applied sciences

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Physicochemical and Sensory Evaluation of Yanggaeng Formulated with *Corni fructus* Powder and Alternative Sweeteners

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Abstract: This study examined the effects of alternative sweeteners—allulose, stevia, and xylose—on the physicochemical, textural, and sensory properties of Yanggaeng fortified with 2% *Corni fructus* powder (CF). A proximate composition analysis revealed that Yanggaeng treated with alternative sweeteners had a significantly higher moisture content and a lower carbohydrate content than that treated with sugar. Colorimetric analysis showed that the xylose treated Yanggaeng decreased lightness (L^*) and increased redness (a^*) and yellowness (b^*), likely due to enhanced browning reactions. The xylose treated Yanggaeng exhibited the highest Brix values and antioxidant activities, including DPPH and ABTS radical scavenging and ferric reducing antioxidant power (FRAP). Although the allulose treated group had the highest total phenolic content, its radical scavenging activity was lower than the xylose treated Yanggaeng. Xylose produced a firmer and more cohesive gel matrix, increasing hardness, gumminess, and chewiness, whereas stevia resulted in a softer, less chewy texture. In sensory evaluations, the xylose treated Yanggaeng scored higher for color, flavor, sweetness, overall acceptance, and purchase intent than other groups. These findings suggest that xylose is the most suitable alternative sweetener for CF-enhanced Yanggaeng, offering reduced caloric content, enhanced antioxidant properties, improved texture, and superior consumer acceptance.

Keywords: alternative sweeteners; *Corni fructus*; Yanggaeng; physicochemical properties; sensory attributes

Academic Editor: Małgorzata Ziarno

Received: 19 December 2024
Revised: 20 January 2025
Accepted: 24 January 2025
Published: 26 January 2025

Citation: Lee, J.-J.; Park, S.; Jang, H.; Kim, Y.-W.; Lee, J.; Lee, J.; Ha, J.-H. Physicochemical and Sensory Evaluation of Yanggaeng Formulated with *Corni fructus* Powder and Alternative Sweeteners. *Appl. Sci.* **2025**, *15*, 1286. https://doi.org/10.3390/app15031286

1. Introduction

Yanggaeng, a cherished traditional Korean dessert, is crafted from a blend of agar, sugar, and red bean paste and has a soft, gelatinous texture. Agar is a dietary fiber that absorbs substantial amounts of water [1–3]. When consumed in appropriate quantities, agar aids in creating a sensation of fullness and effectively alleviates constipation [4–6]. Sugar in Yanggaeng not only enhances sweetness but also serves as a preservative, extending the shelf life [7]. However, excessive sugar consumption can lead to high caloric intake, increasing the risk of metabolic complications, such as obesity [8], diabetes [9], and dyslipidemia [10]. Accordingly, in the food industry, there is increasing interest in developing alternative sweeteners that can maintain the desired sweetness while addressing the concerns associated with conventional sugars [11,12].

Alternative sweeteners confer sweetness to food products while mitigating concerns related to their calorie content and glycemic effects [12,13]. Xylose, a naturally occurring sugar alcohol found in small quantities in various fruits and vegetables, matches the sweetness of sucrose, but has approximately 40% fewer calories [14]. In addition, xylose has a lower glycemic index (GI of 7) than sugar (60–70). Allulose, also known as D-psicose, is a rare sugar that is present in small quantities in certain fruits. Allulose is approximately 70% as sweet as sucrose, but provides only 0.2–0.4 kcal/g [15]. As allulose is not metabolized by the body, its caloric value is extremely low—approximately 0.39 kcal/g. Stevia, a natural sweetener derived from the leaves of *Stevia rebaudiana*, is 200–300 times sweeter than sugar [16]. However, the incorporation of alternative sweeteners can sometimes result in unfavorable physicochemical properties (e.g., a shortened shelf life) or sensory attributes (e.g., an unpleasant aftertaste) in food products [17,18]. Therefore, further research is required to optimize formulations containing alternative sweeteners to enhance the stability and sensory appeal of food products.

Corni fructus is the edible part of *Cornus officinalis*; the pulp is obtained by removing the seeds, flesh, and skin of the fruit. *C. fructus* contains key bioactive compounds, such as iridoid glycosides (e.g., loganin and morroniside), polyphenols, and tannins, which have strong antioxidant [19] and anti-inflammatory effects [20,21]. Furthermore, it is rich in organic acids and vitamin C, contributing to health benefits, including improved metabolism and immune function [22]. *C. fructus* is recognized for its health-promoting properties and potential to prevent diseases linked to oxidative stress. Bioactive compounds have spurred research into their applications in the food industry. *C. fructus* can improve nutritional value, aroma, and flavor. *C. fructus* has been incorporated into a range of products such as cookies [23], yogurt [24], coffee [25], and jelly [26].

In a previous study, we added different concentrations of *C. fructus* powder (CF) to Yanggaeng to analyze its physicochemical characteristics and sensory attributes [2]. The addition of CF significantly acidified Yanggaeng, increased the Brix levels, and enhanced its antioxidative properties. Moreover, CF significantly influenced the textural properties of Yanggaeng. In terms of consumer preferences, Yanggaeng with 2% CF achieved comparable scores for color, flavor, sweetness, scent, taste, purchase intention, and overall acceptance. In the present study, we examined the effects of alternative sweeteners (allulose, stevia, and xylose) on the physicochemical and sensory properties of 2% CF-treated Yanggaeng. The objective of this study was to identify the best sugar substitutes for CF-treated Yanggaeng and create a low-carbohydrate, low-calorie dessert with improved antioxidative properties.

2. Materials and Methods

2.1. Preparation of Corni fructus Powder

C. fructus was sourced from The One Nature (Pocheon, Republic of Korea) and harvested from Gurye, Republic of Korea in November 2021. After cleaning and washing with distilled water, the fruits were dried at 60–65 °C to a moisture content below 15%, then ground into powder (HR2904; Philips Co., Amsterdam, The Netherlands) and stored at −70 °C in a deep freezer (MDFU52V, Sanyo, Osaka, Japan) for further processing.

2.2. Formulation and Preparation of Yanggaeng

Yanggaeng was prepared following a previously described recipe [1–3,27]. Yanggaeng was prepared using 2% CF, white bean paste (Daedoo Food, Seoul, Republic of Korea), distilled water (Merck, Rahway, NJ, USA), white sugar, (Cheiljedang, Seoul, Republic of

Korea), allulose (Samyang, Ulsan, Republic of Korea), stevia (ALTist, Seoul, Republic of Korea), xylose (Kjoonfood, Bucheon, Republic of Korea), and agar powder (Thehadam, Goseong, Republic of Korea), as detailed in Table 1. Agar (10 g) was soaked in 400 g of water for 10 min, boiled for 2 min, and combined with CF, white bean paste, and sweeteners (sugar, allulose, stevia, and xylose). Stevia (50 g) was used for its high sweetness (200–300 times that of sugar [16]), while allulose and xylose (100 g each) matched the sweetness of sucrose. The mixture was simmered for 10 min, poured into a 2 cm-thick mold, and cooled for 2 h before use. Yanggaeng treated with white sugar, allulose, stevia, and xylose are abbreviated as Sug, Alu, Ste, and Xyl, respectively.

Table 1. Formula of Yanggaeng prepared with *Corni fructus* powder and alternative sweeteners.

Ingredients (g)	Sug	Alu	Ste	Xyl
White bean paste	470	470	470	470
Water	400	400	400	400
Sweetener	100	100	50	100
Agar powder	10	10	10	10
Corni fructus powder	20	20	20	20

Sug, control; Yanggaeng treated with 2% *C. fructus* powder (CF) and sugar, Alu, Yanggaeng treated with 2% CF and allulose; Ste, Yanggaeng treated with 2% CF and stevia; Xyl, Yanggaeng treated with 2% CF and xylose.

2.3. Proximate Composition of Yanggaeng

The proximate composition of Yanggaeng, including crude ash, fat, moisture, and protein, was analyzed using standard methods [3]. Carbohydrate content (%) was calculated as follows: 100 − (crude ash + fat + moisture + protein).

2.4. Hunter's Color Value and Physicochemical Properties of Yanggaeng

The lightness (L^*), redness (a^*), and yellowness (b^*) of Yanggaeng were assessed using a colorimeter (LC100; Tintometer Ltd., Amesbury, UK). For pH and Brix analyses, 2 g of Yanggaeng was mixed with 20 mL of distilled water and centrifuged at 3000× g for 10 min (Hanil Science Co., Ltd., Daejeon, Republic of Korea). The supernatant was then used to measure pH using an Orion Star pH meter (Thermo Fisher Scientific (Korea branch), Seoul, Republic of Korea), and Brix values were measured using a Brix meter (Hanna Instruments, Woonsocket, HI, USA), as described in our previous studies [1–3,27].

2.5. Antioxidative Properties of Yanggaeng

The antioxidant capacity of Yanggaeng was analyzed by mixing 2.5 g of the sample with 50 mL of 70% ethanol and incubating the mixture for 24 h. The mixture was then centrifuged at 3000× g for 10 min to separate the components. The antioxidant activity was evaluated by measuring total polyphenol content (TPC), 2,2-diphenyl-1-picrylhydrazyl (DPPH) and 2,2′-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) radical scavenging activities, as well as ferric reducing antioxidant power (FRAP), following established methods [28]. Radical scavenging assays utilized DPPH (300 µM, Sigma-Aldrich Co., St. Louis, MO, USA) and ABTS (7 mM, Sigma-Aldrich Co.).

2.6. Texture Profile Analysis of Yanggaeng

Texture profile analysis (TPA) of Yanggaeng was conducted on 2 cm cube samples using a rheometer (Stable Micro Systems Co., Ltd., Surrey, UK). Parameters measured included hardness, resilience, adhesiveness, springiness, gumminess, cohesion, and chewiness, following previously established methods [1–3,27]. The analysis was performed with a 30 mm flat-bottomed probe under the following settings: 60% compression ratio, 0.5 N trigger force, 1 mm/s testing speed, and 2 mm/s pre- and post-test speeds.

2.7. Consumer Preferences of Yanggaeng

A group of 50 students from Dankook University participated in a consumer preference assessment, building on our previous studies [1–3,27]. Each participant received approximately 1 cm^3 cubes of each Yanggaeng sample. During evaluation, participants were served four cubes, and the entire process took about 10 min. Water was provided to cleanse the palate between tastings. Consumer preferences were recorded using a 9-point categorical scale [29], which evaluated color, flavor, taste, aroma, sweetness, chewiness, overall acceptance, and purchase intent for the Yanggaeng.

2.8. Statistical Analysis

Statistical analyses were conducted using SPSS 26.0 (IBM Corp., Armonk, NY, USA). Differences between treatments were assessed using one-way ANOVA followed Duncan's post hoc test at a significance level of $p < 0.05$. All experiments were conducted in triplicate to calculate the mean values and standard deviations.

3. Results and Discussion

3.1. Proximate Analysis of Yanggaeng

Table 2 shows the results of proximate analysis of Yanggaeng prepared with CF and alternative sweeteners. According to Lee et al., *Corni fructus* comprises 70.2% carbohydrates, 19.9% moisture, 2.6% crude protein, 3.6% crude fat, and 3.7% crude ash [30]. In this study, the moisture content was 47.63%, 56.24%, 55.69%, and 55.29% for Sug, Alu, Ste, and Xyl, respectively. The moisture content of Yanggaeng treated with alternative sweeteners was significantly higher than that of sugar-treated Yanggaeng ($p < 0.05$). However, there were no significant differences between the types of alternative sweeteners. The significant increase in the moisture content in Yanggaeng prepared with alternative sweeteners is likely due to the hygroscopic nature of the alternative sweeteners, which tend to absorb and retain more water than sugar [31]. Furthermore, the difficult-to-crystallize nature of Yanggaeng allows alternative sweeteners to trap more water molecules in it, contributing to an increase in moisture retention [32]. The crude ash, fat, and protein content of Yanggaeng remained unchanged across all treatments. Additionally, the carbohydrate content was significantly lower in Yanggaeng made with alternative sweeteners than in Sug ($p < 0.05$). The decrease in the carbohydrate content suggests that Yanggaeng prepared with alternative sweeteners could serve as a lower-calorie dessert option.

Table 2. Proximate compositions of Yanggaeng made with *Corni fructus* powder and alternative sweeteners.

Proximate Compositions (%)	Sug	Alu	Ste	Xyl
Moisture	47.63 ± 0.32^{b}	56.24 ± 0.06^{a}	55.69 ± 0.71^{a}	55.29 ± 0.12^{a}
Crude ash	$0.39 \pm 0.08^{ns\,1}$	0.43 ± 0.08^{ns}	0.41 ± 0.14^{ns}	0.38 ± 0.03^{ns}
Crude fat	0.13 ± 0.01^{ns}	0.15 ± 0.01^{ns}	0.25 ± 0.08^{ns}	0.27 ± 0.10^{ns}
Crude protein	0.06 ± 0.00^{ns}	0.07 ± 0.01^{ns}	0.07 ± 0.01^{ns}	0.06 ± 0.00^{ns}
Carbohydrate [2]	51.80 ± 0.31^{a}	43.11 ± 0.03^{b}	43.55 ± 0.82^{b}	43.99 ± 0.16^{b}

Sug, control; Yanggaeng treated with 2% *Corni fructus* powder (CF) and sugar; Alu, Yanggaeng treated with 2% CF and allulose; Ste, Yanggaeng treated with 2% CF and stevia; Xyl, Yanggaeng treated with 2% CF and xylose. Data are presented as means ± standard deviation ($n = 3$). All data were analyzed using one-way ANOVA followed by Duncan's post hoc test. Values with different superscript letters (a, b) in the same row differ significantly at $p < 0.05$. [1] ns, not significant, [2] carbohydrate (%) = 100 − (crude ash + fat + moisture + protein).

3.2. Hunter's Color Properties of Yanggaeng

Figure 1 illustrates the visual appearance of the Yanggaeng samples treated with CF and different alternative sweeteners, and Table 3 presents Hunter's color measurements.

The lightness (L^*) values were 24.20, 28.27, 23.70, and 19.40 for Sug, Alu, Ste, and Xyl groups, respectively. The L^* values were the highest in the Alu group and the lowest in the Xyl group ($p < 0.05$). Xyl had a stronger darkening effect on Yanggaeng than other alternative sweeteners. As a reducing sugar, xylose likely participates more actively in the browning reactions [33], significantly affecting the color of Yanggaeng. Interestingly, the Xyl group also exhibited higher a^* and b^* values than the Sug, Alu, and Ste groups. These results suggest that xylose can provide a richer and deeper hue for Yanggaeng. Similarly, Lee et al. demonstrated that macarons with added xylose showed a decrease in L^*, resulting in a darker brown color and increased a^* and b^* values [34–36]. In terms of a^* values, there were no significant differences in a^* values among the Sug, Alu, and Ste groups. However, b^* values were higher for the Yanggaeng samples with alternative sweeteners than for sugar-supplemented Yanggaeng.

Figure 1. Appearance of Yanggaeng prepared with *Corni fructus* powder and alternative sweeteners.

Table 3. Color values of Yanggaeng prepared with *Corni fructus* powder and alternative sweeteners.

Hunter's Color	Sug	Alu	Ste	Xyl
L^{*1}	24.20 ± 0.36 ^{b}	28.27 ± 0.67 ^{a}	23.70 ± 0.20 ^{b}	19.40 ± 0.35 ^{c}
a^{*2}	3.93 ± 0.32 ^{b}	3.90 ± 0.56 ^{b}	4.37 ± 0.25 ^{b}	9.30 ± 0.30 ^{a}
b^{*3}	5.13 ± 0.40 ^{c}	6.93 ± 0.25 ^{b}	6.20 ± 0.46 ^{b}	9.63 ± 0.21 ^{a}

Sug, control; Yanggaeng treated with 2% *Corni fructus* powder (CF) and sugar; Alu, Yanggaeng treated with 2% CF and allulose; Ste, Yanggaeng treated with 2% CF and stevia; Xyl, Yanggaeng treated with 2% CF and xylose. Data are expressed as means ± standard deviation (n = 3). Statistical analysis was performed using one-way ANOVA followed by Duncan's post hoc test. Means in the same row with different superscript letters (a–c) are significantly different at $p < 0.05$. [1] L^*, lightness, [2] a^*, redness, [3] b^*, yellowness.

3.3. pH, Brix, and Water Holding Capacity of Yanggaeng

Table 4 summarizes the pH, Brix values, and water holding capacity (WHC) of Yanggaeng samples. The Ste group exhibited a lower pH (5.04 ± 0.03) than the Sug (5.45 ± 0.04), Alu (5.50 ± 0.02), and Xyl (5.53 ± 0.03) groups ($p < 0.05$), indicating increased acidity due to the inherent properties of stevia. All alternative sweetener groups showed significantly higher Brix values than those of the Sug group, with Xyl achieving the highest Brix value (3.60 ± 0.00), followed by Alu (3.20 ± 0.00), Ste (2.60 ± 0.00), and Sug (2.53 ± 0.06) ($p < 0.05$). The enhancement in Brix value may suggest a higher soluble solid content, which can influence the perceived sweetness and mouthfeel of Yanggaeng. The WHC of Yanggaeng reflects its ability to retain water within its structure, which is crucial to its texture. Formulations with alternative sweeteners generally showed a lower WHC than the Sug group (25.84 ± 2.94), except for the Alu group, which maintained a comparable WHC (27.91 ± 0.40). Notably, the Xyl group had the lowest WHC (19.30 ± 0.42) ($p < 0.05$), potentially affecting the firmness and cohesiveness of the dessert.

Table 4. Comparison of the pH, Brix, and WHC of Yanggaeng made with *Corni fructus* powder and alternative sweeteners.

Items	Sug	Alu	Ste	Xyl
pH	5.45 ± 0.04 [a]	5.50 ± 0.02 [a]	5.04 ± 0.03 [b]	5.53 ± 0.03 [a]
Brix	2.53 ± 0.06 [d]	3.20 ± 0.00 [b]	2.60 ± 0.00 [c]	3.60 ± 0.00 [a]
WHC [1]	25.84 ± 2.94 [ab]	27.91 ± 0.40 [a]	22.75 ± 1.12 [bc]	19.30 ± 0.42 [c]

Sug, control; Yanggaeng treated with 2% *C. fructus* powder (CF) and sugar; Alu, Yanggaeng treated with 2% CF and allulose; Ste, Yanggaeng treated with 2% CF and stevia; Xyl, Yanggaeng treated with 2% CF and xylose. Data are expressed as means ± standard deviation (n = 3). Statistical analysis was performed using one-way ANOVA followed by Duncan's post hoc test. Means in the same row with different superscript letters (a–d) are significantly different at $p < 0.05$. [1] WHC, water holding capacity.

3.4. Antioxidative Properties of Yanggaeng

Table 5 presents the TPC, free radical scavenging rates, and FRAP values of Yanggaeng prepared with CF and alternative sweeteners. The TPC was significantly higher in the Alu and Xyl groups than in the Sug group. Similarly, to the TPC, the DPPH and ABTS radical scavenging activities increased significantly with the addition of alternative sweeteners (Alu and Xyl). Notably, the DPPH scavenging activity of the Xyl group increased 10.5-fold, and the ABTS scavenging activity increased 1.5-fold compared to those of the Sug group, showing the highest radical scavenging ability among all groups. However, stevia-treated Yanggaeng exhibited lower DPPH and ABTS radical scavenging activities than other groups, whereas both the Alu and Ste groups showed significantly lower DPPH and ABTS radical scavenging activities than the Sug group. The FRAP value was higher in the Xyl group than the other groups, whereas both Alu and Ste showed significantly lower values than the Sug group.

Table 5. Antioxidant activities of Yanggaeng prepared with *Corni fructus* powder and alternative sweeteners.

Antioxidant Activities	Sug	Alu	Ste	Xyl
TPC [1] (μg GAE [2]/g)	24.61 ± 0.71 [bc]	35.33 ± 0.88 [a]	21.21 ± 1.43 [c]	34.41 ± 4.96 [ab]
DPPH [3] radical scavenging activities (Inhibition %)	14.75 ± 4.24 [c]	40.88 ± 1.94 [b]	8.13 ± 3.71 [d]	155.35 ± 13.08 [a]
ABTS [4] radical scavenging activities (Inhibition %)	27.71 ± 0.46 [b]	30.99 ± 0.84 [b]	23.73 ± 0.69 [b]	41.59 ± 1.41 [a]
FRAP [5] (mM $FeSO_4$/g)	734.50 ± 42.43 [b]	690.00 ± 19.80 [c]	647.25 ± 10.25 [c]	899.50 ± 20.51 [a]

Sug, control; Yanggaeng treated with 2% *C. fructus* powder (CF) and sugar; Alu, Yanggaeng treated with 2% CF and allulose; Ste, Yanggaeng treated with 2% CF and stevia; Xyl, Yanggaeng treated with 2% CF and xylose. Data are expressed as means ± standard deviation (n = 3). Statistical analysis was performed using one-way ANOVA followed by Duncan's post hoc test. Means in the same row with different superscript letters (a–d) are significantly different at $p < 0.05$. [1] TPC, total polyphenol content; [2] GAE, gallic acid equivalent; [3] DPPH, 2,2-diphenyl-1-picrylhydrazyl; [4] ABTS, 2,2′-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid); [5] FRAP, ferric ion reducing antioxidant power.

Different alternative sweeteners exhibited distinct antioxidant activities, with Xyl showing superior radical scavenging abilities compared to Sug, Alu, and Ste. The exceptionally high DPPH and ABTS radical scavenging activity of Xyl suggest its strong potential as a potent antioxidant, likely due to its unique structural properties that enhance its ability to neutralize free radicals. Xylose, a five-carbon monosaccharide, contains hydroxyl groups on each carbon atom, which enable strong interactions with free radicals through hydrogen bonding [37]. Moreover, the pronounced crystallization properties of xylose contribute to the formation of a more stable and robust structure, which may further enhance its ability to interact with and neutralize free radicals [37,38]. Alu showed the highest TPC among the other groups, indicating a higher content of phenolic compounds, which contributed to its antioxidant capacity, although the observed radical scavenging activity was lower than that of Xyl. Interestingly, despite the widespread use of stevia as a natural sweetener, Ste demonstrated the lowest antioxidant activity in all assays. This suggests that although Ste may offer other health benefits, its contribution to antioxidant defense may be relatively limited. The FRAP assay corroborated these results, with the Xyl exhibiting the highest reducing power. Overall, these findings indicated that xylose may be a promising sugar substitute in terms of its antioxidant potential, whereas stevia, although commonly used, may not provide significant antioxidant benefits.

3.5. Textural Properties of Yanggaeng

Table 6 presents the TPA results for hardness, adhesiveness, resilience, cohesion, springiness, gumminess, and chewiness. Hardness was highest in the Xyl group (1930.75 ± 11.67 g), and this value was significantly higher than that of the Sug group (1800.21 ± 8.01 g), while Alu (1631.22 ± 80.84 g) and Ste (1549.30 ± 21.60 g) showed lower hardness. Resilience was significantly higher in the Alu group (9.30 ± 0.85%) than in the Ste group (6.60 ± 1.36%), with Sug (7.50 ± 0.35%) and Xyl (7.37 ± 0.41%) showing intermediate values. Gumminess and chewiness were highest in the Xyl group (639.09 ± 0.47 and 540.47 ± 21.50, respectively), while Ste showed the lowest values for both gumminess (405.25 ± 4.59) and chewiness (356.06 ± 10.03). However, textural properties, adhesiveness, cohesion, and springiness were not affected by the introduction of alternative sweeteners. The addition of xylose resulted in the hardest texture, with greater gumminess and chewiness compared to that of other sweeteners. This difference may be attributed to the unique molecular structure and physical properties of xylose. Its molecular structure facilitates stronger intermolecular interactions that enhance gel formation and elasticity [39,40]. Furthermore, xylose exhibits crystallization properties that likely contribute to the formation of a denser and more stable gel matrix [38], thereby increasing the hardness and chewiness of Yanggaeng. In contrast, stevia produced the softest texture, characterized by the lowest hardness, gumminess, and chewiness. This suggests that stevia weakens the structural integrity of the gel matrix. Additionally, stevia may contribute to a less elastic texture and a weaker gel structure than other sweeteners [41,42].

Table 6. Textural properties of Yanggaeng prepared with *Corni fructus* powder and alternative sweeteners.

Textural Properties	Sug	Alu	Ste	Xyl
Hardness (g)	1800.21 ± 8.01 ^{b}	1631.22 ± 80.84 ^{c}	1549.30 ± 21.60 ^{c}	1930.75 ± 11.67 ^{a}
Adhesiveness (g.sec)	−40.36 ± 0.35 ^{ns} [1]	−51.64 ± 28.47 ^{ns}	−36.87 ± 1.88 ^{ns}	−61.55 ± 1.42 ^{ns}
Resilience (%)	7.50 ± 0.35 ^{ab}	9.30 ± 0.85 ^{a}	6.60 ± 1.36 ^{b}	7.37 ± 0.41 ^{ab}
Cohesion	0.28 ± 0.03 ^{ns}	0.32 ± 0.03 ^{ns}	0.27 ± 0.02 ^{ns}	0.33 ± 0.02 ^{ns}
Springiness (%)	94.40 ± 5.33 ^{ns}	93.72 ± 6.82 ^{ns}	90.57 ± 2.56 ^{ns}	87.38 ± 1.38 ^{ns}
Gumminess	509.31 ± 24.43 ^{b}	531.17 ± 22.29 ^{b}	405.25 ± 4.59 ^{c}	639.09 ± 0.47 ^{a}
Chewiness	489.34 ± 15.24 ^{b}	452.22 ± 2.46 ^{c}	356.06 ± 10.03 ^{d}	540.47 ± 21.50 ^{a}

Sug, control; Yanggaeng treated with 2% *C. fructus* powder (CF) and sugar; Alu, Yanggaeng treated with 2% CF and allulose; Ste, Yanggaeng treated with 2% CF and stevia; Xyl, Yanggaeng treated with 2% CF and xylose. Data are expressed as means ± standard deviation (n = 3). Statistical analysis was performed using one-way ANOVA followed by Duncan's post hoc test. Means in the same row with different superscript letters (a–d) are significantly different at $p < 0.05$. [1] ns, not significant.

3.6. Consumer Preferences for Yanggaeng

Figure 2 presents the results of the consumer preference evaluations for Yanggaeng samples containing CF and alternative sweeteners. The Xyl group received the highest scores for several attributes, including color (7.53 ± 1.06), flavor (7.33 ± 1.18), sweetness (7.40 ± 1.76), taste (7.67 ± 1.29), overall acceptance (7.20 ± 1.26), and purchase intention

(7.00 ± 1.20), all significantly outperforming the Sug, Alu, and Ste groups ($p < 0.05$). Specifically, the Sug group scored 6.13 ± 1.30 in color, 6.27 ± 1.22 in flavor, 6.73 ± 1.49 in sweetness, 6.73 ± 1.71 in taste, 6.40 ± 1.55 in overall acceptance, and 5.73 ± 1.71 in purchase intention. The Alu and Ste groups generally received lower preference scores across most attributes, with allulose in particular lagging in flavor, sweetness, taste, overall acceptance, and purchase intention. Notably, the Ste group did not differ significantly from the Sug group in attributes such as scent and chewiness, indicating that stevia has weak effects on these sensory aspects. Despite similarities in scent and chewiness across all groups, the Xyl group consistently achieved higher ratings for the most sensory attributes, suggesting that xylose enhances both the visual appeal and overall sensory properties of Yanggaeng. This indicates that xylose may be the most favorable alternative sweetener among those tested for improving the consumer acceptance of CF-treated Yanggaeng.

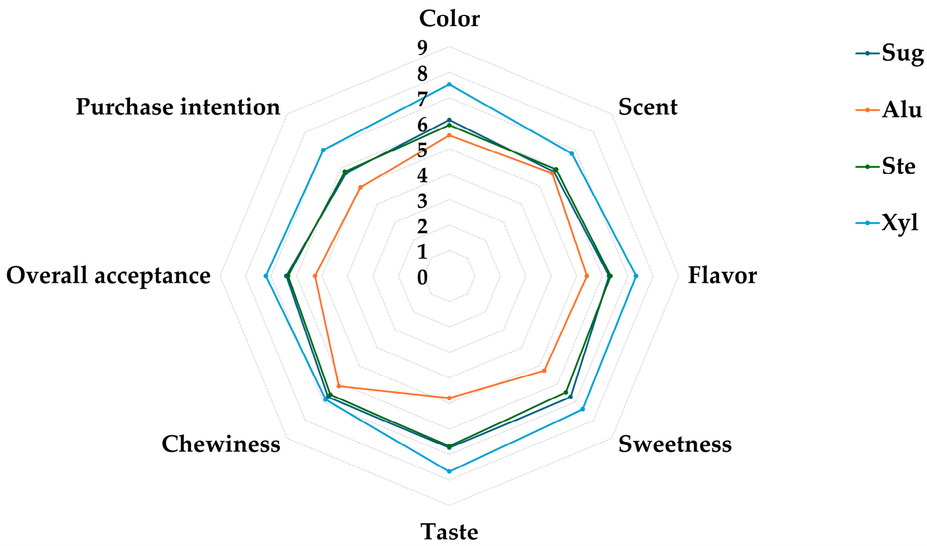

Figure 2. Radar chart of consumer preferences for Yanggaeng made with *Corni fructus* powder and alternative sweeteners. Sug, control; Yanggaeng treated with 2% *C. fructus* powder (CF) and sugar; Alu, Yanggaeng treated with 2% CF and allulose; Ste, Yanggaeng treated with 2% CF and stevia; Xyl, Yanggaeng treated with 2% CF and xylose. Data are expressed as means ± standard deviation ($n = 3$). Statistical analysis was performed using one-way ANOVA followed by Duncan's post hoc test.

4. Conclusions

This study investigated the effects of various alternative sweeteners (allulose, stevia, and xylose) on the proximate composition, antioxidant activity, texture, and consumer preference for Yanggaeng prepared with CF. The inclusion of these alternative sweeteners increased the moisture content, although no significant differences were observed between the sweetener types. Yanggaeng made with xylose had lower carbohydrate content, indicating its potential in a lower-calorie product. Xylose also produced a darker color and demonstrated superior antioxidant activity with higher DPPH, ABTS, and FRAP values, suggesting that it was the most potent antioxidant among the sweeteners tested.

In terms of texture, xylose created a firmer gel, whereas stevia resulted in a softer texture. Consumer evaluations favored xylose in color, flavor, sweetness, and overall acceptance, with higher purchase intention than other groups. These results highlight xylose as a promising sweetener with improved antioxidant and sensory properties for developing healthy, low-calorie desserts. Future research should explore the long-term stability and shelf life of xylose-treated Yanggaeng and assess the potential benefits of combining multiple sweeteners to achieve optimal taste and nutritional balance.

Author Contributions: Conceptualization, J.-J.L., S.P., J.L. (Jisu Lee) and J.-H.H.; methodology, H.J., Y.-W.K., J.L. (Jiwoo Lee) and J.L. (Jisu Lee); software, H.J. and J.L. (Jisu Lee); validation, J.-J.L., S.P., J.L. (Jisu Lee) and J.-H.H.; formal analysis, H.J., Y.-W.K., J.L. (Jiwoo Lee) and J.L. (Jisu Lee); investigation, J.-J.L. and J.-H.H.; resources, J.-J.L. and J.-H.H.; data curation, J.-J.L., S.P., J.L. (Jisu Lee) and J.-H.H.; writing—original draft preparation, J.-J.L., S.P., H.J., Y.-W.K., J.L. (Jiwoo Lee), J.L. (Jisu Lee), and J.-H.H.; writing—review and editing, J.-J.L., S.P., H.J., Y.-W.K., J.L. (Jiwoo Lee), J.L. (Jisu Lee), and J.-H.H.; visualization, H.J. and J.L. (Jisu Lee); supervision, J.-J.L. and J.-H.H.; project administration, J.-J.L. and J.-H.H.; funding acquisition, J.-J.L. All authors have read and agreed to the published version of the manuscript.

Funding: This study was supported by research fund from Chosun University, 2024.

Institutional Review Board Statement: This study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of Dankook University (protocol code DKU-2022-02-038-001, approved on 24 March 2022).

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

Data Availability Statement: Data are contained within the article.

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

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