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Physicochemical, Textural and Sensory Properties of Low-Fat Yogurt Produced by Using Modified Wheat Starch as a Fat Replacer

[1]M. Radi, [2]M. Niakousari and [1]S. Amiri
[1]Department of Food Science and Technology,
Islamic Azad University of Yasooj, Yasooj, Iran
[2]Department of Food Science, Agricultural College, Shiraz University, Shiraz, Iran

Abstract: Low fat (1.6% fat) and non fat yogurts were manufactured from acid treated wheat starch and acid treated cross-linked wheat starch at concentrations of 1.6 and 3.2%. Yogurt samples were manufactured with skim milk (or whole milk for the control and yogurts with 1.6% fat), non fat skim milk powder, yogurt cultures and modified starch. After homogenization, pasteurization and cooling, yogurt mixed were inoculated, poured in to the containers, incubated for approximately 3 h and cooled to 4°C. Titrable acidity, amount of syneresis, texture firmness and sensory scores were determined during storage. Acid treated cross linked starch (1.6%) were more firm than the control, followed by acid treated cross linked starch (3.2%). The yogurts treated with acid treated starch, had a very soft texture which were unacceptable. The full fat yogurts received the highest flavor scores that was followed by acid treated cross linked starch yogurts at 1.6 and 3.2% starch concentration, respectively. Addition of modified starch decreased the water release of the yogurts significantly. As the concentration of starch increased, the syneresis decreased. Good quality non fat and low fat yogurts can be produced by supplementing acid treated cross linked starch. The added starch assists in providing a firm body and minimal whey separation without the use of any other stabilizer.

Key words: Yogurt, wheat starch, fat replacer, modification, cross linking

INTRODUCTION

Low fat and nonfat yogurts have gained popularity in recent years because of the increasing demand for low calorie products (Mistry and Hassan, 1992). Reduced-fat yogurts can be produced by replacing partially the fat content of the milk base with low calorie products known as fat replacers. The fat replacers Simplesse 100 (Microparticulated Whey Protein (MWP)) and Anhydrous Milk Fat (AMF) become an integral part of yogurt microstructure, but the fat replacer particles appear to be larger than the milk fat globules. This fact can explain the higher serum separation and lower firmness of set-style yogurts containing the MWP than those containing AMF (Sandoval-Castilla *et al.*, 2004). Fat replacers exhibit diverse functional, structural and sensory characteristics so it is appropriate to consider their application in the form of blends. However, the blends to be used should be carefully studied prior to recommending their application (Sandoval-Castilla *et al.*, 2004). Non-dairy ingredients, especially polysaccharides such as pectin and starches can also be used in yogurt in conjugation with dairy ingredients or on their own (Oh *et al.*, 2007). The present investigation was carried out to examine the effect of modified starch as a fat replacer in different proportions upon the texture and flavor of reduced-fat yogurt, in comparison to the full-fat yogurt.

MATERIALS AND METHODS

Materials: Commercial grade wheat starch was purchased from Fars Glucosin Co., Shiraz, Iran.

Phosphoryl chloride ($POCl_3$) was obtained from Sigma Chemicals (St. Louis, MO).

Methods

Modification of wheat starch

Acid Treated Starch (ATS): starch (50 g, db) was slurried for 2 h at 25°C in 1 M hydrochloric acid (pH = 0), followed by addition of 1 M sodium hydroxide until the slurry reached pH = 5.5.

Preparation of Acid Treated Cross-Linked Starch (ATCLS): after neutralizing the starch slurry in earlier stage, sodium sulfate (1 g) was added, followed by

Corresponding Author: Mehrdad Niakousari, Department of Food Science and Technology, Agricultural College, Shiraz University, Shiraz, Iran Tel: 0989173001030 Fax: 0987117206376

addition of 1 M sodium hydroxide until the slurry reached pH = 11. $POCl_3$ (0.1% w/w, starch basis) was injected with a microliter syringe into the starch slurry and after 1 h, the slurry was adjusted to pH = 5.5 with 1 M hydrochloric acid. The modified starches were recovered by centrifuging (15000 x g, 10 min), washing with water (100 mL, 2x) and drying at 40°C (Woo and Seib, 2002).

Preparation of yogurt mix: In this Experiment, nonfat yogurts were made by blending skim milk, Skim Milk Powder (SMP) and modified starch in varying concentrations to produce mixes with 3.2% fat content in the control and 1.6 and 0% in the modified starch-supplemented mix. Control was made from raw whole milk with fat content of 3.2%, fortified with SMP to obtain approximately 14% total solids. Nonfat yogurts were made by blending skim milk, ATCLS (or ATS) and SMP in varying concentrations to produce mixes with fat content of zero, starch content of 3.2% and total solids of approximately 14%. For producing low fat yogurts a proper portion of skim milk, whole milk, ATCLS (or ATS) and SMP was used to get a mixture with fat content of 1.6% and approximately 14% total solids.

After blending, the mixes were homogenized with a hand-operated homogenizer (Fisher Scientific Co., Eden prairie, MN, USA). Each mix was pasteurized at 90°C for 10 min (12), cooled to 40°C and inoculated with 2% yogurt starter (commercial plain yogurt). Mixes were incubated at 40°C for approximately 3 h and then cooled to 4°C and hold for 24 h.

Chemical analysis: Yogurts were analyzed for total protein by the Kjeldahl method, fat by Gerber method and total solids by oven drying. Titratable acidity of yogurts was determined every three days by titrating 9 g of yogurt with 0.1 N NaOH to a pink endpoint using phenolphthalein indicator (AOAC, 1995).

Total calorie values (Cal) were calculated using the Atwater method. The following equation was used for calculation (Cengiz and Gokoglu, 2005):

$$K = [(Fp \times P)+ (F_l \times L)+(Fc \times C)]$$

where, K is the calorie; F the multiplication factor for each component (Fp: 4.27 for protein, F_l: 9.02 for lipid, Fc: 4.10 for carbohydrate); P the protein content (g/100 g); C the carbohydrate content (g/100 g) and L the lipid content (g/100 g).

Syneresis measurements: The extent of syneresis with some modification was measured as described by Olson and Aryana (2008). A funnel was lined with cheesecloth and placed on a 10 mL graduated cylinder and a 15 g sample of yogurt at approximately 5°C was placed in the funnel. After 20 min, the volume of whey drained into the graduated cylinder was measured. The amount of syneresis was determined every 3 days.

Texture: Firmness of fresh and 2-weeks-old yogurts (4°C) was measured with a penetrometer (model 431, Precision Scientific Co., Chicago). The device uses a cylindrical probe with 7.7 mm diameter and 77 mm length. The force (expressed as grams) needed for the penetration of probe into the sample at the 0.2 mm sec^{-1} speed and 3 mm penetration was reported in firmness. The lower value indicates the softer texture.

Sensory evaluation: Yogurt samples were examined for color, flavor, texture and overall acceptability by 12 experienced panelists selected from members and students of Besat Education and Research Center food science department. The panelists were asked to evaluate fresh and 2 weeks old samples. A hedonic scale of 1 (dislike extremely) to 10 (like extremely) was used for flavor, 1 (very soft) to 7 (very hard) for body and texture, 1 (poor) to 5 (excellent) for color and 1 (poor) to 100 (excellent) for total acceptance. Panelists were also asked to list defects, if any were detected.

Statistical analysis: The experiments were performed in triplicates. Analysis of Variance (ANOVA) was performed using the Duncan's multiple-range test to compare treatment means. Significance was defined at $p<0.05$.

RESULTS AND DISCUSSION

Energy values: Proximate composition of the yogurts manufactured with different concentrations of modified starch and their energy values are shown in Table 1. Energy values of the yogurts ranged from 58.3 to 74.1 Cal/100g. The effect of fat contents on energy values of the yogurts was significant ($p<0.05$). Energy values of the yogurts decreased significantly ($p<0.05$) with reduced fat levels. Fat reductions of 50 or 100% in yogurts were obtained with a consequent decreases in energy values of 10.66 and 21.32%. The lowest energy value was found in

Table 1: Yogurt samples composition and energy content for nonfat, low fat and high fat yogurts

Treatments	Fat (%)	Protein (%)	Total solids (%)	Carbohydrate (%)	Energy values (Cal/100 g)
ATSY (1.6%)	1.6	5.2	14	7.2	66.2
ATSY (3.2%)	0.0	5.2	14	8.8	58.3
ATCLSY (1.6%)	1.6	5.2	14	7.2	66.2
ATCLSY (3.2%)	0.0	5.2	14	8.8	58.3
FFY	3.2	5.2	14	5.6	74.1

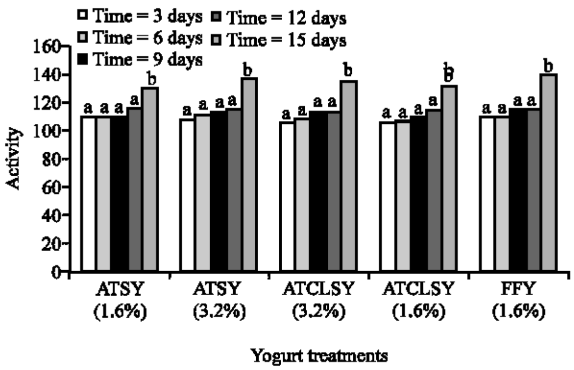

Fig. 1: Acidity values of non fat, low fat and full fat yogurts made from ATS and ATCLS during storage. Mean of triplicates. Column means containing a common letter are not significantly different from each other (p<0.05)

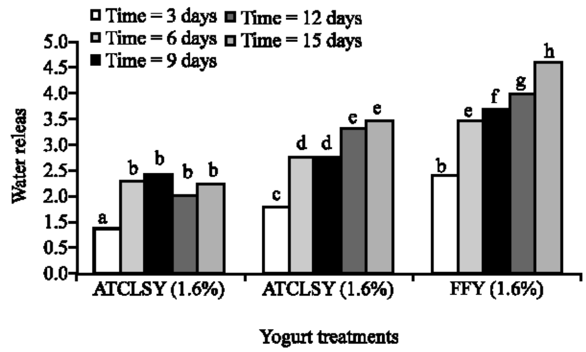

Fig. 2: Water release values of non fat, low fat and full fat yogurts made from ATS and ATCLS during the storage time. Mean of triplicates. Column means containing a common letter are not significantly different from each other (p<0.05)

the ATCLS and ATS (3.2%). Energy values of the yogurts with added ATCLS and ATS at 1.6% were significantly (p<0.05) lower than those of control yogurts (FFY). Addition of ATCLS and ATS significantly (p<0.05) decreased energy values. Woo and Seib (2002) indicated that cross-linked wheat starches could be counted as dietary fiber when assaying a food by the AOAC procedure. Therefore, the energy value of cross-linked wheat starch acted as resistant starch is lower than what is estimated in Table 1.

There were no significant differences in acidity between control and the treated yogurts throughout storage (p<0.05). The acidity of all yogurts increased during storage, but this increment was not significant for all samples until 12 days. After 12 days (Fig. 1), the increase in acidity was significant (p<0.05).

Syneresis: Syneresis was significantly affected by the addition and concentration of starch. The amount of syneresis significantly decreased when the concentration of ATCLS was increased from 0 to 3.2. Syneresis was significantly increased by the storage time, for the FFY and ATCLSY (1.6%). However, the amount of whey separation from the ATCLSY (3.2%) was the least and did not change during two weeks of storage. This may arise from high water binding capacity of starch which reduces free releasable water. The starch may also retrograde that slightly decrease water binding capacity of the molecules but this phenomenon appear to be not important in comparison to the syneresis of protein network during the storage time (Fig. 2).

Texture: The different yogurt samples showed similar texture after two weeks of storage as that of the zero time.

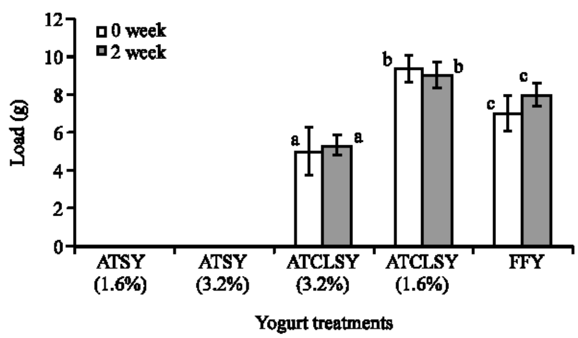

Fig. 3: Texture analysis of non fat, low fat and full fat yogurts made from ATS and ATCLS. Mean of triplicates. Column means containing a common letter are not significantly different from each other (p<0.05)

ATSY exhibited the softest texture so that the device did not report any texture for them. ATCLSY (1.6%) exhibited the highest firmness than ATCLSY (3.2%) and FFY (Fig. 3), however FFY exhibited higher firmness than ATCLY (3.2%) (p<0.05). The particle size of the starch in the yogurt depends on the kind of modification. On the other hand, the concentration of the starch in the yogurt samples differs and has an important relationship to the kind of modification. The positive effect of the starch on texture is achieved until a certain concentration and this is attained by the ability of starch to absorb water. In fact the carbohydrate molecules of starch bind and orient water, that increase the viscosity, but by increasing the concentration, the large size of starch particles (and the high swelling property of them) prohibited formation of a protein network composed of casein chains, which give a more open and loose structure (Sandoval-Castilla *et al.*,

Table 2: Sensory evaluation of non fat, low fat and full fat yogurts made from ATS and ATCLS*

	ATSY (1.6%)		ATCLSY (1.6%)		FFY		ATSY (3.2%)		ATCLSY (3.2%)	
Sensory evaluation	t = 0	t = 14 days	t = 0	t = 14 days	t = 0	t = 14 days	t = 0	t = 14 days	t = 0	t = 14 days
Color	3.1b	3.7b	4.5a	4.7a	5.0a	4.5a	3.2b	3.5b	4.4a	5.0a
Flavor	6.4f	6.0g	9.0b	8.0c	10.0a	9.0b	5.4h	5.0i	7.3d	6.9e
Texture	2.0a	2.0a	5.1b	5.4b	4.9b	5.0b	2.0a	1.5a	5.4b	5.2b
Acceptance	43.6c	40.0c	81.7b	84.5b	100.0a	95.0a	41.7c	42.5c	81.7b	82.5b

*Mean values for a given parameter containing a common letter(s) are not significantly different from each other ($p<0.05$)

2004). This effect is more notable in the case of ATS. The higher water sorption capacity of ATSY and then higher particle swelling and larger particles results in prevention of casein micelles aggregation and formation of the protein network in yogurt. This is why no acceptable curd was formed in the ATSY, even at 1.6% concentration. Woo and Seib (2002) showed that a cross-linked wheat starch with phosphorus oxychloride showed highly restricted swelling. Blends of ATCLS (at low concentration (1.6%)), in addition to casein forming biphasic gelled systems are claimed to possess fat-like characteristic as the yogurts exhibit higher firmness (Sandoval-Castilla *et al*., 2004), but high association of polysaccharide-polysaccharide chains, at higher concentration of ATCLS (3.2%) that did not integrate unto the protein network, inhibited milk protein chains-casein interactions and casein micelles aggregation. Therefore, it results in the loss of network strength in the yogurts, added with ATCL (3.2%).

Sensory evaluation: The sensory (flavor, body/texture, color and total acceptance) scores are given in Table 2. Flavor scores at zero time were significantly ($p<0.05$) higher than that of two weeks, but there were no significant differences in color, texture and acceptance scores ($p<0.05$). FFY received the best flavor score. After FFY, ATCLSY (1.6%) had significantly ($p<0.05$) higher flavor score than the other yogurt samples and ATCLSY (3.2%) placed at the third position. However, the starchy flavor was felt in these samples, which gave them the lower scores as compared to FFY. There were no significant differences in color scores between FFY and ATCLS (1.6 and 3.2%). The ATSY (1.6 and 3.2%) had significantly lower body/texture and color scores ($p<0.05$) than the others. The panelists did not recognize any significant differences between the texture of the FFY and ATCLSY ($p<0.05$). FFY received the best total acceptance score, which was followed by ATCLSY ($p<0.05$). ATSY were not acceptable at all ($p<0.05$). The higher total acceptance score of FFY in comparison to ATCLSY was due to starchy taste of ATCLSY.

CONCLUSION

The purpose of this study was to evaluate the effect of modified starch as a fat replacer in yogurt on quality. Good quality non fat and low fat yogurts can be made with ATCLS. Syneresis was reduced in these yogurts in comparison to the control. Use of ATCLS for the manufacture of non fat (and low fat) yogurts appears to be promising because it is available in a dried form and can be purchased in bulk. It can be stored for a long time and finally the low energy content of this starch encourages the application of it as it can act as resistance starch.

REFERENCES

AOAC., 1995. Official Methods of Analysis. 16th Edn., American Association of Analytical Chemists, Washington, DC., pp: 1-45.

Cengiz, E. and N. Gokoglu, 2005. Changes in energy and cholesterol contents of frankfurter-type sausages with fat reduction and fat replacer addition. Food Chem., 91: 443-447.

Mistry, V.V. and H.N. Hassan, 1992. Manufacture of nonfat yogurt from a high milk protein powder. J. Dairy Sci., 75: 947-957.

Oh, H.E., S.G. Anema, M. Wong, D.N. Pinder and Y. Hemar, 2007. Effect of potato starch addition on the acid gelation of milk. Int. Dairy J., 17: 808-815.

Olson, D.W. and K.J. Aryana, 2008. An excessively high *Lactobacillus acidophilus* inoculation level in yogurt lowers product quality during storage. LWT Food Sci. Technol., 41: 911-918.

Sandoval-Castilla, O., C. Lobato-Calleros, E. Aguirre-Mandujano and E.J. Vernon-Carter, 2004. Microstructure and texture of yogurt as influenced by fat replacers. Int. Dairy J., 14: 151-159.

Woo, K.S. and P.A. Seib, 2002. Cross-linked resistant starch: Preparation and properties. Cereal Chem., 79: 819-825.