006^{e}	0/304±0/006^{d}	0/321±0/006^{bc}	0/302±0/005^{d}	0/322±0/014^{bc}	0/374±0/007^{b}	0/369±0/004^{a}
Adhesiveness (N)	0/398±0/005 ^{a}	^{b} 0/356±0/007	0/155±0/006 ^{de}	0/164±0/007 ^{d}	0/161±0/009 ^{ed}	0/150±0/007 ^{def}	0/164±0/010 ^{d}	0/148±0/006 ^{ef}	0/137±0/004 ^{f}	0/266±0/008 ^{c}

*Means within the same row with different superscript letters differ significantly (P<0.05).

Table **4**. Sensory properties (mean ± SD) of experimental treatments *

Treatment	T1	T2	T3	T4	T5	T6	T7	T8	T9	TC
Mouth feel	2.80± 0.44 ^{c}	2.80± 0.44 ^{c}	4.00±0.00 ^{ab}	2.80± 0.44 ^{c}	3.80± 0.83 ^{b}	4.20± 0.44 ^{ab}	4.20± 0.44 ^{ab}	4.60± 0.54 ^{a}	4.20± 0.44 ^{ab}	4.40±0.54 ^{ab}
Stickiness	2.60± 0.00 ^{e}	3.00± 0.00 ^{ed}	4.20± 0.44 ^{bc}	3.40± 0.54 ^{d}	3.60± 0.54 ^{dc}	4.60± 0.54 ^{ab}	4.20± 0.44 ^{bc}	5.00± 0.00 ^{a}	4.60± 0.54 ^{ab}	4.80± 0.44 ^{ab}
Texture	2.00± 0.00 ^{f}	2.60± 0.00 ^{e}	4.20± 0.44 ^{bc}	3.20± 0.44 ^{d}	4.00± 0.00 ^{c}	4.60± 0.54 ^{ab}	4.00± 0.00 ^{c}	4.80± 0.44 ^{a}	4.80± 0.44 ^{a}	4.80± 0.44 ^{a}
Flavor	4.00±0.70 ^{c}	4.20± 0.44 ^{bc}	3.80± 0.44 ^{c}	4.000±0.00^{c}	4.80± 0.44 ^{ab}	4.20± 0.44 ^{bc}	4.80± 0.44 ^{ab}	5/00± 0.00 ^{a}	5/00± 0.00 ^{a}	5/00± 0.00 ^{a}
Aroma	4.00±0.70 ^{ab}	4.40±0.54 ^{ab}	3.40± 0.54 ^{c}	3.80± 1.09 ^{bc}	4.40± 0.54 ^{ab}	4.40± 0.54 ^{ab}	4.60± 0.54 ^{ab}	4.80± 0.44 ^{a}	4.40±0.54 ^{ab}	4.80± 0.44 ^{a}
Overall acceptability	2.60± 0.00 ^{e}	3.00± 0.00 ^{d}	4.00±0.00 ^{c}	3.00± 0.00 ^{d}	4.00±0.00 ^{c}	4.40±0.54 ^{c}	4.00±0.00 ^{c}	5/00± 0.00 ^{a}	4.80± 0.44 ^{a}	5/00± 0.00 ^{a}

*Means within the same row with different superscript letters differ significantly (P<0.05).