dairy

Article

Effects of Capulin (*C. xalapensis*) on the Microbiological, Physicochemical and Sensory Properties of Yogurt

Cheyli Molina [1], Sindy Karina Campos García [1], Jhunior Marcía Fuentes [1,2], Franklin Ore Areche [3], Ajitesh Yadav [4] and Ricardo S. Aleman [5,*]

1 Faculty of Technological Sciences, Universidad Nacional de Agricultura, Catacamas 16201, Honduras; cmolina19a0548@unag.edu.hn (C.M.); scampos20a0482@unag.edu.hn (S.K.C.G.); jmarcia@unag.edu.hn (J.M.F.)
2 Research and Postgraduate Directorate, Universidad Nacional de Agricultura, Catacamas 16201, Honduras
3 Departamento de Ingeniería Agroindustrial, Universidad Nacional de Huancavelica, Jr. Victoria Garma Barr.Centro 275, Huancavelica 090101, Peru
4 Department of Food Science and Human Nutrition, Iowa State University, Ames Iowa, IA 50011, USA
5 School of Nutrition and Food Sciences, Louisiana State University Agricultural Center, Baton Rouge, LA 70803, USA
* Correspondence: rsantosaleman@lsu.edu; Tel.: +1-(225)-433-5840

Abstract: The capulin fruit (*Conostegia xalapensis*) is a seasonal wild berry. The objective of this study was to evaluate the sensory acceptance and physicochemical characteristics of yogurt with the incorporation of capulin at different concentrations (2, 4, and 6%). The fruits were dehydrated at three different temperatures (40 °C, 50 °C, and 60 °C), and flour was prepared as raw material for microbiological and physicochemical characterization. The moisture (9.05%), ash (4.24%), fat (3.7%), carbohydrates (7.2%), protein (6.9%), and fiber (13.1%) were determined. The pH, viscosity, syneresis, water holding capacity, and microbial counts were determined. The acceptability of yogurt was determined through a sensory evaluation with 100 semi-trained judges using a 9-point hedonic test. The results showed a significant difference between the yogurt containing 4 and 6% capulin fruit and the yogurt with the greatest acceptability containing 2% capulin fruit. The pH was within the range of values recommended for commercial yogurt. Likewise, the proximate of capulin fruit was higher than those reported by other authors who have conducted studies with blueberries or wild peas, making capulin jelly an efficient supplement to naturally color fruit yogurt. The incorporation of capulin-based jelly, as we discovered, holds promise as a potential food alternative and a viable substitute for artificial coloring. This finding could have significant implications for the food industry, offering a natural and healthier option.

Keywords: sensory evaluation; capulin flour; yogurt

Citation: Molina, C.; García, S.K.C.; Marcía Fuentes, J.; Ore Areche, F.; Yadav, A.; Aleman, R.S. Effects of Capulin (*C. xalapensis*) on the Microbiological, Physicochemical and Sensory Properties of Yogurt. *Dairy* **2024**, *5*, 515–525. https://doi.org/10.3390/dairy5030039

Academic Editor: Mingruo Guo

Received: 29 May 2024
Revised: 31 July 2024
Accepted: 17 August 2024
Published: 21 August 2024

1. Introduction

Considering the importance of food safety and quality, consumer health is receiving more attention [1]. However, due to nutrient deficiencies in human societies, especially in certain periods of life, the import and consumption of unclassified foods have increased [1]. In general, adding one or more essential nutrients to a food and increasing its concentration in that particular food to higher than normal levels is known as fortification and aims to prevent and correct deficiencies in one or more nutrients in society or groups of people [1]. Nutrition scientists have mentioned that fortifying food products using natural resources (fruits, cereals, etc.) is one of the best ways to improve the total nutrient intake of foods with minimal side effects [1]. However, compliance notes on the production of fortified foods to safeguard the health of consumers and the lack of toxicity resulting from using this material seem necessary. The well-known relationship between diet and health has generated a lot of interest among today's consumers, who are looking for healthy foods.

For this reason, fruits and vegetables are highly appreciated due to their health benefits, which are directly related to the high number of biologically active components present in their composition [1]. Additionally, the pharmaceutical industry manufactures more than 50% of modern clinical medicines from natural products due to their high solubility and absorption, which do not cause adverse health effects [2]. Among the myriad of fruits that remain unexplored, the capulin fruit (*Conostegia xalapensis*) stands out. This seasonal wild berry, with its flowering commencing between January and February and its harvest occurring from approximately April to July, has yet to be harnessed for any specific use or exploitation. Surprisingly, there is a dearth of scientific studies on its existing characteristics and properties, making it a compelling subject for investigation. Fruits are a good source of bioactive substances such as high-quality plant proteins, fiber, minerals, tocopherols, phytosterols, and phenolic compounds [3]. Thus, fruits may reduce the incidence of several chronic diseases, including cardiovascular diseases [4], reduce the risk of weight gain and obesity [5], and have cholesterol-lowering effects [6]. In the food industry, adding coloring to foods to make them more attractive to consumers is common [7]. Due to this, the industry is currently taking a new approach with these ingredients since consumers have a growing interest in their health and well-being, derived from the concern of including alternatives in their daily diet that contribute to raising their level of satisfaction [8]. The capulin is a purple fruit with a soft texture; it belongs to the *Melastomataceae* family, a predominantly Neotropical family of angiosperms with many apomictic species, which is common in the Campos Rupestres, vegetation rich in endemism in rocky outcrops [9]. Yogurt is a typical fermented dairy product and usually contains active probiotics obtained by the lactic acid bacteria fermentation of milk as a raw material [10]. Among the various bioactive compounds present in fruits, folic acid, selenium, n-3 and n-6 fatty acids, and vitamin E are the most important, as they have been reported to have health benefits, whereas dairy products are not a good source of these components [9]. Therefore, the combination of fruits and milk can provide nutrient-rich dairy products, including fermented products [11]. With the aim of not only steering clear of potential health risks associated with artificial coloring but also introducing a novel breakfast option enriched with superior nutrients, we conducted a comprehensive evaluation of the acceptability and physicochemical characteristics of yogurt infused with capulin fruit (*Conostegia xalapensis*). This fruit, known for its health benefits [9], was used as a functional ingredient in the development of a yogurt that not only promises sensory satisfaction but also boasts high nutritional value. Our intention is to position this yogurt as a compelling choice for health-conscious consumers. Considering this, supplementation with fruits can be effective in increasing the total solid matter content in yogurt, which is important for gel formation, firmness, and viscosity [12]. Similarly, fruits contain a prebiotic source of indigestible carbohydrates. The addition of nuts increases the nutritional value of yogurt [13]. This study is the first to explore the fortification of yogurt with capulin fruit, examining its physicochemical, microbiological, and sensory characteristics. The main objective of this study was to evaluate the effects of capulin fruit on yogurt fermentation, physicochemical properties, and lactobacilli counts. Capulin fruit has bioactive components with nutritional value that could contribute to the production of new functional yogurt.

2. Materials and Methods

2.1. Preparation of C. xalapensis

A total of 1 kg of the product was previously washed and weighed, and it was dried in a dehydrator (Catania, China) for 50 h at 50 °C ± 5 °C, formulating the drying curve every 60 min. Finally, the particle size of the samples was homogenized using a mill (Corona, Mexico, DF) and vacuum-packed until the time of analysis. To obtain the jelly, 200 g of capulin flour was weighed and left to macerate for 24 h. A total of 500 mL of water and 100 g of sugar were added, then placed on the fire for 30 min at 75 °C.

2.2. Preparation of *C. xalapensis* Yogurt

The milk (10 L) was filtered and heated to prepare the yogurt until it reached 50 °C. Subsequently, pasteurization was carried out at 85 °C for 30 min. It was allowed to cool until it reached a temperature of 40–44 °C, and the brand culture (SACCO) was added. It was placed in the incubator for 5 h, and finally, 3 formulations of yogurt with jelly at concentrations of 20, 40, and 60 g plus the control (yogurt with 0 g of jelly) were obtained [13]. The amount of fruit added was based on producing a palatable yogurt. *C. xalapensis* crushed material was weighed at a level of 2 g and 5 g/100 mL, respectively, and sugar was added at a ratio of 6 g/100 mL to formulate a mixture of 500 mL, which was sterilized at 90 °C for 20 min. It was cooled to 42 °C, then inoculated with 4% (*v*/*v*) of yogurt fermenter and incubated at 42 °C for 6 h. *C. xalapensis* yogurt (CCSY2% and CCSY5%) with different concentrations of 2 g and 5 g/100 mL, respectively, were prepared, and yogurts without added nuts were used as a control. The control and *C. xalapensis* yogurts were refrigerated at 4 °C (Figure 1).

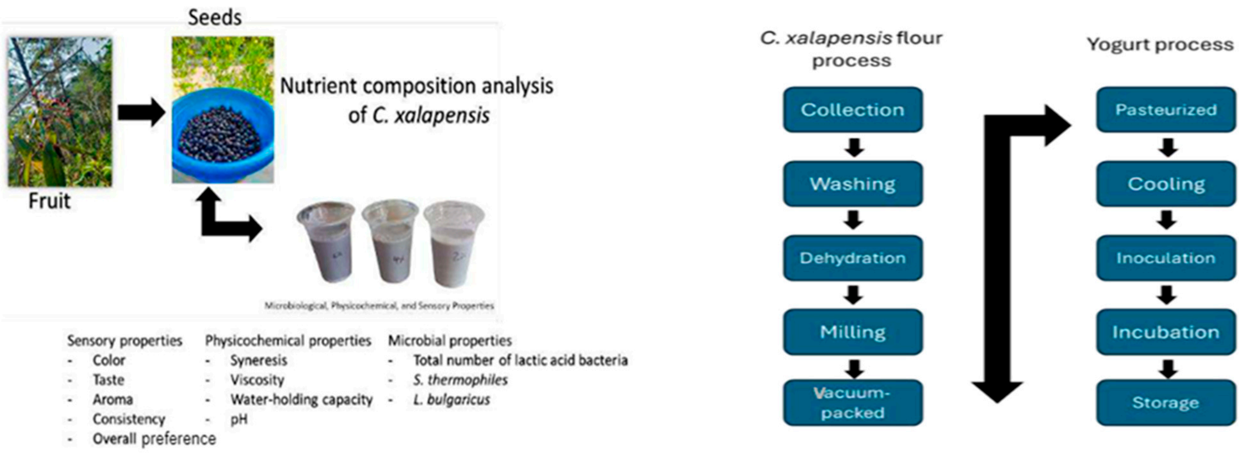

Figure 1. Yogurt process diagram.

2.3. Nutrient Composition Analysis of *C. xalapensis* Flour

The total protein of *C. xalapensis* flour was determined by the Kjeldahl method [14]. According to AOAC (2019) [14], the fat content of *C. xalapensis* flour was determined using a Soxhlet extraction system (Velp Scientific, Usmate, Italy). Carbohydrates in *C. xalapensis* flour, as well as dietary fiber, were determined according to AOAC International (2019) [14]. The total solids content of *C. xalapensis* flour was determined according to AOAC (2019) [14]. All experiments were repeated three times.

2.4. Determination of the Physicochemical Properties of Yogurt

The dehydration shrinkage value and water holding capacity were determined using the Aleman et al. (2023) method (2009) [15]. A total of 100 mL of yogurt samples were placed on a funnel lined with Whatman numbers and assessed for dehydration shrinkage. The filter paper was drained for 6 h, and the separated whey was measured and used as an indicator of dehydration shrinkage. The syneresis was calculated as syneresis (%) = (V1/V2) × 100 (1), where V1 is the volume of whey collected after discharge and V2 is the volume of the yogurt sample. The water holding capacity (WHC) of yogurt was determined using the centrifugation (Sigma 3-18K, Sartorius AG, Göttingen, Germany) method of Aleman et al. (2023), with some modifications. The WHC was calculated by centrifuging 25× *g* of yogurt at 4500× *g* for 15 min at 4 °C as WHC (%) = (1 − M1/M2) × 100 (2), where M1 is the weight of the whey after centrifugation and M2 is the weight of the yogurt sample. The viscosity values (Pa.s) of the yogurt samples were measured at a temperature of 125 °C using a programmable viscometer (Haake, Karlsruhe, Germany) with several spindles of 5. To determine the pH, it was measured by placing 1 g of yogurt sample in a 100 mL glass, adding 50 mL of distilled water, and letting it sit for one hour with gentle stirring during the time interval. Finally, the pH was measured with a potentiometer previously calibrated with three types of buffers, 4, 7, and 10, for greater precision [16].

2.5. Determination of Lactic Acid Bacteria Counts

The total number of lactic acid bacteria (LAB) was detected using the plate counting method. A total of 1 mL of yogurt sample was diluted tenfold with sterile saline (mass fraction 0.9%). A total of 0.1 mL of the dilution was aspirated with a pipette gun into a sterile petri dish, and MRS medium at 42 °C was poured and mixed [17]. The plates were placed in an MCO-18AC carbon dioxide incubator (Sanyo, Panasonic, Osaka, Japan) at 37 °C for 72 h. The number of colonies was expressed as log cfu/mL, and the experiments were repeated 10 times. *Streptococcus thermophilus* (Chr. Hansen) was plated using *S. thermophilus* agar (adjusted to pH 6.8 with 1 N HCl) and incubated aerobically at 37 °C for 24 h before counting. *Lactobacillus bulgaricus* (Chr. Hansen) was plated using Difco Lactobacillus de Man, Rogosa, and Sharpe agar (adjusted to pH 5.2 with 1 N HCl) and incubated anaerobically at 43 °C for 72 h before counting. A Quebec Darkfield Colony Counter (Leica Inc, Wetzlar, Germany) was used to enumerate the colonies. All plating was performed in duplicate.

2.6. Sensory Evaluation of Yogurt

Sensory evaluation of yogurt was carried out on the first day of storage at 4 °C [18]. A 100-person, untrained panel with members ranging in age from 20 to 45 (mean age of 23) who were staff, teachers, and students at the Department of Food Quality and Safety at Anqing Vocational and Technical College conducted the evaluation. Two methodologies were developed: the intensity scale and CATA questions. A total of 100 consumers were used in each case, with ages between 17 and 45 years old, 55% female and 45% males for the methodology intensity scale, and ages between 17 and 43 years old, 50% female and 50% male in the methodology of CATA questions. The consumers were selected through a simple random sampling between students, teachers, and workers based on yogurt consumption and interest in participating in the test. The samples were presented at a temperature of 4–8 °C in plastic cups identified with three digits randomly selected, with 10 g of product made with each of the 4 formulations. Mineral water was available for rinsing between tasted formulations. The evaluation system consisted of six parts: taste, color, aroma, flavor, texture, and overall preference. Each component was evaluated on a 10-point scale [19].

2.7. Statistical Analysis

For the microbiological and physical characteristics of yogurt, the data are expressed as the mean ± standard deviation. Statistical significance was analyzed using one-way analysis of variance (ANOVA) with GraphPad Prism 8.0. Statistical significance was set at $p < 0.05$. An analysis of variance (ANOVA) of randomized blocks and an LSD test were used to evaluate differences in the acceptability of the four yogurt formulations studied. For the intensity scale methodology applied, an ANOVA of randomized blocks and an LSD test were used to assess significant differences between the values and averages of sensory attributes determined by the method of the intensity scale. The ANOVA was developed with the STATGRAPHICS statistical package Plus Version 5.1.

3. Results and Discussion

3.1. Chemical Analysis of Capulin Flour and Yogurt

The proximal analysis of the capulin flour results revealed a moisture percentage comparable to that of freeze-dried blueberries, as found by Lim et al. (1995) [20]. The fat and protein content, similar to yellow corn, is intriguingly high. Capulin flour contains only 0.3 g less fat than yellow corn and surpasses whole wheat by 0.4 g, according to Coral et al. (2018) [21]. The protein values are on par with yellow corn, making capulin flour a promising nutritional alternative.

The ash content in capulin flour is similar to that in potatoes. The data presented by Natividad Bardales et al. (2022) [22] show that the ash percentage in potatoes ranges between 3.7 and 4.4; the ash percentage of the capulin is also within this range.

The fiber content in capulin flour is notably high, making it a unique addition to the diet. While it is challenging to compare with fruit, MAPA (2013) [23] found a similar percentage in almonds, slightly higher than in capulin flour. Similarly, Urango (2018) [24] identified a comparable amount of fiber in wheat. Regarding carbohydrates, capulin presents a substantial 76.2%, a value akin to bee honey, as reported by Ortega et al. (2020) [25]. Urango (2018) [24] also noted 73.7% carbohydrates in rice, a value that mirrors that of capulin. These unique properties of capulin flour make it a fascinating subject of study. Plants produce many secondary metabolites to better adapt to environmental conditions, protect themselves from microbial attacks, and resist biotic and abiotic stresses. Of these compounds, phenolics have received significant attention recently due to their antioxidant, anti-inflammatory, antimutagenic, and anticoagulant properties, which are correlated with a reduced risk of cardiovascular diseases and cancer development [22]. The main dietary source of phenolic compounds is fruit. Plant extracts can potentially be used as functional ingredients in yogurt fortification. Still, the seasonal production of some exotic fruits and vegetables, economic restrictions, and high fruit requirements in the fresh market forced researchers to look for alternative strategies for the bioproduction of natural compounds similar to anthocyanin and phenolic acids [22].

In Table 1, the fruit yogurt with 6% capulin jelly shows a moisture content of 72.80%, a very high percentage compared to the control yogurt. Regarding the ash content, the result is similar to that of yogurt without capulin jelly; however, the fat and protein contents were lower for yogurts produced with capulin jelly than for the control yogurts.

Table 1. Proximal analysis of capulin flour.

Proximal Analysis	g/100 g
Moisture	9.05 ± 1.03
Fat	3.69 ± 0.45
Proteín	6.9 ± 0.69
Ash	4.24 ± 0.24
Fiber	13.1 ± 0.31
Carbohydrates	76.2 ± 2.19

3.2. pH Changes and the Total Number of Lactic Acid Bacteria (LAB) in Yogurt during Fermentation

During the fermentation process, as LAB metabolized acid production using lactose, this resulted in a continuous decrease in the pH of all samples of yogurts (Figure 2A), which ultimately reached a pH of 4.75–4.85. During the fermentation period, there was no significant difference in the pH between different yogurts, suggesting that adding the capulin jelly did not inhibit lactobacilli's metabolism of lactic acid production. These results were within the pH range of a commercial yogurt [26]. A deviation from the required pH can result in a shorter product shelf life or a very sour product. Entering fermentation too soon can cause the liquid whey to separate from the yogurt solids, creating a product without the appropriate consistency. The pH in yogurt is one of the main properties because, in its preparation, manufacturers seek to reduce the pH of the milk (6.5–6.7) and reach the pH of yogurt, which contributes to the characteristic smell and flavor.

As shown in Figure 2B, LAB underwent adaptation, logarithmic, and stabilization periods in the control and capulin-containing yogurts. In the time period of 0~1.5 h, the LAB was in the adaptation period, and the total colony number was around 3.8 CFU/mL. The metabolism was slow; all the pH changes were not significant, and the addition of capulin had a slightly lower pH than the control yogurt. Some of the active components of the capulin might help the LAB adapt to the external environment. During the 1.5~4.5 h, the LAB was in the logarithmic phase [27], and lactobacilli counts rose rapidly, which means vigorous metabolism led to an acceleration of pH decline. At 6 h, all kinds of yogurt reached the stabilization period with a lactic acid bacteria count of 8.05–8.30 CFU/mL. There was no significant difference in the lactic acid bacteria count among the yogurt samples during the entire fermentation period.

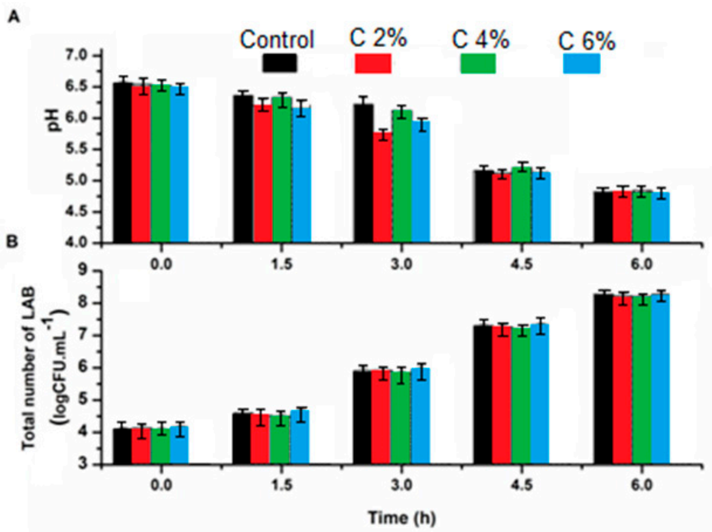

Figure 2. The change in pH (**A**) and Lactobacillus counts (**B**) during fermentation.

3.3. *Effect of Capulin on the pH and Viscosity of Yogurts during Refrigeration*

During 28 days of storage, the lactic acid bacteria slowly continued to metabolize and produce organic acids, resulting in a steady increase in acidity in all yogurt samples and leading to a slow decrease in the pH of the yogurts (Figure 3A). Apart from days 14 and 21, when the addition of 6% capulin helped to alleviate post-acidification, there were no significant differences in pH during the whole refrigeration period compared to the control yogurts, with the pH of the control and capulin yogurts around 4.30 on the 28th day. The difference was that the pH of the 6% capulin yogurt showed a significant decrease during the refrigeration period, which was closely related to the fact that *Lactobacillus bulgaricus* continued to ferment the sugars in the milk into lactic and other organic acids during the refrigeration period. By verifying that fermentation is proceeding to the predetermined pH level, yogurt producers can ensure that their products maintain the desired flavor, texture, and aroma. A deviation from the predetermined pH can reduce the shelf life of yogurt or create a product that is too bitter or sour. In general, the pH tends to decrease during storage. The decrease in pH is because lactic acid bacteria continue their metabolic activity despite the low storage temperature (<5 °C), producing lactic acid, which causes the medium to become acidic and lower the pH.

The viscosities of the control yogurts were in the range of 2.25–2.6 Pa.s (Figure 3B). The viscosities of the capulin-containing yogurts were higher than those of the control yogurts. Yogurt tended to increase in viscosity with increasing capulin addition, primarily due to the increase in nonfat milk solids in the capulin. In addition, the viscosity of the yogurt samples increased during storage for 28 days at 4 °C. The viscosity of yogurt is important in determining its quality and sensory acceptance by the consumer. It is important to know the mechanisms involved and the impact of processing parameters on yogurt viscosity to improve product quality [28].

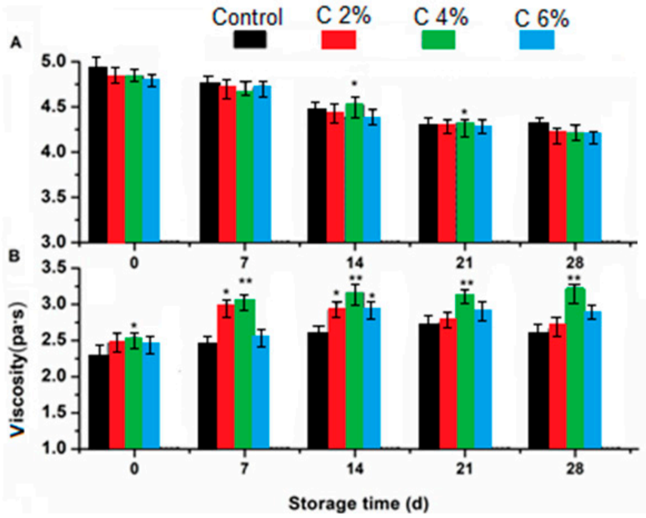

Figure 3. Change in pH (**A**) and viscosity (**B**) of yogurts during refrigeration. Note: * and ** denote a significant difference at $p < 0.05$ and $p < 0.01$, respectively, compared with the control.

3.4. Effect of Capulin on Syneresis and Water Holding Capacity of Yogurts during Refrigeration

"Drainage" or "syneresis", in its simplest expression, consists of the fact that, over a solid phase of gelatinous consistency, we see a variable amount of serum supernatant that should have remained incorporated into the clot. In our study, there was no significant difference in the syneresis among yogurt samples during 28 days of refrigeration, and their syneresis was essentially stable during refrigeration without any substantial changes (Figure 4A). The syneresis of the control yogurt was 22.0–24.1%, whereas the syneresis of the capulin varied in the range of 21.2–24.0%. The water holding capacity of both capulin yogurts increased to varying degrees compared to the control yogurt over the same storage period, and an upward trend was observed with increasing capulin addition. The addition of 6% capulin significantly increased the water holding capacity of the yogurts by a maximum of 6.4 and 8.1%, respectively (Figure 4B). The increase in the water holding capacity of the capulin yogurt may be because the two types of capulin increased the dietary fiber and protein content of the yogurts, generating a cohesive network structure due to soluble solids. The increase in fat content of yogurt could be due to the increase in fat content of capulin, and similar results were observed in capulin yogurt [29].

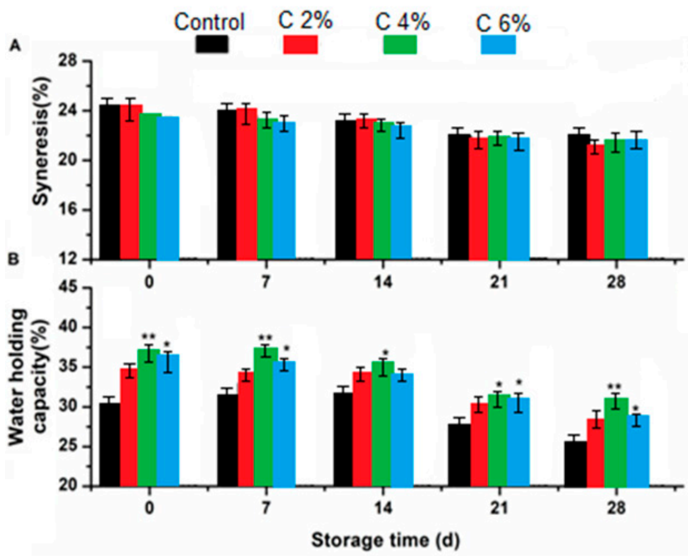

Figure 4. Changes in syneresis (**A**) and water holding capacity (**B**) of yogurts during refrigeration. Note: * and ** denote a significant difference at $p < 0.05$ and $p < 0.01$, respectively, compared with the control.

3.5. The Total Number and Primary LAB during Refrigeration

The total LAB and the number of main LAB, *S. thermophilus* and *L. delbrueckii* subsp. *bulgaricus*, showed a slow decrease in all samples during 28 days of storage (Table 2). There was no significant difference in the total lactic acid bacteria counts of the capulin yogurts throughout the cold storage period. During the same refrigeration period, the number of viable *S. thermophilus* in the capulin yogurt samples increased to varying degrees compared to the control, up to 0.77 log/cfu/mL. The *L. bulgaricus* counts of capulin yogurt increased differently than the control samples, with a maximum increase of 0.38 log/cfu/mL. The *S. thermophilus* viable count and *L. delbrueckii* subsp. *bulgaricus* viable count decreased slowly in all yogurt samples during the whole refrigeration period, with a significant decrease in the control samples on the 28th day compared to the 1st day. In capulin yogurt samples, *S. thermophilus* viable counts decreased significantly ($p < 0.05$) at day 28, and *L. delbrueckii* subsp. *bulgaricus* viable counts decreased significantly ($p < 0.05$) only in capulin yogurt samples with a 6% addition. The total colony counts of lactic acid bacteria in yogurt samples were greater than 10^7 CFU/mL throughout the storage process. Yogurt is a popular fermented dairy product produced by lactic acid bacteria, including *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *Bulgaricus*. During yogurt production, these bacteria produce lactic acid, which lowers the pH and causes the milk protein to clot [30]. A healthy microbiota in humans is achieved through a balance of bacteria. As we said at the beginning of the article, when there are episodes of stress, an unbalanced diet, or excess medications, the microbiota is altered. But it can also be affected by an excess of certain bacteria. The bacteria in yogurt are healthy as long as there is balance among the other bacteria. This balance is achieved with a varied diet, adding more foods such as fruits, vegetables, or legumes, and eliminating or reducing meats or ultra-processed foods. Thus, yogurt bacteria are essential for how milk becomes yogurt [19]. Depending on the bacteria involved in the process, yogurt acquires different textures or flavors. But these bacteria can also help your body with different functions if you maintain a balanced diet [19].

Table 2. Number of lactic acid bacteria in yogurt samples during refrigerated storage.

Lactic Acid Bacteria ($\log CFU \cdot mL^{-1}$)	Day	Control	C2%	C4%	C6%
Total number of lactic acid bacteria	1	8.07 ± 0.26 A	8.05 ± 0.57 A	7.94 ± 0.14 A	8.03 ± 0.46 A
	7	7.94 ± 0.51 A	7.91 ± 0.42 A	7.83 ± 0.32 A	7.93 ± 0.31 A
	14	7.89 ± 0.4 A	7.81 ± 0.46 A	7.78 ± 0.31 A	7.86 ± 0.31 A
	21	7.81 ± 0.44 A	7.78 ± 0.77 A	7.71 ± 0.58 A	7.79 ± 0.36 A
	28	7.69 ± 0.67 B	7.66 ± 0.63 B	7.62 ± 0.45 A	7.68 ± 0.88 A
S. thermophilus	1	7.18 ± 0.22 aA	6.87 ± 0.19 bA	6.84 ± 0.66 bA	7.62 ± 0.73 acA
	7	7.06 ± 0.39 aA	6.75 ± 0.72 aA	6.72 ± 0.65 aA	7.56 ± 0.29 aA
	14	6.90 ± 0.44 aA	6.64 ± 0.7 aA	6.57 ± 0.75 abA	7.48 ± 0.24 adA
	21	6.79 ± 0.16 aB	6.51 ± 0.4 aB	6.49 ± 0.17 aA	7.43 ± 0.84 cA
	28	6.67 ± 0.22 aB	6.42 ± 0.78 aB	6.42 ± 0.85 aB	7.16 ± 0.22 bB
L. bulgaricus	1	6.84 ± 0.57 aA	7.21 ± 0.81 bA	6.98 ± 0.38 abA	6.55 ± 0.86 acA
	7	6.79 ± 0.32 aA	7.10 ± 0.38 aA	6.89 ± 0.88 aA	6.46 ± 0.1 bA
	14	6.77 ± 0.21 aA	7.00 ± 0.79 aA	6.81 ± 0.6 aA	6.39 ± 0.3 bA
	21	6.64 ± 0.67 aA	6.93 ± 0.87 aA	6.71 ± 0.52 aA	6.36 ± 0.51 abA
	28	6.55 ± 0.52 aB	6.90 ± 0.13 bA	6.56 ± 0.68 aB	6.30 ± 0.88 aA

Note: Different lowercase letters in the same row indicate a difference in *lactobacilli* counts at ($p < 0.05$) compared to the control group; different uppercase letters in the same column indicate a difference in *lactobacilli* counts at ($p < 0.05$) compared to the start of cold storage.

3.6. Effect of Capulin on the Sensory Quality of Yogurt

The addition of 4% or 6% capulin had different effects on the taste, consistency, color, and preference scores of yogurt compared to the control yogurt (Table 3). According to these results, the fruit yogurt sample with 2% capulin jelly had the highest average in all the sensory attributes except aroma. The treatments with 0% and 2% jelly are statistically the same for the color attribute. However, they are significantly different from the treatments that contained 4% and 6%. In terms of flavor characteristics, all samples presented significant differences. In comparing the attributes of aroma, consistency, and general acceptability, the samples containing 0% and 2% of capulin jelly were statistically the same, while the others were significantly different. Other edible fruits have also been used to enrich the fermented milk and showed differences in color, flavor, consistency, and general acceptability [31]. In the food processing industry, manufacturers look for flavor and texture. The texture is the "feel" in the mouth when the product is ingested and is usually evaluated by measuring the product's viscosity. In this area, companies seek consistency above all else. Texture can "make or break" a product's reception. Adding to the importance of texture is the intricate way it interacts with higher-profile aspects: aroma and flavor.

Table 3. Sensory attribute evaluation of yogurt.

Treatment	Color	Taste	Aroma	Consistency	Preference
Control	6.87 ± 1.18 a	6.48 ± 1.54 c	6.71 ± 1.11 c	6.77 ± 1.21 c	6.91 ± 1.29 c
C 2%	6.88 ± 1.44 a	7.00 ± 1.30 d	6.64 ± 1.14 c	6.80 ± 1.09 c	6.97 ± 1.06 c
C 4%	4.73 ± 1.17 b	4.95 ± 1.08 b	5.61 ± 1.40 b	5.56 ± 1.10 b	5.83 ± 1.26 b
C 6%	3.92 ± 0.91 c	4.23 ± 0.89 a	4.23 ± 0.92 a	4.36 ± 0.95 a	4.43 ± 0.91 a

Note: Different lowercase letters in the same column indicate a difference in sensory attributes.

4. Conclusions

The percentage of titratable acidity and pH are within the range of values that are recommended for commercial yogurt. Likewise, the proximate analysis was higher than those reported by other authors who have conducted studies with blueberries or wild peas, making capulin jelly an efficient supplement to naturally color fruit yogurt. Consumers accepted the jelly obtained from the capulin fruit applied to yogurt, with yogurt containing 2% of the jelly being the most accepted. This may be because it presented a more attractive color and flavor than the samples containing 4% and 6% jelly. Therefore, capulin jelly is a potential substitute for artificial coloring.

Author Contributions: Conceptualization, C.M. and S.K.C.G.; methodology, F.O.A.; software, C.M.; validation, J.M.F., R.S.A. and A.Y.; formal analysis, C.M.; investigation, C.M.; resources, S.K.C.G.; data curation, J.M.F., R.S.A.; writing—original draft preparation, F.O.A.; writing—review and editing, A.Y., R.S.A.; visualization, A.Y.; supervision, F.O.A.; project administration, J.M.F.; funding acquisition, J.M.F. All authors have read and agreed to the published version of the manuscript.

Funding: This research has been funded by the Academic Directorate of the Research and Postgraduate System (DSIP) Universidad Nacional de Agricultura (Honduras), the International Centre for Research and Development (IDRC), Ottawa, Canada, and the Central American University Council (CSUCA).

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee in Food Research at the Honduran Association of Medicine and Nutrition (ASOHMENU) with form #AS-ASHOMENU-005-2022.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

Acknowledgments: The authors would like to thank the LSU AgCenter.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Fuentes, J.A.M.; López-Salas, L.; Borrás-Linares, I.; Navarro-Alarcón, M.; Segura-Carretero, A.; Lozano-Sánchez, J. Development of an Innovative Pressurized Liquid Extraction Procedure by Response Surface Methodology to Recover Bioactive Compounds from Carao Tree Seeds. *Foods* **2021**, *10*, 398. [CrossRef]

2. Maddela, N.R.; García, L.C. (Eds.) *Innovations in Biotechnology for a Sustainable Future*; Springer: Berlin/Heidelberg, Germany, 2021.
3. Ros, E. Health Benefits of Nut Consumption. *Nutrients* **2010**, *2*, 652–682. [CrossRef]
4. Rusu, M.E.; Simedrea, R.; Gheldiu, A.-M.; Mocan, A.; Vlase, L.; Popa, D.-S.; Ferreira, I.C.F.R. Benefits of tree nut consumption on aging and age-related diseases: Mechanisms of actions. *Trends Food Sci. Technol.* **2019**, *88*, 104–120. [CrossRef]
5. Martínez-González, M.A.; Bes-Rastrollo, M. Nut consumption, weight gain and obesity: Epidemiological evidence. *Nutr. Metab. Cardiovasc. Dis.* **2011**, *21* (Suppl. S1), S40–S45. [CrossRef] [PubMed]
6. Chisholm, A.; Mc Auley, K.; Mann, J.; Williams, S.; Skeaff, M. Cholesterol lowering effects of nuts compared with a Canola oil enriched cereal of similar fat composition. *Nutr. Metab. Cardiovasc. Dis.* **2005**, *15*, 284–292. [CrossRef]
7. Hidalgo, P.; Vasquez, D. Pigmentos vegetales: Una alternativa frente a colorantes sintéticos. *Revista de Divulg. Científica iBIO* **2023**, *5*, CO113.
8. Espinosa, E.B.L.; Martínez, C.J.; Dávila-Ortiz, G. Péptidos Bioactivos de Fuentes Vegetales: Un Nuevo Ingrediente para Alimentos Funcionales. In Tendencias de Innovación en la Ingeniería de Alimentos. OmniaScience. 2015, p. 37. Available online: https://dialnet.unirioja.es/servlet/articulo?codigo=8628654 (accessed on 20 July 2024).
9. Santos, A.P.M.D.; Fracasso, C.M.; Santos, M.L.D.; Romero, R.; Sazima, M.; Oliveira, P.E. Reproductive biology and species geographical distribution in the Melastomataceae: A survey based on New World taxa. *Ann. Bot.* **2012**, *110*, 667–679.
10. Jiao, B.; Wu, B.; Fu, W.; Guo, X.; Zhang, Y.; Yang, J.; Luo, X.; Dai, L.; Wang, Q. Effect of roasting and high-pressure homogenization on texture, rheology, and microstructure of walnut yogurt. *Food Chem. X* **2023**, *20*, 101017. [CrossRef]
11. Yilmaz-Ersan, L.; Sahin, S.; Ozcan, T.; Akpinar-Bayizit, A.; Usta-Gorgun, B.; Ciniviz, M.; Keser, G. Interaction of probiotic activity, antioxidative capacity, and gamma-amino butyric acid (GABA) in chestnut milk-fortified yogurt. *J. Food Process. Preserv.* **2022**, *46*, e17266.
12. Al-Bedrani, D.I.; ALKaisy, Q.H.; Rahi, A.K. Evaluation of milk source on physicochemical, texture, rheological and sensory properties of yogurts. *J. Appl. Nat. Sci.* **2023**, *15*, 128–136.
13. Wairimu, N.; Elkana, O.E.; Koskei, K. Development and evaluation of goat milk yoghurt enriched with baobab fruit pulp. *Eur. J. Agric. Food Sci.* **2022**, *4*, 100–106. [CrossRef]
14. AOAC. *Official Methods of Analysis*, 21st ed.; Association of Official Analytical Chemists: Washington, DC, USA, 2019.
15. Aleman, R.S.; Paz, D.; Cedillos, R.; Tabora, M.; Olson, D.W.; Aryana, K. Attributes of Culture Bacteria as Influenced by Ingredients That Help Treat Leaky Gut. *Microorganisms* **2023**, *11*, 893. [CrossRef] [PubMed]
16. Gocer, E.M.C.; Koptagel, E. Production and evaluation of microbiological & rheological characteristics of kefir beverages made from nuts. *Food Biosci.* **2023**, *52*, 102367. [CrossRef]
17. Marcia, J.; Aleman, R.S.; Montero-Fernández, I.; Martín-Vertedor, D.; Manrique-Fernández, V.; Moncada, M.; Kayanush, A. Attributes of *Lactobacillus acidophilus* as Effected by Carao (*Cassia grandis*) Pulp Powder. *Fermentation* **2023**, *9*, 408. [CrossRef]
18. Medina, L.; Aleman, R.S.; Cedillos, R.; Aryana, K.; Olson, D.W.; Marcia, J.; Boeneke, C. Effects of carao (*Cassia grandis* L.) on physico-chemical, microbiological and rheological characteristics of yogurt. *LWT* **2023**, *183*, 114891. [CrossRef]
19. Aleman, R.S.; Cedillos, R.; Page, R.; Olson, D.; Aryana, K. Physico-chemical, microbiological, and sensory characteristics of yogurt as affected by various ingredients. *J. Dairy Sci.* **2023**, *106*, 3868–3883. [CrossRef]
20. Lim, L.T.; TANG, J.; He, J. Moisture sorption characteristics of freeze dried blueberries. *J. Food Sci.* **1995**, *60*, 810–814. [CrossRef]
21. Coral, V. Determinación Proximal de los Principales Componentes Nutricionales de Siete Alimentos: Yuca, Zanahoria Amarilla, Zanahoria Blanca, Chocho, Avena Laminada, Harina de maíz y Harina de Trigo Integral. Master's Thesis, Pontificia Universidad Católica del Ecuador, Quito, Ecuador, 2014. Available online: https://repositorio.puce.edu.ec/handle/123456789/20991 (accessed on 20 July 2024).
22. Bardales, D.N.; Garay, S.G.M.; Tiburcio, J.E.V.; Portal, R.M.R.; Gómez, R.E.C.; Rosales, C.R.C.; Romaina, J.M.B.; Bedoya, J.R.B.; Aguilar, A.M. Caracterización fisicoquímica de cuatro variedades de papas nativas (*Solanum tuberosum*) con aptitud para fritura, cultivadas en dos zonas en huánuco. *Revista de la Sociedad Química del Perú* **2022**, *88*, 237–250. [CrossRef]
23. MAPA. Almendra, Prunus Amygdalus (en línea). Frutos Secos. 2013, pp. 305–306. Available online: http://www.magrama.gob.es/es/ministerio/servicios/informacion/almendra_tcm7-315319.pdf%0Ahttp://www.fen.org.es/mercadoFen/pdfs/almendra.pdf (accessed on 20 July 2024).
24. Urango, L. Componentes del maíz en la Nutrición Humana (en línea). Nutricionista Dietista, Magíster en Sc y Tecnología de Alimentos. Profesora de cátedra. Escuela de Nutrición y Dietética, Universidad de Antioquia. 2018, pp. 185–209. Available online: https://revistas.udea.edu.co/index.php/biogenesis/article/view/336229 (accessed on 20 July 2024).
25. Ortega, I.L.; Montes, M.C. Composición Nutricional Y Calidad De La Miel Producida En El Territorio Patagonia Verde. *Apic. En El Territ. Patagon. Verde Región De Los Lagos* **2020**, *6*, 107–123.
26. Udayarajan, C.T.; Mohan, K.; Nisha, P. Tree nuts: Treasure mine for prebiotic and probiotic dairy free vegan products. *Trends Food Sci. Technol.* **2022**, *124*, 208–218. [CrossRef]
27. da Silva, A.P.R.; Longhi, D.A.; Dalcanton, F.; de Aragão, G.M.F. Modelling the growth of lactic acid bacteria at different temperatures. *Braz. Arch. Biol. Technol.* **2018**, *61*, e18160159. [CrossRef]
28. Soukoulis, C.; Panagiotidis, P.; Koureli, R.; Tzia, C. Industrial yogurt manufacture: Monitoring of fermentation process and improvement of final product quality. *J. Dairy Sci.* **2007**, *90*, 2641–2654. [CrossRef] [PubMed]

29. Erturk, M.Y.; Bonilla, J.C.; Kokini, J. Relationship of non-linear rheological properties and quantitative network analysis parameters as a function of increasingly large amplitude deformations in non-fat, low-fat and high-fat yogurt products. *Food Hydrocoll.* **2021**, *111*, 106194.
30. Bensmira, M.; Jiang, B. Organic acids formation during the production of a novel peanut-milk kefir beverage. *Br. J. Dairy Sci.* **2011**, *2*, 18–22.
31. Bensmira, M.; Jiang, B. Total phenolic compounds and antioxidant activity of a novel peanut based kefir. *Food Sci. Biotechnol.* **2015**, *24*, 1055–1060. [CrossRef]