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The effect of various concentrations of salep gum on physicochemical characteristics of low-fat white cheese

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ABSTRACT: Today, consumers' tendency to use low-calorie products has been increased. In this study, we investigated the effect of salep gum with three concentrations of 0.1, 0.2 and 0.3 g per kg of skim milk contained 0.5 percent fat on producing the low-fat white cheese. The control sample included fat and had no salep gum. Physicochemical tests for pH, acidity, moisture, protein, and fat, as well as sensory analysis were done on the final product. Our results proved that by increasing the concentration of salep gum and passing of time, moisture level and protein percent were rose. But the increment of salep gum concentration had no significant effect on sensory parameters like color, odor and taste, but its effect on texture firmness, spreadabillity and total acceptance was significant about 5% ($p<0.05$). The optimized sample that had the highest acceptance among the testers with regard to sensory attributes, was the cheese sample contained 0.2 g salep gum.
Keywords: low-fat cheese; texture; salep gum; sensory test

INTRODUCTION

Scientific evidences and findings reveal the correlation between extensive use of fatty foods and increasing risk of some diseases such as excessive obesity, atherosclerosis, cardiovascular diseases, hypertension, histological traumas and some types of cancer. Consequently, and by raising the people's awareness of fat consumption, a considerable increase in demanding of low-fat foods including low-fat cheeses has been developed. Cheese fat not only has a nutritive role, but also it acts positively to improve its texture and appearance. Low-fat cheeses have defects such as firm and rubbery texture, unfavorable color and taste, and weak meltability. By decreasing the fat amount, cheese protein network becomes more tight and compact and cheese texture turns chewy (Oberg, 1999). Thus, new strategies were developed to produce low-fat cheese with the same characteristics of high-fat cheese, some of which are: modifying ordinary methods in production process, selecting starter and adjunct cultures and using fat substitutes. Using of fat substitutes has been proposed as the main strategy to improve functional and textural attributes of low-fat cheese in different studies. Because of their ability to mechanically entrap water and their stronger hydrophilicity, water-soluble and polar fat substitutes have been widely recommended. Following the use of fat substitutes, a sense of lubricity and creaminess is created in cheese (Madadlou et al., 2007).

Therefore, in formulation of low-fat products, it has been recommended to use substances that partially or entirely substitute for fat and developed similar characteristics (Drake, 1999). Fat substitutes are those cominations which affect some product attribute like taste, mouthfeel and other organoleptic traits (Cheng et al., 2008). Hydrocolloids are combinations that provide viscosity/consolidation, increasing of consistency, acting as an emulsifier, forming gel and improving mouthfeel. In fact, hydrocolloids compensate for the low level of fat by their ability to absorb and band water and texturizing characteristics. They also help to create a fat-like gel structure (Bench, 2007). Numerous surveys have been done about replacing fat by different gums in dairy products, among which are followings:

Ghanbari Shendi et al. (2009) studied rheological, physiochemical and sensory properties of Iranian low-fat white cheese, and their findings displayed improvement of low-fat cheese texture by increasing xanthan gum

concentration. Besides, in other studies by Volikakis et al. (2004) cereal beta glucan has been used as a fat substitute in low-fat white cheese which improved its texture significantly, but cheese taste, color and some other parameters were influenced unfavorably.

Salep has a special role in odor/aroma and taste of final product and is added to formulations as a thickener and stabilizer agent. Salep hydrocolloid is obtained from dried tuber of salep plant and its major constitute is glucomannan (circa 16 to 55 percent) (Kaya et al., 2001). Glucomannans are natural, inert, water-soluble fibers that aid adjustment of blood sugar, relieve pressure on pancreas and blood sugar anomalies like hypoglycemia. These compounds are also useful to prevent acute diseases, to control weight and to heal acute constipation in adults. These polysaccharides are of great interest in food industry as gelating, thickener, emulsifier, and film-making agents (Farhoosh and Riazi, 2007).

In this study, we examined the effect of various concentrations of salep gum on physiochemical attributes of low-fat white cheese.

MATERIALS AND METHODS

RAW MATERIAL

Skim milk with 0.5 percent fat was purchased from Kale Dairy Products Factory. Salep hydrocolloid used here was prepared according to Riazi and Farhoosh (2007).

In order to assay the impact of salep gum on cheese physiochemical attribute, we provide five samples in two repeats that were respectively low-fat control samples without fat substitute from skim milk with 0.5 percent fat, and low-fat samples containing 0.1, 0.2 and 0.3 percent (w:w) of salep gum, and the other sample made from whole milk with 3.5 percent fat. Starters used in this research were thermophilic and mesophilic FRC-60 including bacterial species of Lactoccuse lactis subsp. cremoris, Lactoccuse lactis subsp. lactis, Lactoccuse delbruckii subsp. bulgaricus, and Streptococcus thermophilus that were purchased from Hensen Co. (Denmark).

Cheese making process

In each turn of production, we used a batch of low-fat cow milk. Then preliminary tests and adjusting fat percent were carried out according to Iran National Standard Act. The next stage was pasteurization and cooling in order to make milk healthier, in which we used rapid pasteurization at 75 °C for 15 seconds and cooling up to 35 °C. Subsequently, needed salep gum was weighed in predetermined concentrations per each kilogram of skim milk and then was added to milk. Adding starters and chlorination were done after adding amounts of gum and cooling up to 35 °C, a ratio of 0.5 percent (w:w) per each kilogram of skim milk from mixed starter (thermophilic and mesophilic ones) was added to each treatment and the temperature remained constant for 45 minutes to provide sufficient opportunity for activity of starters and sample pH declines, and when pH reaches at 6.4 in each batch, 0.45 percent calcium chloride and 0.15 percent serumease enzyme (w:w) per each kilogram of primary milk was added to every treatment and incubated at 37 °C for 45-65 minutes to form curd. The inoculated milk was transferred to incubator with 4 kilogram containers and stored at 32 °C until the curd formed. To ensure curd preparation for cutting, its viscosity/consolidation should be taken into account. So the curd test was used to ensure. Resulted curd was sliced in related container (cheese making vat) at 0.5 cm dimensions and rest up for 5-10 minutes to withdraw the whey completely from curd. The smaller were curd cubes, the more whey withdrew and the less was the final moisture level. In order to accelerate the removing of the whey from cheese, sliced curds were turned with steady speed from time to time during this period, to wit, the curd was inverted. After complete discharge of whey, samples were put under pressure and stored in 13 percent saltwater until doing tests. All chemical tests were performed in a 50 day period with one repeat per each 10 days.

Chemical tests

Milk attributes including protein and fat amounts, SNF density, and etc. were determined by milk analyzer apparatus (Eko milk).

Samples' pH was measured by SUNTEX Sp-701 pH meter equipped with a temperature sensor (Iran National Standard, No.2852).

Measuring acidity was done according to Iran National Standard, No.2852 (milk and its products, measuring pH and acidity).

Fat measurement was done according to AOAC.1995 international standard.

Determination of moisture amount was performed according to Iran National Standard, No.2344-1 related to Iranian white cheese.

Protein was measured by Kjeldahl method described in Iran National Standard, No.2344.

Sensory analysis

Assessing sensory properties was carried out by 8 trained panelists who had been acquainted with these traits. Sensory analysis consisted parameters of taste, aroma, appearance and total acceptance. This analysis was done at 1, 15 and 50 days after production and during maturing- period.

Statistical analysis

In this study, we used a basic experimental design of factorial type with two repeats. Data analysis and comparison of means were performed respectively by ANOVA tables and Duncan test, through SPSS17 software at probability level of 0.05.

RESULTS AND DISCUSSION

Evaluation of the milk physicochemical properties

Physicochemical characteristics of whole milk and low-fat milk are shown in Table 1.

Table 1. Constituents and physicochemical properties of the milk used for production of low-fat cheese

Compounds	Low-fat milk
Fat (%)	0.50
Protein (%)	3.11
hhMoisture (%)	92
Acidity (by lactic acid)	14.3
pH	6.61

Evaluation the physicochemical and sensory properties of produced cheese

Physicochemical attributes of various cheeses as a function of fat level, time and concentration of gum (fat substitute) are displayed in Tables 2 to 6.

As expected, by decrement of fat in the primary milk, fat level also decreased in produced fat, led to significant statistical differences between treatments.

Results from Table 2 showed that by decreasing cheese fat, pH of related samples declined significantly during storage time ($p<0.05$). Results obtained from variance comparison test in these tables signify that variances of two variables, namely time and gum concentration at 0.1 percent (w:w) in mentioned times, had significant differences regarding pH factor during storage time ($p<0.05$). pH variations in treatments containing fat substitute comparing the high-fat sample were such that the sample with 0.2 percent salep gum was meaningfully different from all other samples during storage period. Produced low-fat cheeses containing fat substitute had significant differences from high-fat cheese at $p<0.05$; it means that the high-fat cheese with 3.5 percent fat was significantly different from cheeses containing 0.1, 0.2 and 0.3 percent salep. according to the above table and analysis of variance of mean data, it can be concluded that pH had significant differences among studied times and concentrations ($p<0.05$). Perhaps this was due to the activity of bacteria existed in milk which results in lactose breakdown and production of lactic acid during storage period (Fox et al., 2000).

Table 2. Study of pH variations in produced cheeses during storage period

Samples/Storage day	0	10	20	30	40	50
High-fat cheese	6.81 ^{f}	6.44 ^{e}	5.2 ^{d}	5.28 ^{cd}	5.77 ^{cd}	5.71 ^{b}
Low-fat cheese without salep	6.35 ^{a}	6.29 ^{b}	5.7 ^{bc}	5.49 ^{c}	5.4 ^{bc}	5.36 ^{c}
Low-fat cheese with 0.1 g salep gum	6.9 ^{d}	6.57 ^{d}	5.76 ^{c}	5.59 ^{b}	5.59 ^{b}	5.5 ^{b}
Low-fat cheese with 0.2 g salep gum	6.5 ^{a}	4.3 ^{a}	5.73 ^{b}	5.62 ^{cb}	5.5 ^{dc}	5.4 ^{d}
Low-fat cheese with 0.3 g salep gum	6.43 ^{a}	6.25 ^{b}	5.5 ^{c}	5.4 ^{cd}	5.41 ^{d}	5.35 ^{d}

$^{a-e}$: Means with different superscripts in each row have significant differences ($p<0.05$).

Results from analysis of variance for acidity showed that in various studied times, there was a significant difference between treatments, especially in the sample or white cheese with 0.1 percent salep. However, the interactions between time and gum concentration for studied variables showed that these parameters had significant intra- and intergroup in mentioned times, excepting that in some occasions these significant differences were so weak that we could neglected their significance (Table 3). The cause of acidity variations was probably that acidity reduction leads to weakness of protein bands by repulsion of charges existed on protein surface, so as the negative charges on the surface of casein molecule were declined by pH increase (Romeiha et al., 2000).

Table 3. Study of acidity variations in produced cheeses during storage period

Sample/Storage day	0	10	20	30	40	50
High-fat cheese	40 ^{a}	44.5 ^{a}	50.5 ^{ab}	59.5 ^{cd}	67 ^{cd}	75 ^{ed}
Low-fat cheese without salep	38 ^{a}	43.5 ^{a}	50.5 ^{ab}	59.5 ^{bc}	67 ^{c}	70.6 ^{c}
Low-fat cheese with 0.1 g salep gum	27 ^{a}	29 ^{a}	46 ^{b}	49 ^{b}	56 ^{cb}	62 ^{c}
Low-fat cheese with 0.2 g salep gum	33 ^{a}	39 ^{ba}	43 ^{b}	52 ^{c}	58 ^{cd}	64 ^{d}
Low-fat cheese with 0.3 g salep gum	34 ^{a}	39 ^{ab}	48 ^{bc}	55 ^{de}	65 ^{de}	71 ^{cd}

$^{a-e}$: Means with different superscripts in each row have significant differences ($p<0.05$).

Concerning protein amount, differences among low-fat cheeses and high-fat sample are evidently seen in Table 5. Results from ANOVA table for protein implied that in the sample with 0.2 percent salep, protein amount decreased substantially due to proteolysis, but in low-fat samples containing fat substitute, the reverse situation happened, meaning that by passing the time, amount of protein increased significantly. It should be mentioned that the interaction of time and gum concentration on this parameter demonstrated a significant difference at the same probability level. Considering that by passing the time and increase in proteolysis, the protein level declined, it might be deduced that the existence of salep gum in open space of protein matrix on one hand, and the increase in moisture level on the other hand, results in significant increase in protein amount in treatments containing fat substitute (Koca, 2003).

What is important for improving texture of low-fat cheese is increasing the moisture level or moisture ratio to protein ratio in comparison with high-fat sample. So, the high moisture level in fat-free cheeses and in cheeses containing fat substitute compared to high-fat ones, is of crucial importance (Zalazar, 2000). The discrepancy of moisture level in high-fat and low-fat cheeses is probably due to their different protein levels, so as the high amount of protein in cheeses containing less fat can be accompanied with increase in water absorbance within protein network and consequently the raise of moisture amount (Ghanbari Shendi et al., 2011).

Compared to control low-fat cheese (without salep) and the high-fat cheese, however, the moisture to protein ratio was higher in low-fat cheeses with fat substitute, and the high level of moisture in the samples containing fat substitute was possibly due to synergistic activity of the formed curd. This is due to the fact that water binds directly to substitute agents which results in crease of protein matrix (Zisu et al., 2005). Among low-fat cheese samples containing 0.1, 0.2 and 0.3 g salep gum, the highest degree of moisture absorbance belonged to low-fat sample with 0.2 g gum, which even showed increasing of moisture in comparison with comparative sample (the high-fat one). As carbohydrate-based fat substitutes have more ability to absorb water because of an open electron array in their structure, it would lead to compressing and creasing of carbohydrate-protein matrix, and these reactions in turn, result in increasing of moisture in cheeses containing fat substitute comparing with low-fat and high-fat controls (Table 4-6) (Drak, 1995).

Table 4. Study of fat variations in produced cheeses during storage period

Sample/Storage day	0	10	20	30	40	50
High-fat cheese	17.1 ^{a}	17.5 ^{b}	17.6 ^{b}	18.2 ^{c}	18.45 ^{c}	18.75 ^{c}
Low-fat cheese without salep	3.89 ^{a}	3.90 ^{a}	4.00 ^{a}	4.01 ^{a}	4.28 ^{ab}	4.03 ^{ab}
Low-fat cheese with 0.1 g salep gum	3.25 ^{a}	3.47 ^{a}	3.45 ^{a}	3.34 ^{a}	3.23 ^{a}	3.34
Low-fat cheese with 0.2 g salep gum	3 ^{a}	3.54 ^{ab}	3.54 ^{ab}	3.44 ^{ab}	3.54 ^{ab}	3.34 ^{ab}
Low-fat cheese with 0.3 g salep gum	3.15 ^{a}	3.3 ^{ab}	3.3 ^{ab}	3.3 ^{ab}	3.4 ^{a}	3.5 ^{ab}

$^{a-e}$: Means with different superscripts in each row have significant differences ($p<0.05$).

Table 5. Study of protein variations in produced cheeses during storage period

Sample/Storage day	0	10	20	30	40	50
High-fat cheese	6.602 ^{f}	6.26 ^{ef}	6.41 ^{e}	6 ^{c} ±	5.3 ^{b}	4.9 ^{a}
Low-fat cheese without salep	5 ^{a}	5.47 ^{a}	5.76 ^{b}	6.04 ^{b}	6.5 ^{b}	6.33 ^{b}
Low-fat cheese with 0.1 g salep gum	5.57	6.4	7.3	7.5	8.42	8.73
Low-fat cheese with 0.2 g salep gum	5.08 ^{a}	5.55 ^{b}	6.44 ^{c}	6.95 ^{d}	7.04 ^{c}	7.18 ^{f}
Low-fat cheese with 0.3 g salep gum	5.43 ^{a}	5.44 ^{a}	6.25 ^{b}	7.05 ^{b}	7.87 ^{c}	8.2 ^{d}

$^{a-e}$: Means with different superscripts in each row have significant differences ($p<0.05$).

Sensory analysis

Results related to sensory properties of low-fat white cheese are illustrated in Table 7 as a function of fat substitute percent during shelf-time/storage period.

In the regard of taste, the high-fat cheese level gained higher score. This sample had significant difference with other cheeses. Studies showed that the low-fat, substitute-free sample had a very weak grade. Milk fat has a strong impact on the taste of milk products including cheese. Low-fat cheeses have weaker taste, which is due to the high level of moisture and lowering fat share in determination of cheese total taste (Rashidi, 2011). The results of Table 7 showed that the linear effect of fat reduction on taste was significant at $p<0.05$, but the linear effect of adding gum on taste was not significant; and as a whole, addition of gum had not significant effect on taste. The linear and mutual effects of fat reduction, time and gum concentration and their interactions on the appearance of low-fat cheese were not significant at the level of $p<0.05$. As seen in Table 7, reducing fat had no significant effect on the odor ($p<0.05$). Obtained results demonstrated that the linear effect of fat reduction on low-fat cheese odor was not significant at probability level of 0.05, and testers could not distinguish the challenging difference between samples. However, the high-fat sample or low-fat salep-free cheese, and to some extent cheese containing 0.2 percent salep had a significant difference from other samples in view of aroma ($p<0.05$). The effect of reducing fat, the linear effect of adding gum and their interaction on total acceptance were significant at probability level of 0.05. Generally, by increment of the fat amount, total acceptance increased, and among samples with fat substitute, the treatment containing 0.2 percent salep gained the best score from testers. Most of the testers believed that this cheese had the maximum similarity to the high-fat sample regarding studied parameters. The sample containing 0.3 percent salep stood on the next level with respect to acceptance.

Table 6. Study of moisture variations in produced cheeses during storage period

Sample/Storage day	0	10	20	30	40	50
High-fat cheese	63 ^{a}	65 ^{ab}	61 ^{a}	63 ^{b}	63 ^{b}	63 ^{a}
Low-fat cheese without salep	66 ^{a}	69 ^{a}	70 ^{b}	71 ^{ab}	71 ^{ab}	72 ^{b}
Low-fat cheese with 0.1 g salep gum	70 ^{a}	71 ^{a}	71 ^{a}	69 ^{a}	69 ^{a}	72 ^{a}
Low-fat cheese with 0.2 g salep gum	72 ^{a}	73 ^{ab}	72 ^{ab}	72 ^{ab}	74 ^{c}	74 ^{c}
Low-fat cheese with 0.3 g salep gum	74 ^{a}	77 ^{b}	74 ^{a}	74 ^{c}	72 ^{c}	72 ^{cd}

$^{a-e}$: Means with different superscripts in each row have significant differences ($p<0.05$).

Table 7. Coefficients of regression model and results from analysis of variance for response variables.

Cheese type	Taste	Texture	Aroma	Total acceptance
High-fat cheese	8.1 ^{c}	9.4 ^{d}	6.4 ^{b}	7.1 ^{bc}
Low-fat cheese without salep	3.5 ^{a}	6.4 ^{c}	3.7 ^{a}	4.5 ^{b}
Low-fat cheese with 0.1 g salep gum	6.0 ^{ab}	7.5 ^{d}	5.7 ^{a}	5.8 ^{a}
Low-fat cheese with 0.2 g salep gum	6.8 ^{b}	6.9 ^{b}	5.9 ^{a}	6.6 ^{b}
Low-fat cheese with 0.3 g salep gum	5.8 ^{a}	6.4 ^{b}	5.8 ^{a}	5.9 ^{ab}

CONCLUSION

Results of this investigation signifies that the use of salep gum as other fat substitutes can be a suitable way to obtain a cheese with proper quality and with decrement of received energy. But it should not be disregarded that yet, there is no favorable substitute which can replace fat as an ideal texturizer and flavoring.

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