Effect of pre-gelatinized starches on physicochemical and sensory properties of skim milk

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ABSTRACT: Starch is the commonest disintegrant used in tablet formulation. The aim of the study was to investigate the physicochemical and sensory properties of pre-gelatinized starches as fat replacer. Modified starch were manufactured from 3 plant source (rice, corn and potato) which added to skim milk with concentrations of 0.15%, 0.30% and 0.45%. Consequently viscosity, total solid, titrable acidity, pH and sensory scores were evaluated for milk samples. Result demonstrated that the effect of plant source on physicochemical and sensory properties of the milk sample was significant. The results indicated that pre-gelatinized starch at concentration of 0.45% can be a good choice for adding to skim milk.

Keywords: Pre-gelatinized, Rice starch, Corn starch, Fat replacer

INTRODUCTION

Starch is one of the most used hydrocolloids in the food industry. It exhibits a wide range of textural properties of many foods and is extensively applied in food and industrial applications as a thickener, colloidal stabilizer, gelling agent, bulking agent and water retention agent. (Svegmark & Hermansson, 1993). Starches from various plant sources, such as wheat, maize, rice and potato have received extensive attention in relation to structural and physico-chemical properties (Takeda & Priess, 1993).

Modified starches, also called starch derivatives, are prepared by physically, enzymatically or chemically treating native starch, thereby changing the properties of the starch. The different types of modifications include heat gelatinization, enzymatic hydrolysis, acid hydrolysis and other various forms of chemical modifications (Okafor, 2000). Pre-gelatinized starch is a common type of physically modified starch with wide applications, especially in food industry. Pre-gelatinized starches, also referred to as instant starch slurries, are those that have been simply precooked and drum dried to give products that readily disperse in cold water to form moderately stable suspensions (Hodge & Osman, 1976). Drum-drying results in specific physicochemical modifications of starch granules performed in two consecutive stages: gelatinization and drying.

The process of gelatinization results in substantial changes in both chemical and physical nature of granular starch through the rearrangement of intra- and intermolecular hydrogen bonding between water and starch molecules causing the collapse or disruption of molecular orders within the starch granules. This results in irreversible changes in the starch properties including loss of organized structure of starch, granule swelling, loss of birefringence and crystallinity (Cooke and Gidley, 1992; Anastasiades ., 2002).

From the literature, it can be concluded that the physicochemical and sensory characteristics of pre-gelatinized starches are affected by the source of starch used for production of pre-gelatinized starches. The aim of this study...
is to investigate the sensory and physicochemical properties of pre-gelatinized starches from three sources (rice, corn and potato) as fat replacer.

MATERIALS AND METHODS

Materials
Pure potato and corn starches were purchased from GlucosinCo. Qazvin, Iran. Other chemicals including POCl3, NaOH, HCl, NaHSO4, ethanol, zinc acetate, citric acid and KOH were analytical grades and obtained from Merck, Germany.

Methods
1. Preparation of Pre-gelatinized starch
Pre-gelatinized starch was performed using gelatinizing starch in Brabender Viscoamylograph Type E (Duisburg, Germany). A starch suspension 6% (w/v) was heated from 25 to 95 °C at the rate of 1.5 °C/min held 15 min at 95 °C and cooled to 50 °C at the same rate. The suspension of starch was spreaded to form thin layer next sample was dried overnight in an oven (60 °C). The pre-gelatinized starch sample (containing 10% water) was milled and sieved using a 100-mesh sifter to achieve the starch powder sample.

2. Physico-Chemical analysis
Total solid of individual sample was measured according to AOAC method 990.19 (AOAC, 2005). Titrable acidity of each sample was determined as described in AOAC method 974.05 and protein content was analyzed using AOAC 975.17. The pH was determined by pH meter with a combined glass electrode and temperature probe (pH meter Micro pH 2002; Crison, Spain). Before analyzing, instrument was calibrated, by using buffer solutions at pH 4.0 and 7.0. Viscosity of prepared milk samples were determined using a Brookfield DV-III Ultra Programmable Rheometer (Brookfield Engineering Lab Inc., Massachusetts, USA).

3. Sensory Evaluation
The sensory evaluation of milk samples performed through the judgment of 18 trained panelists. The samples were coded with three digit random numbers in odorless plastic cups with all the orders of servings completely randomized. A 9-point hedonic scale was employed to determine the degree of liking of the products (9= Extreme like, 5= Neither like nor dislike, 1= Extreme dislike). The samples were rated for color and appearance, flavor/taste, texture and overall acceptability as prescribed by Herald, (2008). Physicochemical and sensory analyses of the final products were conducted 1 day past production.

4. Statistical Analysis
In order to calculate significant differences among the different treatments, analysis of variance (ANOVA) was performed and two-tailed independent-sample T-test in SPSS 19.0 software (SPSS Inc., Chicago, IL, USA) was applied. To approve the statistical significance of all data, total experiments were conducted in triplicates and values of means ± S.D (standard deviation) were reported.

RESULTS AND DISCUSSION
This research compared of the sensory and physicochemical properties of prepared milk samples with different modified starches in an attempt to determine color, flavor, texture and overall acceptability, viscosity values, total solid, acidity, fat content and pH for milk samples. Sensory evaluation of milk samples containing modified starches are presented in Tables 1.
Table 1. Sensory properties of milk samples containing various modified starches

<table>
<thead>
<tr>
<th>Samples</th>
<th>Concentration</th>
<th>Color</th>
<th>Flavor</th>
<th>Texture</th>
<th>Overall acceptance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-gelatinized rice</td>
<td>0.15%</td>
<td>5.40±0.45bc</td>
<td>6.33±0.52cd</td>
<td>6.67±0.57bc</td>
<td>6.33±0.57de</td>
</tr>
<tr>
<td>Pre-gelatinized rice</td>
<td>0.3%</td>
<td>6.00±1.01bc</td>
<td>6.67±0.97bc</td>
<td>7.00±0.98bc</td>
<td>7.00±0.57cd</td>
</tr>
<tr>
<td>Pre-gelatinized corn</td>
<td>0.15%</td>
<td>7.55±0.47a</td>
<td>7.67±0.45ab</td>
<td>8.67±0.65a</td>
<td>8.33±0.45ab</td>
</tr>
<tr>
<td>Pre-gelatinized corn</td>
<td>0.3%</td>
<td>5.00±0.55cd</td>
<td>5.33±0.85ab</td>
<td>6.45±0.45f</td>
<td>5.33±0.80df</td>
</tr>
<tr>
<td>Pre-gelatinized potato</td>
<td>0.45%</td>
<td>6.00±0.89bc</td>
<td>6.00±0.45fd</td>
<td>7.60±0.85ab</td>
<td>6.45±0.55de</td>
</tr>
<tr>
<td>Pre-gelatinized potato</td>
<td>0.15%</td>
<td>7.33±0.57bc</td>
<td>7.00±0.97bc</td>
<td>8.55±0.47a</td>
<td>7.33±0.97bc</td>
</tr>
<tr>
<td>Pre-gelatinized potato</td>
<td>0.3%</td>
<td>5.00±0.81f</td>
<td>5.00±0.45f</td>
<td>7.00±0.89f</td>
<td>6.00±0.45fe</td>
</tr>
<tr>
<td>Milk with 1.5% fat</td>
<td>0.45%</td>
<td>6.80±0.49ab</td>
<td>6.33±0.97cd</td>
<td>7.00±0.55c</td>
<td>7.33±0.57bc</td>
</tr>
<tr>
<td>Milk with 1.5% fat</td>
<td>0.45%</td>
<td>8.45±0.94c</td>
<td>8.55±0.54c</td>
<td>9.00±0.59c</td>
<td>8.69±0.45c</td>
</tr>
<tr>
<td>Skim milk</td>
<td>0.45%</td>
<td>4.40±0.59de</td>
<td>5.02±0.35bc</td>
<td>5.68±0.47f</td>
<td>5.33±0.65de</td>
</tr>
</tbody>
</table>

Data are means ± S.D of triplicate measurements. Values with different superscript upper case letters in a column are statistically significant at P < 0.01. Based on 9-point hedonic scoring: 9 for excellent, 1 for very poor.

In this context, we found that samples containing pre-gelatinized rice starch had higher flavor, texture and overall acceptance score than skim milk sample. Samples containing pre-gelatinized rice starch had yellow color and sweet flavor. Although, samples with pre-gelatinized corn starches had acceptable colors and flavors. Hence the effect of type of starch was employed for modification on sensory properties of the milk sample was significant. Researchers reported content of amylopectin (Jane ., 1992) and size distribution of starch granule population (Hung and Morita, 2005) may influence on starch modification and different properties of modified starch.

The results (Table 1) indicated that the different concentrations of modified starches which added to milk samples obtained significant difference of sensory properties. Milk sample with 0.45% pre-gelatinized starch had higher flavor score than samples containing pre-gelatinized starch at concentration of 0.3%. Milk samples treated with pre-gelatinized starch (0.15 and 0.3%) had unacceptable textures. Control (milk with 1.5% fat) received the highest overall acceptance score followed by sample with 0.45% pre-gelatinized starch. Therefore sensory evaluation of samples containing pre-gelatinized starch at concentration of 0.45% can be a good choice for adding to skim milk. Table 2 gives the results for the physicochemical properties of milk containing modified starches.

Table 2. Physicochemical properties of milk samples containing various modified starches

<table>
<thead>
<tr>
<th>Samples</th>
<th>Concentration</th>
<th>Total solid (% w/v)</th>
<th>Viscosity (cP)</th>
<th>Acidity</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-gelatinized rice</td>
<td>0.15%</td>
<td>9.54±0.25bc</td>
<td>2.19±0.14cd</td>
<td>14.40±0.25f</td>
<td>6.62±0.10</td>
</tr>
<tr>
<td>Pre-gelatinized rice</td>
<td>0.3%</td>
<td>9.55±0.27bc</td>
<td>2.23±0.21b</td>
<td>14.40±0.40f</td>
<td>6.62±0.30</td>
</tr>
<tr>
<td>Pre-gelatinized corn</td>
<td>0.45%</td>
<td>10.40±0.18ab</td>
<td>2.27±0.15a</td>
<td>14.40±0.22f</td>
<td>6.62±0.10</td>
</tr>
<tr>
<td>Pre-gelatinized corn</td>
<td>0.15%</td>
<td>9.55±0.15bc</td>
<td>2.16±0.14ab</td>
<td>14.40±0.25f</td>
<td>6.62±0.20</td>
</tr>
<tr>
<td>Pre-gelatinized corn</td>
<td>0.3%</td>
<td>9.64±0.49bc</td>
<td>2.20±0.21bc</td>
<td>14.40±0.20f</td>
<td>6.62±0.10</td>
</tr>
<tr>
<td>Pre-gelatinized corn</td>
<td>0.45%</td>
<td>10.13±0.27g</td>
<td>2.25±0.15c</td>
<td>14.40±0.30f</td>
<td>6.62±0.20</td>
</tr>
<tr>
<td>Pre-gelatinized potato</td>
<td>0.15%</td>
<td>9.54±0.25bc</td>
<td>2.08±0.13c</td>
<td>14.40±0.30f</td>
<td>6.62±0.20</td>
</tr>
<tr>
<td>Pre-gelatinized potato</td>
<td>0.3%</td>
<td>9.58±0.15f</td>
<td>2.12±0.14i</td>
<td>14.40±0.25f</td>
<td>6.62±0.20</td>
</tr>
<tr>
<td>Milk with 1.5% fat</td>
<td>0.45%</td>
<td>9.87±0.27h</td>
<td>2.15±0.15a</td>
<td>14.40±0.22f</td>
<td>6.62±0.10</td>
</tr>
<tr>
<td>Milk with 1.5% fat</td>
<td>0.45%</td>
<td>11.07±0.18a</td>
<td>1.93±0.12j</td>
<td>14.40±0.20f</td>
<td>6.62±0.10</td>
</tr>
<tr>
<td>Skim milk</td>
<td>0.45%</td>
<td>9.46±0.23f</td>
<td>1.60±0.15l</td>
<td>14.40±0.25f</td>
<td>6.62±0.10</td>
</tr>
</tbody>
</table>

Data are means ± S.D of triplicate measurements. Values with different superscript upper case letters in a column are statistically significant at P < 0.01.

Table 2 shows that increasing pre-gelatinized starch causes significantly higher water solubility and absorption indices. This can be attributed to the destruction of starch granules, reduction of the degree of crystallinity, and degradation of starch molecules during pre-gelatinization. Apparently, the porous structure of pre-gelatinized starch can readily absorb more water compared to the skim milk. Slaughter . (2001) also reported higher water solubility and swelling for fully gelatinized wheat, maize, and rice starches. Higher solubility and water absorption values were also reported for pre-gelatinized banana starch by Waliszewski . (2003).
Determination of intrinsic viscosity of the samples (Table 2) showed that samples containing modified starch had significantly higher viscosity than that of skim milk (P< 0.01). The highest values were obtained for the samples with 0.45% of pre-gelatinized starch and significant difference (P> 0.01) found with milk containing 1.5% fat. This may indicate that using drum drying could cause molecular degradation of starch molecules since the drums attain high temperatures that can intensify thermal processing (Vallous ., 2002). Similar observation was also reported for pre-gelatinized wheat starch produced by a single drum drier (Colonna ., 1984) and for pre-gelatinized corn starch produced by twin drum drier (Anastasiades ., 2002). They indicated that in drum drying, the reduction of the intrinsic viscosity may indicate the degradation of the starch macromolecules. Such modifications may occur during the gelatinization stage in the pool or during the subsequent intense heating or both. Additionally, many researchers have resulted that using higher levels of modified starches would lead to increasing viscosity in dairy products (Kaya and Tekin, 2001; Minhas ., 2002; Muse and Hartel, 2004; Moeenfard and Mazahri, 2008; Milani and Koocheki, 2010).

Increasing modified starch level had no significant effect on acidity and pH values of milk samples. Overall, the results of sensory and physicochemical properties of milk samples showed that pre-gelatinized rice starch at concentration of 0.45% can be a good choice for adding to skim milk.

In Iran, as well as many parts of the world, cereal starch is the most available starch that may be modified using different methods. Based on these properties, pre-gelatinized starch can be used mainly as a thickening and gelling agent in refrigerated and instant foods or heat sensitive products such as cold desserts, salad dressing, cake and bakery mixes, and baby foods. Pre-gelatinized starch is able to viscofy the solutions or mixes in which it is being used without any heat treatment (Karaoglu, 2001; Fechner, 2005). The results of this study could be useful in predicting the final quality of the products made with pre-gelatinized cereal starch.

CONCLUSION

We produced pre-gelatinized modified starches as fat replacer from three source of starch (rice, potato and corn). Physicochemical and sensory properties of prepared milk samples were evaluated. Results show that the effect of plant source on physicochemical and sensory and physicochemical properties of the milk samples was significant and milk samples with 0.45% pre-gelatinized rice starch were better due to its acceptable texture and flavor.

REFERENCES