ABSTRACT

Growing consumer demand for healthy and nutritious products has motivated scientists and food manufacturers to design novel dairy products with higher fiber levels and lower fat content that are free of chemical additives. Chia seed mucilage (CSM) is a healthy natural gel extensively used as a dietary source of soluble fiber, a bulking agent, and a fat replacer in a large variety of foods. In this study, we evaluated the effect of CSM on the nutritional, technological, and sensory properties of skimmed yogurts. The addition of 7.5% CSM to a yogurt formula lowered the degree of syneresis of the resulting yogurt during storage compared with full-fat yogurts. The nutritive value of the enriched yogurts improved due to higher levels of dietary fiber compared with full-fat and skimmed yogurts. Moreover, rheological measurements revealed greater consistency, firmness, and viscosity, as well as the formation of a highly structured network and better resistance to stress in yogurts containing 7.5% CSM. The sensory acceptance of the yogurts enriched with 7.5% CSM was similar to the reference samples in acidity, creaminess, and viscosity terms. These results confirm the feasibility of using CSM as a fat replacer to design novel skimmed yogurts.

Key words: chia seed mucilage, nonfat yogurts, rheology, sensory analysis

INTRODUCTION

Yogurt is an extensively consumed daily product obtained by the fermentation of milk with a combination of Lactobacillus spp. and Streptococcus spp. bacteria. In recent years, the demand for low-fat yogurts has risen because fat is associated with a high risk of obesity, arteriosclerosis, coronary heart illness, high blood pressure, and some cancer types (Kaminarides et al., 2007). Nevertheless, reducing the fat content of yogurt can lead to unpleasant changes in its physical and sensory properties (Zhao et al., 2018). To overcome these problems, hydrocolloids are widely used as fat replacers in the dairy food industry owing to their gelling and stabilizing characteristics and because they improve different yogurt properties, such as texture, mouth feel, appearance, viscosity, and consistency (Sanchez et al., 2000).

Chia (Salvia hispanica L.) is an herbaceous plant from southern Mexico and northern Guatemala (Cappitani et al., 2012). When chia seeds come into contact with water, they produce a transparent mucilaginous gel mostly composed of soluble fiber. This gel possesses an excellent water-holding capacity and good viscosities, even at low concentrations (Segura-Campos et al., 2014). These nutritional and technological properties make chia seed mucilage (CSM) a promising candidate for food applications, with potential applications as a thickener, gel former, fat replacer, and chelator (Cappitani et al., 2012). Recently, CSM and other plant-based gels have been used as fat substitutes in yogurts owing to their ability to improve the rheological properties and stability of dairy products, while reducing calories (Darwish et al., 2018; Kim et al., 2020). However, it is important to highlight that yogurts enriched with CSM have a fat content between 1 and 3% (Darwish et al., 2018), and they are considered low-fat yogurts because they contain no more than 3 g of fat per 100 g for solids or 1.5 g of fat per 100 mL for liquids (European Parliament, Council of the European Union, 2006). As far as we know, CSM has not been used as a fat substitute in fermented skim milk products for achieving equal or better technological qualities in comparison with full-fat yogurts.

Hence, this work evaluated the possibility of adding CSM as a fat replacer to skimmed yogurts and investigated the effect of its incorporation on the nutritional, technological, and organoleptic properties of skimmed yogurts during storage.
Materials and Methods

Yogurt Ingredients, Media, and Chemicals

For the yogurt formulation, full-fat and skim milk powder (Central Lechera Asturiana, Siero, Spain) and commercial chia seeds (Pedon S.P.A, Molvena, Italy) were purchased from a local Spanish market. Lyophilized Streptococcus salivarius ssp. thermophilus (CECT 801) and Lactobacillus delbrueckii ssp. bulgaricus (CECT 4005), obtained from Colección Española de Cultivos Tipo (CECT, University of Valencia, Burjasot, Spain), were used to prepare starter cultures.

For culture media, M17 and de Man, Rogosa, and Sharpe (MRS; broth and agar) and d-lactose monohydrate were used, all of which were supplied by Scharlab (Barcelona, Spain). All other chemicals were purchased from Sigma-Aldrich (Madrid, Spain).

Preparation of the Starter Cultures

Starter cultures were prepared by adding 1 mL of M17 broth, enriched with d-lactose monohydrate (1%, wt/vol; M17-lactose), to the phial containing the lyophilized S. salivarius ssp. thermophilus, and 1 mL of MRS broth to the freeze-dried L. delbrueckii ssp. bulgaricus phial. They were mixed to obtain homogeneous suspensions, which were transferred to test tubes containing 10 mL of M17-lactose for S. salivarius ssp. thermophilus and 10 mL of MRS broth for L. delbrueckii ssp. bulgaricus. The M17-lactose tube was incubated aerobically at 37°C for 24 h, and the MRS tube was incubated anaerobically at 37°C for 72 h using anaerobic jars. Test tubes were centrifuged (2,057 × g for 5 min at 20°C), supernatants were discarded, and 10 mL of each broth was added to the pellet. Serial dilutions were done, and colonies were enumerated by plating 1 mL in M17-lactose agar and 1 mL in MRS agar. Finally, plates were incubated aerobically at 37°C for 24 h (S. salivarius ssp. thermophilus) and anaerobically at 37°C for 72 h (L. delbrueckii ssp. bulgaricus) using anaerobic jars.

Mucilage Extraction from Chia Seeds

To extract CSM, whole chia seeds were submerged in distilled water (water:seed ratio of 30:3), and the mixture was gently stirred at 500 rpm for 3 h at 80°C. After cooling to 20°C, it was centrifuged at 12,857 × g for 15 min at 20°C (Centrifuge 5804 R, Eppendorf AG, Hamburg, Germany). The obtained CSM was freeze-dried (LyoQuest-55, Telstar, Terrassa, Spain) for 48 h before being stored in sterile containers at room temperature before use.

Yogurt Manufacture

Five yogurt types were prepared in this study: 1 full-fat yogurt (FFY), 1 skimmed yogurt (SY), and 3 formulations of SY enriched with different CSM concentrations (2.5, 5.0, and 7.5%, wt/vol).

Milk was prepared by adding 100 g of commercial full-fat or skim milk powder to 1 L of distilled water. The mixture was heated in a bath (JP Selecta S.A., Abrera, Spain) at 85°C for 30 min. Afterward, milk was cooled to 45°C and CSM was added to the mixture at the previously indicated concentrations. No CSM was added to the FFY and SY samples. Each yogurt culture was added at a concentration of 10⁷ cfu/mL. Next, 125 mL of the final mixture was poured into sterilized glass containers, which were placed in an incubator at 40°C and fermented until pH values of 4.5 to 4.6 were achieved. The glass containers were sterilized at 121°C for 15 min by using an autoclave. Finally, yogurts were stored at 4°C until analyses at 1, 7, 14, and 21 d. Each formulation was manufactured in duplicate.

Physicochemical Characterization of Yogurts

A Crison Basic 20+ pH meter (Crison S.A., Barcelona, Spain) was used to measure the pH of yogurts. For the total titratable acidity (TTA) determinations, 10 g of each sample was mixed with 40 mL of distilled water and titrated with a 0.1 N NaOH solution until pH 8.30 ± 0.01 (Pelaes Vital et al., 2015). Titratable acidity was expressed as grams of lactic acid per 100 g of yogurt. Syneresis was determined by centrifuging 5-mL samples of yogurt at 3,214 × g for 20 min at 4°C (Centrifuge 5804 R, Eppendorf AG). The results are reported as the volume of separated whey per 100 g of yogurt.

The color parameters (L*, a*, and b*; lightness, red-green color, yellow-blue color, respectively) of yogurts were measured by a spectrocolorimeter (CM-3600d, Minolta Co., Tokyo, Japan) with an observer 10° and illuminant D65. Whiteness index (WI) and color variations (ΔE*) were calculated by Equations [1] and [2], respectively:

\[
WI = 100 - [(100 - L*)^2 + a^2 + b^2]^{0.5}, \quad [1]
\]
\[
\Delta E^* = [(\Delta L*)^2 + (\Delta a*)^2 + (\Delta b*)^2]^{0.5}. \quad [2]
\]

Nutritional Composition of Yogurts

The nutritional value of yogurts (moisture, protein, fat, ash, and total dietary fiber) was determined following AOAC procedures (AOAC International, 2016).
Protein, fat, fiber, and ash contents were analyzed using lyophilized yogurt samples. Finally, carbohydrates were estimated by difference. All the tests were run in triplicate.

**Rheological and Viscoelastic Measurements**

The rheological and viscoelastic measurements were taken by a stress-controlled rheometer RS1 (Thermo Haake, Karslruhe, Germany). Assays were performed at 4°C using a C60/2° Ti cone-plate geometry with a 2-mm gap. Samples were placed in the measuring system and allowed to stand for 300 s for structure recovery and temperature equilibration before being tested. All rheological measurements were done in triplicate.

**Steady Shear Rheological Tests.** The steady shear rheological tests were performed within the range of 0.1 to 200 s\(^{-1}\) for 120 s. To rule out any possible dependence on flow time, a 4-step operation (2 upward and 2 downward curves) was applied to samples and flow curve was fitted to the Hershel-Bulkley model (Sah et al., 2016). Finally, the yield stress (\(\tau_0\)), consistency (\(K\)), and flow behavior indices (\(n\)) were calculated, as was apparent viscosity (\(\eta_{app50}\)) (Equation [3]) (Morell et al., 2015).

\[
\eta_{app50} = (K \times 50^{n-1}). \tag{3}
\]

**Dynamic Rheological Tests.** To determine the linear viscoelastic region, stress sweeps were performed within a stress range from 0.01 to 10 Pa at 1 Hz. Frequency sweep tests were conducted at 1 Pa (in the linear viscoelastic region) to cover a 0.1- to 10-Hz frequency range at 4°C.

The viscoelastic parameters, namely elastic or storage modulus (\(G'\)), viscous or loss modulus (\(G''\)), complex modulus (\(|G'|\)), loss tangent (\(\tan \delta\)), and complex viscosity (\(|\eta'|\)), were obtained from the rheometer software (RheoWin 3 Data Manager, Thermo Haake).

**Creep and Recovery Tests.** Creep and recovery tests were carried out by applying constant stress (1 Pa within the linear viscoelastic region), which was maintained for 300 s. Afterward, stress was stopped and samples were released for recovery for 300 s.

The Burger model parameters (\(G_0 = \) instantaneous elastic modulus of the Maxwell unit; \(\eta_0 = \) residual viscosity) were taken from the rheometer software (RheoWin 3 Data Manager). The system’s final percentage of recovery (\(R\)) was calculated with Equation [4]:

\[
R (\%) = (J_{\max} - J_\infty/J_{\max}) \times 100, \tag{4}
\]

where \(J_{\max}\) is the maximum deformation corresponding to the compliance value for the longest time (300 s) in the creep rest; \(J_\infty\) is the residual deformation (Kurt et al., 2016).

**Sensory Evaluation**

The sensory evaluation of yogurts was conducted by a semi-trained panel. The participants were between 24 and 50 yr old and included 20 women and 10 men. Panel selection emphasized interest in the sensory evaluation of yogurts, availability, being a nonsmoker, and lack of allergies, following the general guidelines of UNE-ISO 8586:2012 (ISO, 2012). Training sessions were performed to introduce the panelists to the sensory analysis and to identify and score the quality attributes that define the samples. A structured 9-point hedonic scale (1 = very unpleasant; 9 = very pleasant; UNE-ISO 4121:2003, ISO, 2003) was used to evaluate the appearance, color, viscosity, granularity, creaminess, acidity, and global acceptance attributes. The panelists tested 3 different samples: FFY (prepared with whole milk powder), SY (manufactured with skim milk powder), and SY + 7.5% CSM (produced with skim milk powder enriched with 7.5% CSM). The evaluated samples were selected according to the data observed in the nutritional and rheological tests. The sensory analysis was carried out 24 h after preparing yogurts, which were stored at 4°C. Samples were presented to the panelists in a plastic cup, coded with 3 random digits. Sensory evaluations were made by following the Institute of Food Science and Technology Guidelines for Ethical and Professional Practices for the Sensory Analysis of Foods (Institute of Food Science and Technology, 2015). Every panelist gave written consent before conducting the sensory analysis.

**Statistical Analysis**

The results obtained from the physicochemical characterization, the nutritional composition, and the rheological assays of yogurts were analyzed by a multifactor ANOVA to evaluate differences among the samples and storage times. The results of the influence of using CSM on the sensory characteristics of yogurts were analyzed by a one-way ANOVA. The least significance procedure was used to test for any differences between averages at a 5% level of significance. Data were statistically processed by Statgraphics Centurion XVI (Statgraphics Technologies Inc., The Plains, VA).
RESULTS AND DISCUSSION

Physicochemical Characterization of Yogurts

The changes in pH, TTA, and syneresis of the different manufactured yogurts are shown in Figure 1. The pH values of all the samples progressively declined at 4°C, with a significant ($P < 0.05$) decrease throughout the storage period. The differences observed among samples were significant ($P < 0.05$) after 14 d of storage.

A slight rise in TTA occurred over the storage time as a result of greater lactic acid production, which could be caused by continued fermentation and lactic bacteria growth. Higher TTA leads to greater casein micelle matrix contraction, which means more whey is released (Fox et al., 2000). For instance, the lactic acid concentration in the stored yogurts initially ranged from 0.617 ± 0.002 g/100 g to 0.767 ± 0.023 g/100 g, whereas it ranged from 0.672 ± 0.023 g/100 g to 0.815 ± 0.009 g/100 at the end of the study (Figure 1B).

Furthermore, slightly significant differences ($P < 0.05$) were observed in sample types. The TTA values of the SY, with or without fortification with CSM, were higher than those exhibited by the FFY sample. In line with this, Yazici and Akgun (2004) reported that higher TTA values could be attributed to the moisture content of low-fat and nonfat yogurts.

Regarding samples’ degree of syneresis, more whey became separated throughout the storage time for FFY and SY samples, which could be explained by increased acidity during storage, which would bring about casein micelle matrix contraction and subsequent release of whey (Canbulat and Ozcan, 2015). Conversely, the sample prepared with the highest CSM concentration (7.5%) had a lower degree of syneresis during the study, and this depletion came close to 2% after 21 d of analysis. The latter finding could be explained by interactions between casein micelles (positively charged) and CSM (negatively charged), which in turn enhanced matrix stabilization and reduce separated whey (Figure 1C).

With regard to the color parameters, the $L^*$ values ranged from 86.9 ± 0.5 to 89.8 ± 0.1, and the WI values were between 83.4 ± 1.2 and 86.4 ± 0.6. Moreover, the $\Delta E^*$ values ranged from 0.5 ± 0.1 to 1.8 ± 0.5 throughout the evaluation (Figure 2). These results suggest that the $\Delta E^*$ of yogurts stored at 4°C for 21 d did not exceed the just noticeable difference (Baldevbhai and Aanand, 2012).

Nutritional Composition of Yogurts

Figure 3 presents the results of the nutritional composition of yogurts. As expected, storage time did not significantly affect ($P > 0.05$) moisture, protein, fat, and ash contents, which remained practically constant over the study period for each sample type. Significant differences ($P < 0.05$) in protein content were noted among formulations, with SY having the least protein. In addition, the yogurts prepared with CSM exhibited slightly higher protein values than SY (Figure 3B),...
which may be due to the protein content of CSM, as indicated by Felisberto et al. (2015) in their study characterizing lyophilized CSM.

Full-fat yogurt had a fat content of 3.9 ± 0.2 g/100 g throughout storage. The fat content of the modified yogurts increased with the CSM content (Figure 3C). This finding could be explained through data reported by several authors on proximate lyophilized CSM composition (Capitani et al., 2013; Felisberto et al., 2015). A similar trend was noted for ash content. The yogurts made with CSM presented a slightly higher ash content than the control and SY samples (Figure 3D).

Figure 3E shows that the higher the mucilage concentration, the larger the fiber content. This fact could be accounted for by the high dietary fiber levels present in the extracted mucilage (Felisberto et al., 2015), which would improve the nutritional characteristics of the novel yogurts. Storage time did not significantly affect the fiber content of yogurts.

**Rheological Measurements**

**Steady Shear Rheological Tests.** Table 1 shows the results of the rheological parameters from the steady shear test of yogurts. Yield stress (τ₀) is a typical characteristic of these products and is well correlated with their early firmness during sensory tests (Costa et al., 2019; Harte et al., 2007). As observed throughout the evaluation period, the formulations with higher yield stress (τ₀) were FFY and the yogurt enriched with 7.5% CSM. This outcome could be associated with the presence of an interactive or cross-linked structure (Yu et al., 2016), which was more pronounced in the samples with the highest amount of the CSM. A slightly reduction in this parameter was observed during the storage time, which could be related to the preservation of the cross-linked structure with time.

The consistency index (K) of yogurts is linked with different intermolecular interactions and attraction forces between proteins (Costa et al., 2019). Higher K values were observed for the reference sample (FFY) during the study. Moreover, marked concentration dependency was noticed among the products containing CSM. Addition of CSM to yogurts significantly (P < 0.05) increased the K values, which became higher when larger amounts of CSM were used. This finding could be explained by the capacity of swollen CSM particles to act as fillers, which reduces the protein matrix mobility and increases enriched yogurts' consistency (Morell et al., 2015). Furthermore, significant differences (P < 0.05) were found among samples during storage. As seen in Table 1, higher K values were detected in the samples stored for 21 d at 4°C. Similarly, Cardines et al. (2018) observed higher K values for all their samples.

![Figure 2](image-url)  
**Figure 2.** Color parameters: (A) luminosity (L*), (B) whiteness index (WI), and (C) color variations (ΔE*) of the different yogurts stored during 21 d of storage at 4°C. Mean values (n = 3) ± standard deviation. FFY = full-fat yogurt; SY = skimmed yogurt; CSM = chia seed mucilage.
throughout storage due to whey spontaneously migrating to the surface of the product.

The flow behavior index ($n$) indicates the rheological nature of the fluid. As the fluid approaches Newtonian behavior, the $n$ value approaches 1 (Kaur and Kaler, 2008). The $n$ values decreased below 1 for all tested yogurts, which indicates shear-thinning behavior once yield stress was overtaken. Generally, $n$ values became lower with higher CSM concentrations. Similar results have been described by Paseephol et al. (2008) regarding the addition of oligofructose and medium-chain inulin to yogurts. Conversely, a rise in those values...
was observed over storage time for each sample, which accords with the results reported by Paseephol et al. (2008).

A marked increase in the manufactured samples' viscosity ($\eta_{app50}$) was observed in the SY products containing more CSM (Table 1). As the mucilage concentration rose, viscosity increased owing to the interactions between polysaccharides and dairy proteins (Sodini et al., 2004). It is worth mentioning that by the end of storage, higher $\eta_{app50}$ values were observed in the samples formulated with 7.5% CSM compared with FFY (Table 1).

Lastly, noticeable differences were found as a result of storage. The longer the storage, the lower the manufactured yogurts' viscosity values (Aryana et al., 2006), which could be explained by the depleted water-binding capacity of the proteins present in each formulation (Jaster et al., 2018).

Dynamic Rheological Tests. Table 2 shows the viscoelastic properties of the different manufactured yogurts. For comparative purposes, the storage modulus ($G'$) and loss modulus ($G''$) values were considered at a frequency of 1 Hz. A predominant elastic behavior ($G' > G''$), which is common in weak viscoelastic systems (Morell et al., 2015), was observed throughout the study. The FFY sample presented higher $G'$ and $G''$ values than the SY sample. Indeed, increasing $G'$ and $G''$ values were noticed when the CSM concentrations were higher. This finding can be explained by the interactions taking place between negatively charged mucilage and the positively charged surface of casein micelles, which lead to a highly structured network that provides samples with good gel strength and makes them more viscous (Foster and Wolf, 2011). Furthermore, for the enriched yogurts, and despite storage time, the highest $G'$ and $G''$ values were exhibited by the yogurts formulated with 7.5% CSM. Thus, large amounts of CSM could increase skimmed yogurts’ firmness due to the strength of the developed network structure, which would diminish the mobility of particles and the synergistic rate, as already mentioned.

Prolonged cold storage significantly affected ($P < 0.05$) the $G'$ and $G''$ values of all the yogurts formulated in this study. Higher values were observed after 21 d of storage at 4°C, regardless of yogurt type (Sah et al., 2016). Cooling processes can bring about conformational changes in products, such as xanthan gum and gelatin, reflected by increasing $G'$ values of acid milk gels (Pang et al., 2017). Hence, conformational changes in CSM molecules during cooling storage could explain the higher values found for the 7.5% CSM yogurts.

Complex modulus ($|G^*|$) is a measure of the product stiffness (Mezger, 2006). The higher the complex modulus ($|G^*|$) is, the greater the yogurt firmness (Costa et al., 2019). Thus, FFY and 7.5% CSM were the formulations with the best firmness. This outcome indicates that using larger amounts of CSM could increase skimmed yogurts’ firmness because of the robust network structure created.

Indeed, the firmness of all the products significantly ($P < 0.05$) increased during storage. Walstra et al. (1999) pointed out that yogurt gel firmness increased

### Table 1. Rheological parameters from the steady shear tests of the different yogurt formulations during 21 storage days at 4°C: yield stress ($\tau_0$), consistency coefficient ($K$), flow behavior index ($n$), and apparent viscosity ($\eta_{app50}$)

<table>
<thead>
<tr>
<th>Item</th>
<th>Day of analysis</th>
<th>FFY</th>
<th>SY</th>
<th>SY + CSM 2.5%</th>
<th>SY + CSM 5.0%</th>
<th>SY + CSM 7.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tau_0$, Pa</td>
<td>1</td>
<td>3.192 ± 0.047&lt;sup&gt;a,b&lt;/sup&gt;</td>
<td>1.982 ± 0.036&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.469 ± 0.030&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.853 ± 0.091&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.157 ± 0.029&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>3.107 ± 0.056&lt;sup&gt;b,d&lt;/sup&gt;</td>
<td>1.970 ± 0.058&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.449 ± 0.048&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.812 ± 0.043&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.089 ± 0.042&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>3.069 ± 0.031&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1.778 ± 0.020&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.204 ± 0.052&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.767 ± 0.038&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.044 ± 0.101&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>2.951 ± 0.113&lt;sup&gt;c,d&lt;/sup&gt;</td>
<td>1.731 ± 0.059&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.163 ± 0.077&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.722 ± 0.052&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.968 ± 0.029&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>$K$, Pa·s</td>
<td>1</td>
<td>4.667 ± 0.138&lt;sup&gt;c&lt;/sup&gt;</td>
<td>3.256 ± 0.092&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.272 ± 0.036&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.388 ± 0.064&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.479 ± 0.105&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>4.921 ± 0.106&lt;sup&gt;d&lt;/sup&gt;</td>
<td>3.222 ± 0.014&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.559 ± 0.041&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.620 ± 0.050&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.885 ± 0.092&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>5.344 ± 0.063&lt;sup&gt;e&lt;/sup&gt;</td>
<td>4.364 ± 0.040&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.589 ± 0.047&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.169 ± 0.029&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.333 ± 0.041&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>5.216 ± 0.022&lt;sup&gt;d&lt;/sup&gt;</td>
<td>4.160 ± 0.073&lt;sup&gt;a&lt;/sup&gt;</td>
<td>4.303 ± 0.049&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.070 ± 0.087&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.088 ± 0.106&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>$n$</td>
<td>1</td>
<td>0.631 ± 0.019&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.640 ± 0.011&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.624 ± 0.007&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.612 ± 0.019&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.613 ± 0.026&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>0.656 ± 0.028&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.686 ± 0.036&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.673 ± 0.006&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.619 ± 0.028&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.644 ± 0.023&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>0.671 ± 0.013&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.696 ± 0.026&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.755 ± 0.073&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.663 ± 0.004&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.641 ± 0.014&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>0.160 ± 0.011&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.064 ± 0.008&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.071 ± 0.007&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.147 ± 0.008&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.195 ± 0.029&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>$\eta_{app50}$, Pa·s</td>
<td>1</td>
<td>0.135 ± 0.006&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.054 ± 0.001&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.059 ± 0.005&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.128 ± 0.002&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.165 ± 0.006&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>0.104 ± 0.009&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.045 ± 0.011&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.047 ± 0.014&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.102 ± 0.016&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.147 ± 0.012&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>0.090 ± 0.010&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.028 ± 0.009&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.030 ± 0.008&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.085 ± 0.007&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.106 ± 0.009&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a-b</sup>Lowercase letters indicate significant differences among the storage time expressed in days ($P < 0.05$).

<sup>A-B</sup>Uppercase letters indicate significant differences among the samples ($P < 0.05$).

<sup>1</sup>Mean values (n = 3) ± standard deviation. FFY = full-fat yogurt; SY = skimmed yogurt; CSM = chia seed mucilage.
Table 2. Viscoelastic properties, at a frequency of 1 Hz, of the different yogurt formulations during 21 storage days at 4°C: elastic or storage modulus (G'), viscous or loss modulus (G″), complex modulus (|G*|), complex viscosity (|η*|), and loss tangent (tan δ)1

<table>
<thead>
<tr>
<th>Item</th>
<th>Day of analysis</th>
<th>FFY</th>
<th>SY</th>
<th>SY + CSM 2.5%</th>
<th>SY + CSM 5.0%</th>
<th>SY + CSM 7.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>G', Pa</td>
<td>1</td>
<td>297 ± 91abc</td>
<td>81 ± 42a</td>
<td>121 ± 89abc</td>
<td>169 ± 25abc</td>
<td>281 ± 28abc</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>453 ± 62abc</td>
<td>165 ± 49a</td>
<td>279 ± 38abc</td>
<td>354 ± 20abc</td>
<td>482 ± 22abc</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>671 ± 30abc</td>
<td>230 ± 91a</td>
<td>413 ± 29abc</td>
<td>626 ± 53abc</td>
<td>770 ± 29abc</td>
</tr>
<tr>
<td>G″, Pa</td>
<td>1</td>
<td>183 ± 43abc</td>
<td>64 ± 24a</td>
<td>90 ± 11abc</td>
<td>127 ± 36abc</td>
<td>199 ± 31abc</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>236 ± 21abc</td>
<td>138 ± 22abc</td>
<td>161 ± 50abc</td>
<td>232 ± 32abc</td>
<td>250 ± 17abc</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>271 ± 36abc</td>
<td>178 ± 21abc</td>
<td>240 ± 26abc</td>
<td>275 ± 45abc</td>
<td>287 ± 28abc</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>337 ± 19abc</td>
<td>267 ± 14abc</td>
<td>283 ± 12abc</td>
<td>302 ± 18abc</td>
<td>362 ± 19abc</td>
</tr>
<tr>
<td></td>
<td>G*,</td>
<td>Pa</td>
<td>1</td>
<td>287 ± 14abc</td>
<td>109 ± 46a</td>
<td>183 ± 26abc</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>336 ± 45abc</td>
<td>227 ± 31abc</td>
<td>324 ± 51abc</td>
<td>381 ± 23abc</td>
<td>361 ± 37abc</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>503 ± 51abc</td>
<td>364 ± 42abc</td>
<td>446 ± 40abc</td>
<td>496 ± 32abc</td>
<td>598 ± 31abc</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>760 ± 15abc</td>
<td>413 ± 10abc</td>
<td>542 ± 31abc</td>
<td>671 ± 83abc</td>
<td>816 ± 18abc</td>
</tr>
<tr>
<td>tan δ</td>
<td>1</td>
<td>0.596 ± 0.008abc</td>
<td>0.709 ± 0.002abc</td>
<td>0.746 ± 0.005abc</td>
<td>0.756 ± 0.007abc</td>
<td>0.710 ± 0.006abc</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>0.501 ± 0.009abc</td>
<td>0.792 ± 0.002abc</td>
<td>0.567 ± 0.004abc</td>
<td>0.774 ± 0.001abc</td>
<td>0.563 ± 0.008abc</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>0.434 ± 0.004abc</td>
<td>0.756 ± 0.002abc</td>
<td>0.680 ± 0.008abc</td>
<td>0.560 ± 0.004abc</td>
<td>0.463 ± 0.010abc</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>0.466 ± 0.008abc</td>
<td>0.708 ± 0.007abc</td>
<td>0.681 ± 0.007abc</td>
<td>0.510 ± 0.004abc</td>
<td>0.473 ± 0.004abc</td>
</tr>
<tr>
<td></td>
<td>η*,</td>
<td>Pa·s</td>
<td>1</td>
<td>61 ± 11abc</td>
<td>50 ± 1abc</td>
<td>55 ± 17abc</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>94 ± 33abc</td>
<td>85 ± 13abc</td>
<td>89 ± 16abc</td>
<td>94 ± 31abc</td>
<td>100 ± 9abc</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>129 ± 45abc</td>
<td>124 ± 26abc</td>
<td>128 ± 44abc</td>
<td>132 ± 35abc</td>
<td>170 ± 28abc</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>252 ± 38abc</td>
<td>159 ± 24abc</td>
<td>177 ± 33abc</td>
<td>187 ± 19abc</td>
<td>250 ± 39abc</td>
</tr>
</tbody>
</table>

1Mean values (n = 3) ± standard deviation. FFY = full-fat yogurt; SY = skimmed yogurt; CSM = chia seed mucilage.

when pH values decreased. In this study, lower pH values were obtained at the end of storage, increasing |G*| values and improving gel firmness.

Values for tan δ can be used to indicate the system’s physical behavior. Values above 1 are indicative of dilute solutions, while values between 0.1 and 1 denote weak gels (Irani et al., 2019). All the formulations had tan δ values below 1, which reinforces that elastic properties prevail over viscous ones. The tan δ values for all the formulations remained practically constant throughout storage. Moreover, the addition of CSM significantly (P < 0.05) increased the complex viscosity (|η*|) of the different samples suggesting that the obtained mucilage had a thickening effect on yogurts and increased internal cohesive forces (Giri et al., 2018). Similarly, the increase in |η*| that took place during storage could be explained by post-acidification processes (Saint-Eve et al., 2008).

Creep and Recovery Tests. Figure 4 shows the creep and recovery curves of the different yogurts. High compliance values [J(0)] indicate a weaker product structure (Sozer, 2009). According to this view, the SY sample presented the weakest gel structure, whereas samples formulated with increasing CSM concentrations had lower J(0) values, which reflected more elastic behavior. Notably, the FFY and 7.5% CSM samples displayed similar behavior for the first 7 d of analysis. Afterward, the J(t) values significantly (P < 0.05) decreased for the sample enriched with 7.5% CSM. For this reason, it can be stated that using CSM reinforced the gel structure of the developed yogurts.

Regarding the Burger model parameters (Table 3), the instantaneous shear modulus (G0) was higher when larger amounts of extracted mucilage were used. This rise could indicate increased elastic strength of the bonds forming the interfacial network structure of yogurts (Karaman et al., 2012). Significant differences (P < 0.05) were observed in the G0 values throughout the study as yogurts had higher G0 values at the end of the study, suggesting the reinforcement of the gel matrix. These results agree with those previously observed.

In contrast, the Jmax and J∞ values decreased when higher CSM concentrations were used (Table 3). This finding could be explained by the final product’s enhanced elastic bonds, which diminished the number of irreversible broken bonds (Kurt et al., 2016). Last, the recovery rates (R, %) exhibited better elastic behavior for 7.5% CSM yogurts than FFY and SY samples. This phenomenon was clearly observed when storage time ended. Thus, as suggested by Kurt et al. (2016), adding anionic polysaccharides to milk bases could increase resistance to stress due to stronger interactions among the constituents of foods.

Sensory Analysis

The sensory analysis is an essential tool for determining the acceptance of new foods. For this reason,
a sensory evaluation of FFY (control), SY, and the yogurt prepared with 7.5% CSM was carried out. The incorporation of extracted CSM into yogurts did not modify acidity, creaminess, or viscosity compared with the FFY sample. Nevertheless, the appearance, color, and granularity of the manufactured yogurts were affected when CSM was added (Table 4).

The color attribute findings observed by the panelists were in accordance with those observed in the characterization of the different yogurt formulations. Notably, the global acceptance of the sample enriched with 7.5% CSM obtained a lower score probably due to the effect of mucilage on the sample’s granularity.

**CONCLUSIONS**

The use of CSM in skimmed yogurts led to significant changes in their nutritional, technological, and sensory characteristics compared with full-fat and skimmed controls. Enriching yogurts with mucilage reduced the degree of syneresis during storage compared with the full-fat and skimmed samples. Moreover, its incorporation improved the nutritional value of the yogurts by increasing their fiber content. The technological characteristics of the yogurts formulated with CSM were enhanced in terms of greater consistency, network structure, firmness, viscosity, and resistance to stress versus skimmed or full-fat yogurts. Storage time positively affected the technological properties of the manufactured yogurts. The sensory evaluation showed that using CSM as a fat replacer in yogurts did not modify the acidity, creaminess, and viscosity of samples, whereas their appearance, color, and granularity played an important role in the products’ global acceptance compared with full-fat yogurt. This work provides an interesting alternative for the food industry to reduce fat content in dairy products, increase their nutritional value, and improve the technological features of skimmed yogurts. Our findings could represent an advance in developing novel nonfat yogurts with equal

![Figure 4](image-url)  
**Figure 4.** Creep and recovery curves of the different yogurts stored at 4°C for (A) 1 d; (B) 7 d; (C) 14 d; and (D) 21 d. Mean values (n = 3). FFY = full-fat yogurt; SY = skimmed yogurt; CSM = chia seed mucilage. J = deformation; t = time.
<table>
<thead>
<tr>
<th>Item</th>
<th>Day of analysis</th>
<th>FFY</th>
<th>SY</th>
<th>SY + CSM 2.5%</th>
<th>SY + CSM 5.0%</th>
<th>SY + CSM 7.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>$G_0$, Pa</td>
<td>1</td>
<td>114.0 ± 10.0&lt;sup&gt;a&lt;/sup&gt;B</td>
<td>87.6 ± 5.3&lt;sup&gt;a&lt;/sup&gt;A</td>
<td>262.6 ± 33.3&lt;sup&gt;a&lt;/sup&gt;C</td>
<td>172.9 ± 71.2&lt;sup&gt;a&lt;/sup&gt;BC</td>
<td>282.6 ± 39.4&lt;sup&gt;a&lt;/sup&gt;BC</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>257.1 ± 47.7&lt;sup&gt;a&lt;/sup&gt;AB</td>
<td>187.6 ± 23.8&lt;sup&gt;a&lt;/sup&gt;A</td>
<td>264.7 ± 20.6&lt;sup&gt;a&lt;/sup&gt;B</td>
<td>213.9 ± 22.1&lt;sup&gt;a&lt;/sup&gt;B</td>
<td>481.4 ± 78.5&lt;sup&gt;a&lt;/sup&gt;C</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>291.8 ± 22.3&lt;sup&gt;a&lt;/sup&gt;AB</td>
<td>155.5 ± 48.6&lt;sup&gt;a&lt;/sup&gt;A</td>
<td>227.5 ± 71.3&lt;sup&gt;a&lt;/sup&gt;AB</td>
<td>260.6 ± 54.1&lt;sup&gt;a&lt;/sup&gt;B</td>
<td>671.3 ± 92.6&lt;sup&gt;a&lt;/sup&gt;C</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>395.3 ± 15.9&lt;sup&gt;a&lt;/sup&gt;C</td>
<td>269.0 ± 38.6&lt;sup&gt;a&lt;/sup&gt;A</td>
<td>348.2 ± 23.2&lt;sup&gt;a&lt;/sup&gt;B</td>
<td>316.7 ± 66.2&lt;sup&gt;a&lt;/sup&gt;AB</td>
<td>1329.0 ± 36.5&lt;sup&gt;a&lt;/sup&gt;BC</td>
</tr>
<tr>
<td>$\eta_0 \times 10^5$, Pa·s</td>
<td>1</td>
<td>2.992 ± 0.199&lt;sup&gt;a&lt;/sup&gt;C</td>
<td>1.024 ± 0.161&lt;sup&gt;a&lt;/sup&gt;A</td>
<td>2.266 ± 0.295&lt;sup&gt;a&lt;/sup&gt;B</td>
<td>3.687 ± 0.502&lt;sup&gt;a&lt;/sup&gt;D</td>
<td>3.851 ± 1.376&lt;sup&gt;a&lt;/sup&gt;C</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>4.565 ± 0.994&lt;sup&gt;a&lt;/sup&gt;C</td>
<td>2.722 ± 0.358&lt;sup&gt;a&lt;/sup&gt;A</td>
<td>3.222 ± 0.189&lt;sup&gt;a&lt;/sup&gt;AB</td>
<td>2.935 ± 0.275&lt;sup&gt;a&lt;/sup&gt;B</td>
<td>3.912 ± 0.602&lt;sup&gt;a&lt;/sup&gt;B</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>3.543 ± 0.502&lt;sup&gt;a&lt;/sup&gt;B</td>
<td>1.928 ± 0.604&lt;sup&gt;a&lt;/sup&gt;A</td>
<td>2.685 ± 0.791&lt;sup&gt;a&lt;/sup&gt;AB</td>
<td>2.416 ± 0.622&lt;sup&gt;a&lt;/sup&gt;AB</td>
<td>6.735 ± 0.751&lt;sup&gt;a&lt;/sup&gt;C</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>7.206 ± 1.094&lt;sup&gt;a&lt;/sup&gt;C</td>
<td>1.925 ± 0.363&lt;sup&gt;a&lt;/sup&gt;A</td>
<td>5.014 ± 0.906&lt;sup&gt;a&lt;/sup&gt;B</td>
<td>4.379 ± 2.326&lt;sup&gt;a&lt;/sup&gt;BC</td>
<td>5.014 ± 0.908&lt;sup&gt;a&lt;/sup&gt;B</td>
</tr>
<tr>
<td>$J_{\text{max}}$, Pa&lt;sup&gt;-1&lt;/sup&gt;</td>
<td>1</td>
<td>0.0031 ± 0.0001&lt;sup&gt;a&lt;/sup&gt;A</td>
<td>0.0144 ± 0.0002&lt;sup&gt;a&lt;/sup&gt;C</td>
<td>0.0047 ± 0.0002&lt;sup&gt;a&lt;/sup&gt;B</td>
<td>0.0041 ± 0.0000&lt;sup&gt;a&lt;/sup&gt;AB</td>
<td>0.0030 ± 0.0000&lt;sup&gt;a&lt;/sup&gt;AB</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>0.0040 ± 0.0008&lt;sup&gt;a&lt;/sup&gt;AB</td>
<td>0.0065 ± 0.0007&lt;sup&gt;a&lt;/sup&gt;C</td>
<td>0.0042 ± 0.0007&lt;sup&gt;a&lt;/sup&gt;AB</td>
<td>0.0057 ± 0.0007&lt;sup&gt;a&lt;/sup&gt;BC</td>
<td>0.0031 ± 0.0002&lt;sup&gt;a&lt;/sup&gt;AB</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>0.0029 ± 0.0006&lt;sup&gt;a&lt;/sup&gt;B</td>
<td>0.0047 ± 0.0004&lt;sup&gt;a&lt;/sup&gt;C</td>
<td>0.0040 ± 0.0011&lt;sup&gt;a&lt;/sup&gt;BC</td>
<td>0.0042 ± 0.0011&lt;sup&gt;a&lt;/sup&gt;BC</td>
<td>0.0019 ± 0.0007&lt;sup&gt;a&lt;/sup&gt;AB</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>0.0013 ± 0.0004&lt;sup&gt;a&lt;/sup&gt;AB</td>
<td>0.0073 ± 0.0005&lt;sup&gt;a&lt;/sup&gt;C</td>
<td>0.0022 ± 0.0005&lt;sup&gt;a&lt;/sup&gt;AB</td>
<td>0.0018 ± 0.0004&lt;sup&gt;a&lt;/sup&gt;AB</td>
<td>0.0015 ± 0.0005&lt;sup&gt;a&lt;/sup&gt;B</td>
</tr>
<tr>
<td>$J_{\infty}$, Pa&lt;sup&gt;-1&lt;/sup&gt;</td>
<td>1</td>
<td>0.0020 ± 0.0008&lt;sup&gt;a&lt;/sup&gt;AB</td>
<td>0.0036 ± 0.0006&lt;sup&gt;a&lt;/sup&gt;C</td>
<td>0.0029 ± 0.0007&lt;sup&gt;a&lt;/sup&gt;B,BC</td>
<td>0.0030 ± 0.0004&lt;sup&gt;a&lt;/sup&gt;B,BC</td>
<td>0.0011 ± 0.0001&lt;sup&gt;a&lt;/sup&gt;B</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>0.0027 ± 0.0010&lt;sup&gt;a&lt;/sup&gt;BC</td>
<td>0.0042 ± 0.0002&lt;sup&gt;a&lt;/sup&gt;C</td>
<td>0.0030 ± 0.0009&lt;sup&gt;a&lt;/sup&gt;B,BC</td>
<td>0.0028 ± 0.0001&lt;sup&gt;a&lt;/sup&gt;BC,AB</td>
<td>0.0010 ± 0.0005&lt;sup&gt;a&lt;/sup&gt;AB</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>0.0018 ± 0.0009&lt;sup&gt;a&lt;/sup&gt;BC</td>
<td>0.0029 ± 0.0004&lt;sup&gt;a&lt;/sup&gt;C</td>
<td>0.0027 ± 0.0011&lt;sup&gt;a&lt;/sup&gt;B,BC</td>
<td>0.0026 ± 0.0011&lt;sup&gt;a&lt;/sup&gt;BC,AB</td>
<td>0.0007 ± 0.0003&lt;sup&gt;a&lt;/sup&gt;A</td>
</tr>
<tr>
<td>$R$, %</td>
<td>1</td>
<td>58.07 ± 2.31&lt;sup&gt;a&lt;/sup&gt;AB</td>
<td>49.31 ± 2.29&lt;sup&gt;a&lt;/sup&gt;B</td>
<td>52.75 ± 1.40&lt;sup&gt;a&lt;/sup&gt;A</td>
<td>56.10 ± 5.43&lt;sup&gt;a&lt;/sup&gt;A</td>
<td>51.21 ± 5.04&lt;sup&gt;a&lt;/sup&gt;AB</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>50.31 ± 5.09&lt;sup&gt;a&lt;/sup&gt;AB</td>
<td>45.37 ± 5.28&lt;sup&gt;a&lt;/sup&gt;AB</td>
<td>33.78 ± 6.99&lt;sup&gt;a&lt;/sup&gt;A</td>
<td>48.37 ± 1.39&lt;sup&gt;a&lt;/sup&gt;B</td>
<td>63.99 ± 2.35&lt;sup&gt;a&lt;/sup&gt;C</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>39.20 ± 6.12&lt;sup&gt;a&lt;/sup&gt;A</td>
<td>40.81 ± 6.45&lt;sup&gt;a&lt;/sup&gt;A</td>
<td>49.06 ± 2.30&lt;sup&gt;a&lt;/sup&gt;B</td>
<td>40.63 ± 0.83&lt;sup&gt;a&lt;/sup&gt;A</td>
<td>58.73 ± 4.62&lt;sup&gt;a&lt;/sup&gt;B</td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>38.68 ± 3.10&lt;sup&gt;a&lt;/sup&gt;A</td>
<td>42.44 ± 8.11&lt;sup&gt;a&lt;/sup&gt;AB</td>
<td>35.36 ± 6.64&lt;sup&gt;a&lt;/sup&gt;A</td>
<td>40.08 ± 3.45&lt;sup&gt;a&lt;/sup&gt;AB</td>
<td>64.57 ± 4.64&lt;sup&gt;a&lt;/sup&gt;B</td>
</tr>
</tbody>
</table>

<sup>a–d</sup>Lowercase letters indicate significant differences among the storage time expressed in days ($P < 0.05$).

<sup>A–D</sup>Uppercase letters indicate significant differences among the samples ($P < 0.05$).

<sup>1</sup>Mean values ($n = 3$) ± standard deviation. FFY = full-fat yogurt; SY = skimmed yogurt; CSM = chia seed mucilage.
or better characteristics than full-fat yogurts and with several functional benefits for consumers. However, further studies need to be conducted to reduce the impact of CSM on products’ color and sensory acceptance.

### ACKNOWLEDGMENTS

We did not receive any specific grant for this research from funding agencies in the public, commercial, or not-for-profit sectors. The authors declare that they have no conflicts of interest.

### REFERENCES


ORCIDs

Susana Ribes https://orcid.org/0000-0002-6813-2590
Ana Fuentes https://orcid.org/0000-0002-4144-2396
Pau Talens https://orcid.org/0000-0001-7318-3336