Acid thinned jicama and maize starches as fat substitute in stirred yogurt

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Abstract

Jicama and maize starches were hydrolyzed with HCl (1.5, 3.0 or 4.5 g/100 g of starch), at a temperature of 40 °C using two hydrolysis times (3 and 6 h). The acid degradation of both starches was not excessive as revealed by the positive blue value, amylose content, gel formation and gel thermo-reversibility. Jicama starches were more susceptible to acid hydrolysis than maize starches. Hydrolyzed jicama starches showed low values of gel strength and water solubility index, and high values of damaged starch, total sugar content and water absorption index. Stirred yogurt formulated with hydrolyzed starches showed different properties of syneresis index according to the starch type and hydrolysis conditions. Yogurt samples with hydrolyzed jicama starches added did not show significant differences in pH and viscosity. Sensorial testing showed that it is possible to produce yogurt with good functional and sensorial properties using hydrolyzed jicama starches as a fat substitute.

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Keywords: Jicama; Maize; Fat substitute; Yogurt

1. Introduction

Consumers are concerned about their health and quality of life. They are exercising more, eating healthy foods and decreasing the consumption of food with high sugar, salt, and fat content. Yogurt production in Mexico increased from 163,000 tons in 1994 to 307,000 tons in 1999. The national annual yogurt consumption per capita also increased from 1.8 kg in 1994 to 3.2 kg in 1999 (FIRA, 2001). The Mexican market offers a broad range of yogurts to suit all preferences. Low-fat yogurt has an important share of this market. Their quality depends on their body and texture because the amount of solids in these products is rather low. Formulation and production of low-fat dairy products with good textural qualities represent a big challenge for today’s manufacturers. Yogurt manufacturers have responded to this requirement and, as a consequence, there has been a fast growing increase in low-calorie skimmed or semi-skimmed yogurts by selecting specific ingredients that produce the desired quality (Tamime, Barclay, Davies, & Barrantes, 1994). For instance, stabilizers such as gelatin, carrageenan, alginate, pectin, starch, or starch derivatives are added to formulations of milk-based custards and yogurts to improve viscosity and texture, minimize syneresis, and increase stability throughout storage life (Ma, Cai, Wang, & Sun, 2006; Malinski, James, Xia, & Roy, 2003; Mistry & Hassan, 1992; Mounsey & O’Riordan, 1999, 2001; Nielsen, Thygesen, & Olesen, 1991; Schmidt, Herald, & Khatib, 2001; Tamime & Robinson, 1988; Tziboula & Muir, 1993). As pastes and gels produced from native starches are often cohesive (gummy) or rubbery, the modification of the molecular weight and the starch amylose/amylopectin ratio may improve the functional properties of dairy products (Schmidt et al., 2001; Thomas & Atwell, 1999). Native jicama starch shows interesting structural and functional
characteristics as a new source of starch; the round granules had a polygonal form, with low size (3–11 μm) and low apparent amylose (ApA) content (12 g/100 g) (Martínez-Bustos, López-Soto, San Martín-Martínez, Zazueta-Morales, & Velázquez-Medina, 2007; Martínez-Bustos, López-Soto, Zazueta-Morales, & Morales-Sánchez, 2005). Thus, the aim of this research was to evaluate acid-modified jicama and maize starches as fat substitutes in the preparation of stirred yogurt.

2. Materials and methods

2.1. Materials

Maize starch was purchased from National Starch Co. (Bridgewater, NJ). Jicama was purchased from a local market and the starch was isolated following the method reported by Galván-Mendoza, Vásquez-Barrios, Martínez-Bustos, and Mercado-Silva (2001). Hydrochloric acid was purchased from Harcros Chemicals Inc. (Kansas City, KS).

2.2. Chemical composition

Official methods (AOAC, 1999) were used to determine moisture (no. 925.09), protein (no. 979.09), lipid (no. 923.05), and ash (no. 923.03) contents. The ApA content was determined by the iodine affinity method (Knutson, 1986).

2.3. Preparation of acid-thinned jicama and maize starches

Thinned starches were prepared following the methodology of Zambrano and Camargo (2002). A 40 g/100 g (w/w) starch slurry was prepared by adding aqueous HCl solution (5 g of pure HCl/100 mL) in a water bath at 40°C with constant stirring. The hydrolysis conditions are shown in Table 1. After hydrolysis, the pH was adjusted to 5.5 ± 0.2 by slowly adding aqueous sodium hydroxide (5 g/100 mL). The starch was washed three times with distilled water and dried in a convection oven at 45°C for 48 h. The dried powder was sieved through a 0.150 mm sieve opening.

2.4. Gel formation and gel strength

Starch samples were heated using the heating cycle of the Rapid Visco Analyzer 3C (Newport Scientific Pty Ltd., Sydney, Australia) at 92°C for 5 min, cooled to room temperature and refrigerated to 5°C for 18 h. The starch suspension was left at room temperature for 2 h and the formation of gel was registered (National Starch and Chemical Corporation, 1985). Gel strength was measured according to the method described by National Starch and Chemical Corporation (1985) using a universal TA–XT2 Texture Analyzer (Texture Technologies Corp., Scarsdale, NY, USA; Stable Micro System, Godalming, Surrey, UK) in the compression puncture mode to record the force required to penetrate the gel. The samples were placed transversally on the platform over a 1 cm thick metal sheet, and punctured with a 12.5 mm diameter cylindrical probe. The texturometer head moved the probe downward at a speed of 5 mm s⁻¹ to a 4 mm penetration distance. Four replicates were made per treatment.

2.5. Gel colour

The determination was done using the Lab Miniscan Hunter colorimeter XE (Virginia, USA).

2.6. Thermo-reversibility

The gel was melted in a water bath with constant stirring (Precision Scientific Reciprocal Shaking Bath), and let cool to room temperature and refrigerated to 5°C for 18 h. The formation of gel was observed and registered.

2.7. Water absorption index (WAI) and water solubility index (WSI)

WAI and WSI were determined according to the method of Anderson (1982).

2.8. Damaged starch

The iodine reaction was evaluated using spectrophotometric procedures (Williams & Fegol, 1969). The damaged starch value was expressed in Farrand equivalent units (FEU) using the regression equation \( X = 0.286 + 5.30Y \); where \( X \) is FEU and \( Y \) is absorbance value. The Farrand units were related to the percentage of damaged starch (g/100 g DS) using the expression \( FEU = 5.2 \times DS \), where DS is the damaged starch. So,

\[
DS = \frac{FEU + 10.3}{5.2}.
\]
2.9. Apparent amylose (ApA)

The ApA was determined following the method of Morrison and Laignelet (1983).

2.10. Total sugars

Total sugars were determined according to the colorimetric method of Dubois, Gilles, Hamilton, Rebers, and Smith (1956).

2.11. Preparation of yogurt

Raw milk (4.5–4.7 g of fat/100 mL) was standardized to 2.5 g of fat/100 mL and the density was registered. Milk samples were heated to 35 °C; the hydrolyzed starch samples (2.03 g/100 mL) were added and total solids were adjusted to 13 g/100 mL. The samples were stirred (Braun Multipractic) for 1 min, homogenized at 35 °C and pasteurized at 85 °C for 20 min. They were cooled to 45 °C and Lactobacillus delbrueckii subsp. bulgaricus (1.5 w/w) and Streptococcus thermophilus (0.2 w/w) were added as starter cultures. The samples were placed into 100-mL plastic cups. The cups were incubated at 45 °C as recommended by the culture supplier and terminated at pH 4.50 ± 0.05 in approximately 3 h. After fermentation, yogurt samples were cooled to 4 °C and stored at this temperature over 18 h for further analysis. Control yogurt was prepared following the same methodology without the addition of starch and adjusted to 13 g/100 mL of total solids with whole milk powder.

2.12. Characterization of yogurt

2.12.1. Syneresis index (SI)

A yogurt sample (20 g) was centrifuged at 1250 rpm for 10 min at 4 °C. The clear supernatant was poured off, weighed and recorded as syneresis (g/100 g).

2.12.2. pH value

The pH value of the yogurt samples was measured after concluding the refrigeration time. Samples were vigorously stirred to break the formed gel and the pH was registered at 4–7 °C using a pH meter (model SS-3, Beckman, Fullerton, CA, USA).

2.12.3. Yogurt viscosity

Measurements of yogurt viscosity were carried out using a Brookfield viscosimeter (model LVT) equipped with a helipath drive.

2.12.4. Sensory test

Trials were conducted with a trained panel of eight judges. The attributes evaluated by the judges were whey separation (syneresis), colour, firmness, maintenance of shape, flavour intensity, acidity, sweetness, astringency and grainy texture.

2.13. Experimental design and data analysis

All treatments were performed randomly using a block design. Hydrolysis time, hydrochloric acid concentration, starch type and their effect on the response variables were evaluated (Table 1). Comparison of means was performed by one-way analysis of variance (ANOVA) followed by Tukey–Kramer HSD at p < 0.05 using JMP software V.5.0.1.2 (SAS Institute Inc., NC, USA).

3. Results and discussion

3.1. Characteristics of the hydrolyzed starches

3.1.1. Chemical composition

The moisture content of the raw materials was 11.3 and 5.9; total protein 0.30 and 0.09; lipid 0.56 and 0.70; ash 0.24 and 0.27 g/100 g, for maize and jicama starches, respectively.

3.1.2. Properties of acid-thinned starches

Table 2 shows the ApA, WSI, WAI, damaged starch, and gel strength. All the hydrolyzed samples showed the characteristic blue value. Native maize and jicama starches had ApA values of 18 and 12 g of amylose/100 g of starch, respectively. Some hydrolyzed samples had similar or higher ApA content with relation to their native starch counterparts. This increase of ApA was attributed to the rapid de-polimerization of amylopectin and the liberation of more linear fragments. Also, the increase of ApA can be attributed to the formation of intramolecular and intermolecular linkages between residues of amylose which increase the length of these chains and their capacity to form complexes with iodine. The degree of acid hydrolysis causes an increase in the content of ApA in starches of the same species (Betancourt & Chel, 1997; Buttrose, 1963). Also, all the evaluated thinned starches had the capacity to form gel and thermo-reversibility with some differences in gel strength. Maize gels were firmer, although mild hydrolysis of jicama starches did result in slightly firm gels. These starches developed a sticky consistency with high hydrolysis conditions; probably they were more susceptible to the acid hydrolysis due to its low amylose content (12 g/100 g). Acid thinning improved gelation of maize, potato and rice starch (Lawal, Adebowale, Ogun-sanwo, Barba, & Ilo, 2005; Wang & Wang, 2001). During hydrolysis, the acid breaks the amylose chains, progressively decreasing their length; depending on hydrolysis conditions, most of the amylose can be degraded, affecting the formation, strength, thermo-reversibility and colour of the gel. The WAI values of hydrolyzed maize starches were statistically lower, and the WSI were higher than maize native starch. The WAI and WSI values of hydrolyzed jicama starches increased when the acid concentration and hydrolysis time were increased. The type of starch and acid concentration showed significant differences in WAI and WSI of both starches.
Wang and Wang (2001) reported higher damaged starch with respect to native starch, while maize starch did not show notable increase in starches and 14.42–210.70 mg/g for hydrolyzed jicama during hydrolysis, 7.62–114.50 mg/g for hydrolyzed maize maize starch, was reflected in the sugar content released the matrices of starch molecules. The susceptibility of ers suggested that an increase in the starch crystallinity as a result of increased mobility of starch molecules, which solubility in oxidized and thinned hybrid maize starch was Lawal et al. (2005) reported that an increase in swelling and

Table 2

<table>
<thead>
<tr>
<th>Assay</th>
<th>Apparent amylose (g/100g)</th>
<th>WSI</th>
<th>WAI</th>
<th>DS</th>
<th>GS</th>
</tr>
</thead>
<tbody>
<tr>
<td>NM</td>
<td>18.11 ± 1.62^b,c,d</td>
<td>1.86 ± 0.04^d</td>
<td>1.13 ± 0.18^e</td>
<td>2.56 ± 0.03^b</td>
<td>0.40 ± 0.04^a</td>
</tr>
<tr>
<td>NJ</td>
<td>11.77 ± 1.00^e</td>
<td>2.06 ± 0.05^e</td>
<td>0.76 ± 0.05^e</td>
<td>4.04 ± 0.08^b</td>
<td>0.08 ± 0.01^e</td>
</tr>
<tr>
<td>T1</td>
<td>18.43 ± 1.50^b,c,d</td>
<td>1.89 ± 0.04^d</td>
<td>0.72 ± 0.05^e</td>
<td>3.40 ± 0.06^b</td>
<td>0.22 ± 0.03^b</td>
</tr>
<tr>
<td>T2</td>
<td>17.38 ± 0.42^c,d</td>
<td>1.82 ± 0.05^d</td>
<td>0.91 ± 0.06^e</td>
<td>3.15 ± 0.07^b</td>
<td>0.22 ± 0.02^b</td>
</tr>
<tr>
<td>T3</td>
<td>19.93 ± 2.50^h</td>
<td>1.88 ± 0.10^d</td>
<td>0.49 ± 0.05^e</td>
<td>3.83 ± 0.18^b</td>
<td>0.18 ± 0.02^e</td>
</tr>
<tr>
<td>T4</td>
<td>21.53 ± 1.52^d</td>
<td>1.81 ± 0.01^d</td>
<td>0.61 ± 0.17^e</td>
<td>3.33 ± 0.19^b</td>
<td>0.12 ± 0.02^d</td>
</tr>
<tr>
<td>T5</td>
<td>17.51 ± 1.23^d</td>
<td>1.85 ± 0.07^e</td>
<td>0.53 ± 0.01^e</td>
<td>3.64 ± 0.38^b</td>
<td>0.21 ± 0.03^b</td>
</tr>
<tr>
<td>T6</td>
<td>16.96 ± 0.70^e</td>
<td>1.87 ± 0.03^d</td>
<td>0.74 ± 0.04^e</td>
<td>3.08 ± 0.16^E</td>
<td>0.11 ± 0.01^d,e</td>
</tr>
<tr>
<td>T7</td>
<td>11.63 ± 0.39^e</td>
<td>2.48 ± 0.06^e</td>
<td>2.12 ± 0.02^d</td>
<td>12.00 ± 0.54^b</td>
<td>0.04 ± 0.01^f</td>
</tr>
<tr>
<td>T8</td>
<td>12.94 ± 2.09^f</td>
<td>2.38 ± 0.03^b</td>
<td>2.15 ± 0.04^d</td>
<td>11.44 ± 0.36^b</td>
<td>0.03 ± 0.00^f</td>
</tr>
<tr>
<td>T9</td>
<td>17.42 ± 0.14^b,c,d</td>
<td>2.35 ± 0.04^b</td>
<td>2.87 ± 0.04^b,c,d</td>
<td>14.76 ± 0.17^a</td>
<td>0.02 ± 0.00^f</td>
</tr>
<tr>
<td>T10</td>
<td>14.76 ± 1.70^d,e</td>
<td>2.35 ± 0.05^b</td>
<td>2.80 ± 0.01^c</td>
<td>12.59 ± 0.15^b</td>
<td>0.03 ± 0.00^f</td>
</tr>
<tr>
<td>T11</td>
<td>12.88 ± 3.07^d</td>
<td>2.39 ± 0.06^b,</td>
<td>3.47 ± 0.02^b</td>
<td>16.68 ± 0.65^a</td>
<td>0.03 ± 0.00^f</td>
</tr>
<tr>
<td>T12</td>
<td>14.40 ± 0.66^e</td>
<td>2.38 ± 0.01^a,b</td>
<td>3.65 ± 0.02^a</td>
<td>16.60 ± 0.51^a</td>
<td>0.03 ± 0.00^f</td>
</tr>
</tbody>
</table>

WSI: water solubility index; WAI: water absorption index; DS: damaged starch; GS: gel strength. Means within the same column that have no common superscript are significantly different (p < 0.5). Hydrolysis conditions are described in Table 1.

Lawal et al. (2005) reported that an increase in swelling and solubility in oxidized and thinned hybrid maize starch was a result of increased mobility of starch molecules, which facilitated easy percolation of water. Also, these researchers suggested that an increase in the starch crystallinity possibly restricted absorption of both water and oil within the matrices of starch molecules. The susceptibility of jicama starch to the hydrolysis conditions, in contrast with maize starch, was reflected in the sugar content released during hydrolysis, 7.62–114.50 mg/g for hydrolyzed maize starches and 14.42–210.70 mg/g for hydrolyzed jicama starches. Maize starch did not show notable increase in damaged starch with respect to native starch, while hydrolyzed jicama starch increased the percentage of damage 2–3 times. Wang and Wang (2001) reported higher values of gel strength (GS) than those found in this work. The values reported by these researchers were 0.306, 0.484 and 0.094 g for acid-thinned corn, potato, and rice starches, respectively. The lower values of GS in this research are due to hydrolysis time, starch origin and method of determination of GS. The percentage of long chains in acid-thinned potato starch might contribute to its long-term gel formation and firmer gel, and the lower gel strength of rice acid-thinned starch may be ascribed to a higher percentage of short chains (Wang & Wang, 2001). Thus, short chains in amylopectin inhibited amylopectin retrogradation, resulting in low gel strength (Shi & Seib, 1992).

Zambrano and Camargo (2002) evaluated the effect of the interaction of time (3, 6, 9, 11 h), acid concentration (1.5, 2.0, 3.0, 4.0, 4.5 g/100 g) and hydrolysis temperature (40, 43, 45, 47, 51, 54 °C) on the hydrolysis of native cassava starch. The treatment 3.0 g/100 g HCl, 40 °C/6 h, showed acceptable values of gel formation and thermo-reversibility with low hydrolysis degree and it was selected as reference in this study.

3.2. Characterization of yogurt

3.2.1. Syneresis index (SI)

The most important causes for syneresis in fermented products include the use of high temperatures of incubation, low solids content or inadequate storage temperatures (Lucey, 2004). Yogurt added with hydrolyzed starches showed an increase in the percentage of syneresis compared to the control. Yogurt formulated with starch of treatment 5 (M/4.5 g/3 h) showed the highest SI value, while the sample formulated with starch of treatment 4 (M/3.0 g/6 h) showed the lowest SI, slightly higher than the control sample. These results indicate that the acid concentration used in hydrolyzed maize starch had an important effect on the syneresis of yogurt. Yogurt samples with hydrolyzed jicama starch did not show significant differences to those found in this work. The values reported by these researchers were 0.306, 0.484 and 0.094 g for acid-thinned corn, potato, and rice starches, respectively. The lower values of GS in this research are due to hydrolysis time, starch origin and method of determination of GS. The percentage of long chains in acid-thinned potato starch might contribute to its long-term gel formation and firmer gel, and the lower gel strength of rice acid-thinned starch may be ascribed to a higher percentage of short chains (Wang & Wang, 2001). Thus, short chains in amylopectin inhibited amylopectin retrogradation, resulting in low gel strength (Shi & Seib, 1992).

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fat substitutes were used for the production of set-style yogurt from reconstituted skimmed milk powder. The yogurts contained 14.0–15.8 g/100 of total solids and 7.3–9.1 g/100 g of carbohydrates. The fat content of all the batches was 0.1 g/100 g except the control (1.5 g/100 g), which was made with anhydrous milk fat. A decrease in whey syneresis and an increase in firmness in all the yogurts was observed after 20 days of storage at 5°C. The use of a higher concentration (5 g/100 g) of fat substitutes increased the firmness, but impaired the flavour and mouthfeel of the yogurts (Tamime, Barrantes, & Sword, 1996). According to Williams, Glagovskaia, and Augustin (2004) the addition of starch to yogurts with 10 g/100 g total dairy solids generally caused a reduction in the whey drained, while at 12 g/100 g total dairy solids, the addition of starch had little effect. Also these researchers found that at lower levels of whey protein concentrate (WPC35) solid substitution (0–15 g/100 g), there was little difference between yogurts with or without starch. At high levels of substitution (20 and 25 g/100 g), a greater volume of whey drained from yogurts that did not have added starch.

3.2.2. pH value

This parameter is considered as control to measure the fermentation time. The changes of pH before and after the cooling step indicate the activity of the initiator culture and its capacity to produce lactic acid from the lactose. During the period before refrigerated storage of the yogurt samples a decrease in the pH values was registered, without significant differences between them, which indicates that the starch type, hydrochloric acid concentration and the hydrolysis time did not influence the final pH of the formulated yogurt (Fig. 2). The pH values of whole and skimmed yogurt, stored at 10, 20 and 30°C for 91, 21, and 3 days, respectively, did not develop much acidity under any storage conditions (Salvador & Fiszman, 2004). Yogurt of skim milk powder (10–14 g/100 g dairy solids) with whey protein concentrate (WPC) showed that the addition of starch had no effect on the fermentation time of the yogurt (Williams et al., 2004).

3.2.3. Yogurt viscosity

Many authors indicate that viscosity is one of the typical major parameters for semiliquid food products (Dobraszczyk & Vincent, 1999). Viscosity measurement was applied successfully in the evaluation of yogurt texture, as shown in the works of Suwonsichon and Peleg (1999) and Salvador and Fiszman (2003, 2004). The viscosity of yogurt formulated with hydrolyzed samples of both starches did not show differences according to the hydrolysis conditions (Fig. 3). Some authors have indicated that smoothness is a highly desirable sensory characteristic in food emulsions such as dairy products. Smoothness can be related to creaminess and thickness, which depends on the viscosity (Guinard & Mazzucchelli, 1996). The ability of starches to thicken, gel and hold water has been exploited in yogurt manufacture (Doreau, 1994; Nielsen et al., 1991), also some workers have found that casein interacts with some types of starch (Antonov, Lefebvre, & Doublier, 1999) increasing viscosity but promoting phase separation. Williams et al. (2004) reported that the effects of adding starch to yogurt (10–14 g/100 g dairy solids) depended on the level of total dairy solids and degree of substitution of skim milk powder with whey protein concentrate. They suggested that the viscosity-enhancing effect of starch addition was reduced when the addition of starch caused the yogurt to become unstable on heating.

3.2.4. Sensorial evaluation of stirred yogurt

Natural yogurts available on the market present a wide range of sensory properties (Szczepaniak & Gorecka, 2002). Consumers may not detect the same particular sensory attributes as trained assessors, and results obtained from an analytical panel are usually more precise and repeatable than those from consumers (Barylko-Pikielna & Matuszewska, 1996; Kilcast, 2002). The results of the
sensorial analysis (smoothness, texture, creaminess, colour, thickness and preference) were associated to the starch type, and hydrolysis conditions. The judges' comments are shown in Table 3. Samples of formulated yogurts with hydrolyzed samples M/1.5 g/3 h, M/1.5 g/6 h, J/1.5 g/3 h, and J/3.0 g/3 h achieved the best scores judged by the trained panel. These yogurts showed smooth flavours as well as a firm and smooth texture, while samples M/4.5 g/3 h and M/4.5 g/6 h were less acceptable due to high acidity and a residual unpleasant flavour. Coarseness was detected in yogurt formulated with J/3.0 g/6 h attributable to severe hydrolysis. In line with Guinard and Mazzucchelli (1996), the trained panel found increasing coarseness of texture to be increasingly unacceptable, while more creaminess and smoothness was more acceptable. Granule size and amylose content of jicama starch was associated with better functional and sensorial properties of the formulated yogurt. According to Malinski et al. (2003) the small starch granules of wheat, amaranth and corn incorporated into reduced fat frozen dessert mixes (2 g/100g, w/w) showed that

Table 3
Comments of the trained panel of the of yogurt samples formulated with the addition of hydrolyzed maize and jicama starches

<table>
<thead>
<tr>
<th>Yogurt sample added with hydrolyzed starches</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>Very good</td>
</tr>
<tr>
<td>M/1.5 g/3 h</td>
<td>Good</td>
</tr>
<tr>
<td>M/1.5 g/6 h</td>
<td>Good flavour, not acid flavour</td>
</tr>
<tr>
<td>M/3.0 g/3 h</td>
<td>Not good flavour, very acid</td>
</tr>
<tr>
<td>M/3.0 g/6 h</td>
<td>Not good flavour</td>
</tr>
<tr>
<td>M/4.5 g/3 h</td>
<td>Not good flavour, remained flavour</td>
</tr>
<tr>
<td>M/4.5 g/6 h</td>
<td>Very acid</td>
</tr>
<tr>
<td>J/1.5 g/3 h</td>
<td>Very good, without remained flavour showed good acidity</td>
</tr>
<tr>
<td>J/1.5 g/6 h</td>
<td>Not good flavour, remained flavour</td>
</tr>
<tr>
<td>J/3.0 g/3 h</td>
<td>Good</td>
</tr>
<tr>
<td>J/3.0 g/6 h</td>
<td>Not good flavour, remained flavour, grainy textures</td>
</tr>
<tr>
<td>J/4.5 g/3 h</td>
<td>Not good flavour, grainy textures</td>
</tr>
<tr>
<td>J/4.5 g/6 h</td>
<td>Not good flavour, remained fermented flavour</td>
</tr>
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</table>
the starch was suitable for use as a fat mimetic. Lucey (2004) referred that coarseness in yogurt usually is due to the presence of large protein aggregates that can vary from 1 to 5 mm in size. The more common causes are high incubation temperatures, high ratio of whey protein to casein, low solids content, and physical damage of the product during storage and distribution.

Williams et al. (2004) proposed that a combination of the rate of acidification and pH are the significant influences on the formation of grainy textures in yogurts with added starch. Schmidt et al. (2001) reported that to make an appealing yogurt for 11–14-year-old consumers, stabilizers (wheat starches) resulting in a thick texture should be used with a “kid friendly” flavour and bright colour.

4. Conclusions

Gels of hydrolyzed maize and jicama starch showed thermo-reversibility, although hydrolyzed maize gels were firmer than hydrolyzed jicama starch. The former starch showed low WSI, damaged starch, total sugar content and WAI compared to hydrolyzed jicama starch. The syneresis index of stirred yogurt with added hydrolyzed starch varied according to the starch type and hydrolysis conditions. The pH and viscosity of yogurt samples were not modified by the addition of hydrolyzed starches. Jicama starch was more susceptible to the hydrolysis conditions than maize starch. Mild hydrolysis (treatments 1, 2, 7 and 9) conditions were appropriate for the preparation of stirred yogurt, which was judged favourably by a trained panel who did not detect the grainy texture characteristic of some milk products added with starch. The addition of hydrolyzed jicama starch (2.03 g/100g) as a fat substitute in the preparation of stirred yogurt had good functional and sensorial properties. The amount of hydrolyzed jicama or maize starches used for yogurt formulations decreased the caloric value of yogurt by approximately 17.7 g/100 g, providing the samples with similar functional characteristics to those of the control.

References


