Journal of Food Science

ORIGINAL ARTICLE OPEN ACCESS

Sensory and Consumer Sciences

Variations in Sensory and Emotional Responses to Gluten-Containing and Gluten-Free Cookie Products Under Blind and Labeled Conditions

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Received: 21 January 2025 | **Revised:** 8 April 2025 | **Accepted:** 28 April 2025

Funding: This study was based upon work that is supported, in part, by the United States Department of Agriculture National Institute of Food and Agriculture Hatch Act funding (7001030) to Han-Seok Seo.

Keywords: cookie | emotion | gluten | gluten-free | label | sensory

ABSTRACT: The gluten-free food market is expanding rapidly. However, consumer acceptance and emotional responses to gluten-free food, especially commercially available products, have received relatively underexplored. This study aimed to determine how consumer perceptions, acceptance, and emotional responses differ between gluten-containing (C) and gluten-free (F) chocolate chip cookies from three brands under both blind and labeled conditions. In the labeled condition, 84 participants without celiac disease evaluated 3 F cookies labeled "gluten-free" and 3 C cookies presented without claims on a plain white card. In the blind condition, they tested the six cookies without labels. Participants provided hedonic ratings, Just-About-Right (JAR) ratings, and checked their emotional responses for each cookie. Results showed that participants liked the texture and overall aspects of the C cookies more than their F counterparts. Significant variations were observed in hedonic ratings of appearance, flavor, texture, and overall impression between C and F cookies, with brand playing a notable role. Although the gluten condition had a minimal effect on emotional responses to C and F cookies, this impact varied by brand. The influence of gluten-free labeling on sensory and emotional responses to C and F cookies was limited. In conclusion, this study demonstrated that sensory and emotional responses to gluten-containing versus gluten-free cookies can differ significantly across brands, and gluten-free claims had little impact on these responses.

Practical Application

Our study revealed that gluten-free cookies from some brands can rival their gluten-containing counterparts. However, there is still room for improvement in the sensory quality of gluten-free products, particularly regarding texture.

1 | Introduction

Gluten is a plant protein present in cereal grains such as wheat, barley, and rye (Toth et al. 2020). In baked goods, gluten functions as a binding agent that gives the dough strength and elasticity, therefore improving overall baking quality (Cantrell et al. 2020; Susman et al. 2021; Aguiar et al. 2022). Despite the widespread use of gluten in food, it can have an adverse effect on individuals with gluten-related diseases such as celiac disease and gluten ataxia. The most common gluten-related disease affecting approximately 3% of the world population is celiac disease (Silva-Paz et al. 2023). Celiac disease is a recognized autoimmune and inflammatory condition in the upper part of the small intestine that is caused by the presence of gluten. Individuals with celiac disease commonly

experience symptoms such as malnutrition, diarrhea, stunted growth, anemia, and exhaustion (Xu et al. 2020). The only proven treatment for celiac disease is the complete elimination of gluten from the diet (Puerta et al. 2022). Adhering strictly to a gluten-free diet alleviates symptoms, facilitates intestinal healing, reverses malabsorption effects, and significantly lowers the mortality rate associated with the condition (Demirkesen and Ozkaya 2022).

According to the US Food and Drug Administration, gluten-free foods are defined as those containing less than 20 ppm of gluten (U.S. Food and Drug Administration 2023). This category includes foods naturally free of gluten-containing grains as well as those that have been processed to remove gluten. The global demand for gluten-free products has surged in recent years, driven by their effectiveness in treating celiac disease, attributed to their potency and non-toxicity (Ye et al. 2023). The gluten-free market is experiencing rapid growth and is projected to reach approximately $24 billion by 2027 (Aguiar et al. 2022). A review by Xhakollari et al. (2019) highlighted an increasing number of non-celiac individuals who are adopting gluten-free diets and are willing to pay a premium for such products, fueling market demand. This trend is driven by various factors, including a growing focus on health-conscious lifestyle, care for well-being, emotional and hedonic values, family members of celiac patients adopting gluten-free diets to prevent cross-contamination, and the genetic predisposition to the disease prompting early dietary changes (Xhakollari et al. 2019; Zerbini et al. 2024). Furthermore, the popularity of gluten-free diet has been amplified by social media trends and endorsements from celebrities, making them a fashionable choice (Xhakollari et al. 2019).

Despite the rapid growth of the gluten-free food market, improvements in product quality have not kept pace. Gluten-free foods are often reported to be of lower quality compared to their gluten-containing counterparts (Torbica et al. 2010; Laureati et al. 2012). Gluten-free foods often contain a high carbohydrate content and low levels of fiber. They also tend to have a shorter shelf life and face textural challenges, such as thicker crumbs (Demirkesen and Ozkaya 2022; Dogruer et al. 2023). Furthermore, evidence suggests that gluten-free products, including bread, pizza, and cookies, are frequently perceived as less tasty compared to their traditional counterparts (Laureati et al. 2012; Ervina 2023). For example, 71% of consumers have reported difficulty finding gluten-free food items that are both delicious and satisfying (Xhakollari et al. 2019). In response, manufacturers are increasingly prioritizing the production of gluten-free products that meet consumer expectations for improved texture and overall quality. In addition, research on the sensory qualities of gluten-free foods has expanded significantly, with the number of related publications increasing from 17 in 2012 to 105 in 2022 (Capriles et al. 2023).

Despite the expanding body of literature, significant knowledge gaps remain. Notably, few studies have examined the sensory characteristics and consumer purchase behaviors associated with commercially available gluten-free products (Xu et al. 2020; Capriles et al. 2023). Although prior research has primarily focused on how ingredient composition and processing techniques influence the sensory quality of gluten-free food samples (Jnawali et al. 2016; Xu et al. 2020; Aguiar et al. 2022; Capriles and Arêas 2023; Ervina 2023; Melo et al. 2023), there is limited documentation comparing consumer perception and acceptance of commercial gluten-free products. Exploring how current gluten-free products align with consumer expectations in terms of sensory quality and attributes is essential for providing valuable insights into the development of improved gluten-free products. Second, little is known about how emotional responses toward food could differ depending on the gluten presence, such as gluten-containing versus gluten-free counterparts. As consumers' emotions evoked by food products play a crucial role in determining their acceptance and choice of food products (Seo et al. 2009; Samant and Seo 2020; Gurdian et al. 2022; Baranda et al. 2024), it is worth comparing emotional responses toward gluten-containing and gluten-free counterparts. In particular, little scholarly attention has been paid to comparing emotional responses to food products between gluten-containing and gluten-free counterpart products. Several studies have examined how specific variations, such as sweetener types in gluten-free muffin (Wardy et al. 2018) or flour mix ratios in gluten-free bread (Aguiar et al. 2022; Aleman et al. 2023), influenced food-evoked emotions. Lastly, as a review by Capriles et al. (2023) suggested, more research regarding the effect of label information on consumers' acceptance, emotions, and purchase behaviors in gluten-free products should be conducted. Notably, compared to other label claims (e.g., organic), the impact of gluten-free label on consumer perception and behavior is still scarce (Prada et al. 2019). Additionally, such previous research regarding the effect of gluten-free label has been conducted either in online setting or using product images more often rather than in realistic setting using food samples (Shin and Mattila 2018; Prada et al. 2019). Prada et al. (2019) demonstrated that Portuguese consumers who do not follow a gluten-free diet consider a gluten-free diet as more healthful, less caloric, and more adequate to weight loss compared to a conventional diet. Related, when consumers were given images of various food products, including flour, bread, rice, and rice crackers, in the presence or absence of the gluten-free label claim, they evaluated the products to be more healthful, less caloric, less processed in the presence of the label claim than in its absence (Prada et al. 2019). Another online study by Shin and Mattila (2018) showed that participants, especially individuals with low levels of dietary restraint, expected to decrease their food consumption when a menu item (pizza) was labeled gluten-free compared to when it was conventional, and this observation was found to be mediated by expected taste, that is, gluten-free pizza is not tasty. Therefore, there is a critical need to conduct research examining the effect of gluten-free label on consumer acceptance, emotions, and purchase behaviors by conducting sensory evaluations using real food items. Although the main intent of gluten-free labeling is to raise nutritional awareness, it also serves as a marketing tool to persuade consumers to purchase the product (Xhakollari et al. 2019). Consequently, manufacturers of naturally gluten-free products have increasingly labeled them as such to capitalize on this trend (Cantrell et al. 2020).

Building on the above-mentioned knowledge gaps from previous studies, this study aimed to compare commercially available gluten-containing and gluten-free cookie products in terms of sensory acceptance and evoked emotions in both blind and informed-label conditions of gluten-free claim. The research addressed the following three research questions (RQs):

RQ 1: How do gluten-containing and gluten-free cookie products differ in terms of consumer perception and acceptance?
RQ 2: How do gluten-containing and gluten-free cookie products differ in the emotions they evoke, as measured by the circumplex-inspired emotion questionnaire (CEQ) (Jaeger et al. 2021; see Section 2.3. procedure for details)?
RQ 3: How do consumer acceptance and evoked emotions toward cookie products differ depending on label conditions of gluten-free claims?

Gluten-free bakery goods are the most marketed types of gluten-free products due to their variety, including bread, cookies, cakes, and pasta products (Xu et al. 2020; Melo et al. 2023), with bread being the most extensively researched (Aguiar et al. 2022; Capriles and Arêas 2023). However, given that cookies are also widely consumed among consumers with celiac disease due to their convenience, a long shelf life, and affordability, making them suitable for consumption at any time of the day (Alencar et al. 2021; Silva-Paz et al. 2023), this study focused on sensory and emotional responses to gluten-free chocolate chip cookie products. Among various types of cookies available on the market, chocolate chip cookies are one of the most popular varieties of cookies, mostly because they are readily available, affordable, and versatile (Perry et al. 2003).

2 | Materials and Methods

The protocol of this study (2311502798) was approved by the University of Arkansas' Institutional Review Board (IRB) in Fayetteville, AR, USA. Prior to participation, the experimental procedure was explained to all participants, and a written consent indicating voluntary participation was obtained from each participant.

2.1 | Participants

Eighty-four participants (54 females and 30 males) ranging from age 18 to 70 years (mean age ± standard deviation [SD] = 41 ± 14 years) participated in this study. They were recruited using the consumer profile database of the University of Arkansas Sensory Science Center. Participants self-reported neither clinical history of gluten sensitivity and dietary avoidance nor major diseases that influence sensory functions. They also reported consuming cookies at least once per month. Table S1 represents demographic profiles of the participants in this study.

2.2 | Cookie Samples

Six commercially available chocolate chip cookie products from three different brands were used in this study: Brand A (Favorite Day Chewy Chocolate Chip Cookies, Target Brands, Inc., Minneapolis, MN, USA), Brand B (Tate's Chocolate Chip Cookies, Tate's Bake Shop, Southampton, NY, USA), and Brand C (Walkers Pure Butter Chocolate Chip Shortbread, Walker's Shortbread Ltd., Aberlour, Scotland). Each brand provided both a gluten-containing (C) chocolate chip cookie product and its gluten-free (F) counterpart. Specifically, Figure 1 shows these six samples: CA and FA for Brand A; CB and FB for Brand B; and CC and FC for Brand C. Each cookie sample was assigned a unique three-digit code. All samples were purchased within 2 weeks prior to the testing dates.

Tables S2 and S3 summarize the color and textural attributes of each test sample. Color measurements for the L^*, a^*, and b^* parameters were obtained using a colorimeter (MiniScan XE Plus, HunterLab, Reston, VA, USA) on 10 cookies from the same batch used in sensory evaluation. Texture analysis was performed via a compression test using a TA-XT2i Texture Analyzer (Stable Micro Systems, Godalming, UK) on four cookies to measure hardness of each cookie sample. Each cookie was compressed with a spherical probe (6.25 mm diameter) to 70% strain. The pre-test, test, and post-test speeds were set at 1.0, 0.5, and 1.0 mm/s, respectively. This procedure measured both the maximum force (g) and the work (positive area under the force-distance curve) required to deform the cookie, offering an objective assessment of its hardness (or firmness) (Gagneten et al. 2023).

2.3 | Procedure

Participants took part in this study on 2 separate days, that is, one for each condition involving either blind tasting or labeled tasting, with a 1-week interval between them. On Day 1, the first half of the participants (e.g., Group A in Figure 1) evaluated the cookies under the labeled condition, whereas the second half (e.g., Group B in Figure 1) tested them without labels. On Day 2, the conditions were switched so that by the end of the study, each participant had evaluated all six cookies in both labeled and blind conditions. Following the Williams Latin Square Design (Williams 1949), the test samples were presented in a randomized and balanced sequence, ensuring that all six cookie samples appeared across both test conditions. As shown in Figure 2, in the blind condition, participants evaluated the test samples without any accompanying information. In the labeled condition, three gluten-free cookies were presented with a white card (5.1 cm × 8.3 cm) labeled "gluten-free," whereas three gluten-containing cookies were accompanied by a plain white card without any text, following the procedure used in a previous study (Jarma Arroyo et al. 2020). This reflects typical market practices, as commercially available gluten-containing cookies are generally not labeled as such on their packaging.

Across both conditions, for all samples, participants responded to eight questions related to sensory acceptances, attribute intensities, and evoked emotions. In both conditions, sensory acceptances (appearance liking, flavor liking, texture liking, and overall liking) were evaluated using a 9-point hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely). The intensities of specific attribute (chocolate flavor, sweetness, and hardness) were evaluated using a 5-point Just-About-Right (JAR) scale, where 1 indicated "much too weak," 2 "too weak," 3 "JAR," 4 "too strong," and 5 "much too strong." Emotional responses toward each cookie sample were assessed using self-reported measures in a Check-All-That-Apply (CATA) format, on the basis of 12 emotional terms from the CEQ developed by Jaeger et al. (2020). These terms included "active/alert," "energetic/excited," "enthusiastic/inspired," "happy/satisfied," "secure/at ease," "relaxed/calm," "passive/quiet," "dull/bored,"

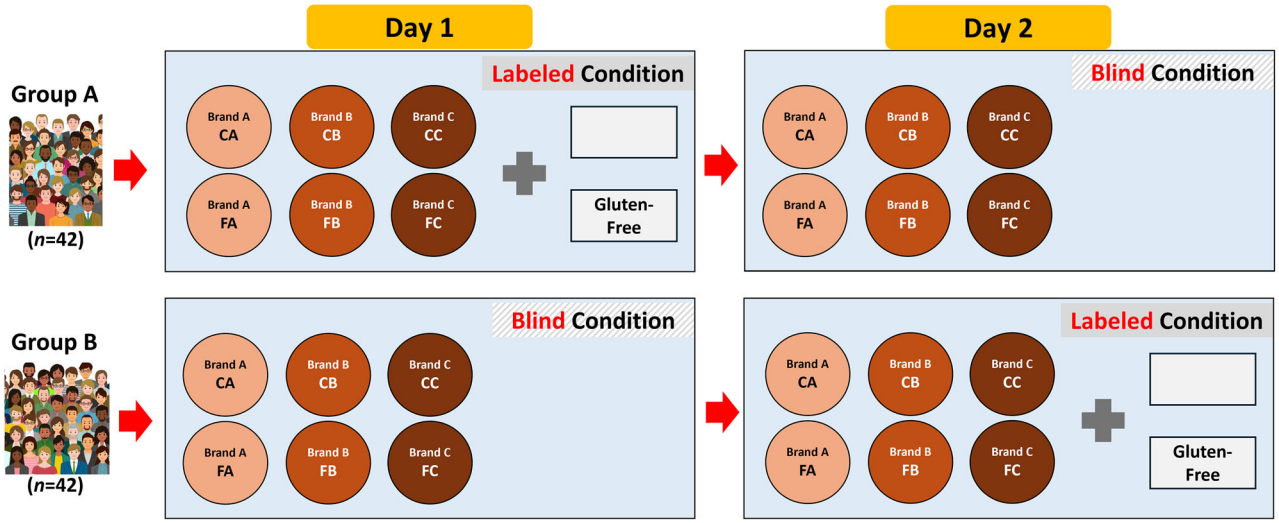

FIGURE 1 | **Overall scheme of experimental setting**. Participants took part in this study on 2 separate days—one for each condition involving either blind tasting or labeled tasting, with a 1-week interval between them. On Day 1, the first half of the participants evaluated the gluten-containing (C) and gluten-free (F) cookies under the labeled condition, whereas the second half tested them without labels. On Day 2, the conditions were switched.

FIGURE 2 | **Visualization of blind and labeled conditions**. In the blind condition, participants evaluated test samples without any information. In the labeled condition, they evaluated three gluten-free cookies accompanied by a white card labeled "gluten-free" and three gluten-containing cookies presented with a plain white card without any text.

"blue/uninspired," "unhappy/dissatisfied," "tense/bothered," and "jittery/nervous" (Jaeger et al. 2020). The CEQ was chosen for its balanced representation of pleasant and unpleasant emotions and its coverage of both valence and arousal dimensions. This aspect is an advantage over other scales such as the EsSense Profile questionnaire (King and Meiselman 2010). Furthermore, previous studies have shown that the CATA format captures differences in food-evoked emotions more effectively than single-response methods within the CEQ framework (Jaeger et al. 2021; Seo et al. 2023), supporting its use in the present study. To minimize the carry-over effect, a 1-min break was given between sample presentations with spring water and unsalted crackers as palate cleansers.

2.4 | Statistical Analysis

Data collection of this study was performed using Compusense Cloud (Compusense Inc., Guelph, ON, Canada). Data were analyzed using JMP Pro (version 18, SAS Institute Inc., Cary, NC, USA) and XLSTAT (Addinsoft, New York, NY, USA). To determine the effects of "gluten" (C vs. F), "brand" (Brands A, B, and C), and "label" (blind vs. labeled) conditions on hedonic ratings of cookies, a mixed model, treating "gluten," "brand," and "label" as a fixed effect and "participant" as a random effect, was performed. Post hoc tests were conducted using Tukey's honest significant difference (HSD) tests.

For JAR scale data, the absolute delta ($|\Delta|$) JAR scores were computed by subtracting each JAR rating from the JAR value (i.e., 3), as shown in previous research (Jarma Arroyo et al. 2020). As conducted for analyzing the hedonic ratings of cookies, a mixed model was conducted, treating "gluten," "brand," and "label" as a fixed effect and "participant" as a random effect.

For CATA-based emotion data, Cochran's Q-test was performed to test whether six cookie samples (two gluten conditions × three brands) differed in either label condition in terms of the proportions of selection of individual attributes of the CEQ emotions. For each emotion attribute, multiple pairwise comparisons were performed using the critical difference (Sheskin) procedure. To visualize associations between cookie samples and evoked emotions in either label condition, a correspondence analysis was conducted. A statistical difference was defined when $p < 0.05$.

TABLE 1 | Summary of the effects of brand, gluten, and label conditions, and their interactions, on the hedonic ratings of cookie samples.

Category	Brand (B)	Gluten (G)	Label (L)	B × G	B × L	G × L	B × G × L
Appearance liking	36.77[a] (<0.001)	2.20 (0.14)	1.78 (0.18)	58.54 (<0.001)	0.13 (0.88)	4.95 (0.03)	0.16 (0.85)
Flavor liking	12.17 (<0.001)	0.02 (0.89)	0.49 (0.48)	3.69 (0.03)	0.45 (0.64)	0.18 (0.67)	1.12 (0.33)
Texture liking	6.65 (0.001)	12.90 (<0.001)	0.21 (0.65)	6.77 (0.001)	0.67 (0.51)	0.38 (0.54)	0.01 (0.99)
Overall liking	0.42 (0.66)	7.76 (0.006)	2.12 (0.15)	6.10 (0.002)	1.36 (0.26)	0.46 (0.50)	0.02 (0.98)

[a]*F*-ratio (*p* value).

3 | Results

3.1 | Hedonic Ratings of Cookie Samples

Table 1 summarizes the main effects of brand, gluten, and label conditions, along with their interactions, on the hedonic ratings of cookie samples. There were no significant interactions among brand, gluten, and label conditions affecting the hedonic ratings ($p > 0.05$).

3.1.1 | Effects of Brand and Gluten Conditions on Hedonic Ratings of Cookies

The brand condition had a significant impact on participants' hedonic ratings of appearance, flavor, and texture (Table 1). Overall, participants liked the appearance of Brand A's cookies the most (mean ± SD = 6.13 ± 1.93), followed by Brand C's (5.43 ± 2.02) and Brand B's (5.02 ± 2.01). Participants favored the flavor of Brand B's cookies the most (6.31 ± 1.83), while showing no significant difference in their acceptance of the flavors of Brand A's (5.74 ± 1.98) and Brand C's (5.70 ± 2.13). In contrast, participants liked the texture of Brand B's cookies the least (4.80 ± 2.28), but there was no significant difference in their acceptance of textures between Brand A's (5.35 ± 2.13) and Brand C's (5.24 ± 2.24) cookies. There was no significant difference in participants' overall liking for the three brands of cookies: Brands A (5.40 ± 2.12), B (5.44 ± 2.13), and C (5.30 ± 2.30).

The gluten condition (i.e., C vs. F) did not significantly affect hedonic ratings of appearance (Table 1), which is consistent with the lack of significant differences in L^*, a^*, and b^* color parameters between gluten-containing and gluten-free cookies, as measured by a colorimeter (for all, $p > 0.05$). Similarly, no significant differences were observed in hedonic ratings of flavors between the two gluten conditions (Table 1). However, participants liked the texture of gluten-containing cookies (mean ± SD = 5.36 ± 2.24) more than gluten-free cookies (4.90 ± 2.19). Instrumental texture analysis revealed that gluten-containing cookies (mean ± SD = 22,776.33 ± 16,164.91) had a significantly greater positive area under the force-distance curve compared to gluten-free cookies (11,503.64 ± 7387.23) ($p = 0.04$). However, there was no significant difference in maximum force between the two gluten conditions: gluten-containing (3899.13 ± 2592.61) versus gluten-free (2342.36 ± 1182.91) cookies ($p = 0.07$). For overall liking, gluten-containing cookies (5.55 ± 2.15) received significantly higher ratings compared to gluten-free cookies (5.20 ± 2.20) (Table 1).

Notably, there was a significant interaction between the gluten and brand conditions, indicating that the effect of gluten condition varied across brands. Specifically, as shown in Figure 3, participants liked the appearance of gluten-containing cookies (mean ± SD = 6.89 ± 1.60) more than gluten-free cookies (5.38 ± 1.93) for Brand A, whereas the opposite trend was observed for Brand B's cookies: gluten-containing cookies (4.36 ± 1.93) versus gluten-free cookies (5.69 ± 1.87). Moreover, no significant difference was noted between the gluten-containing and gluten-free cookies in Brand C. For flavor liking, participants liked gluten-containing cookies (5.92 ± 2.05) more than gluten-free ones (5.48 ± 2.19) for Brand C, but no significant differences were observed for Brands A and B (Figure 4). With respect to texture, participants favored gluten-containing cookies across all brands, except for Brand A, where no significant difference was noted (Figure 5). Additionally, overall liking for gluten-containing cookies (5.77 ± 2.12) was higher than for gluten-free cookies (4.83 ± 2.39) in Brand C, with no significant differences for Brands A and B (Figure 6).

3.1.2 | Effect of Label Condition on Hedonic Ratings of Cookies

There were no significant effects of label condition on hedonic ratings for appearance, flavor, texture, and overall liking, as shown in Table 1. Additionally, interactions between brand and label conditions, as well as between gluten and label conditions, were not significant, except for the interaction between gluten and label conditions for appearance liking (Table 1). As shown in Figure 3, participants liked the appearance of gluten-containing cookies (mean ± SD = 5.66 ± 2.13) more than gluten-free ones (5.26 ± 1.99) in the blind condition ($p = 0.04$). However, no significant difference in appearance liking was observed between gluten-containing (5.56 ± 2.04) and gluten-free (5.64 ± 1.95) cookies in the labeled condition ($p = 0.95$).

3.2 | JAR Ratings of Cookies

Table 2 summarizes the main effects of brand, gluten, and label conditions, along with their interactions, on the absolute delta (|Δ|) JAR scores for each attribute of cookie samples. There was no significant three-way interaction among brand, gluten, and label conditions on the JAR ratings ($p > 0.05$).

3.2.1 | Effects of Brand and Gluten Conditions on JAR Ratings of Cookies

The brand condition significantly affected participants' JAR ratings for chocolate flavor, sweetness, and hardness (for all, $p < 0.05$). For chocolate flavor intensity, the absolute delta JAR scores were significantly smaller for Brand B's cookies

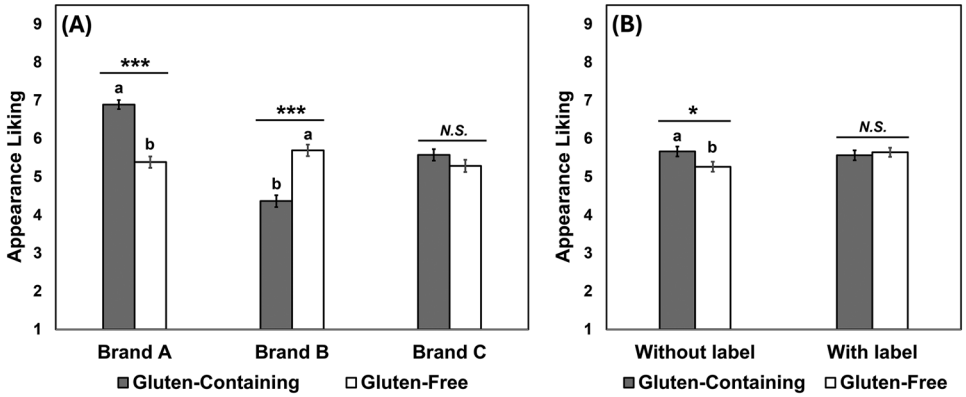

FIGURE 3 | **Mean comparisons (with error bars representing the standard error of the means) between gluten-containing and gluten-free cookies in terms of appearance liking, by brand (A) or label (B) conditions**. N.S. represents no significant difference at $p < 0.05$. * and *** represent a significance at $p < 0.05$ and $p < 0.001$, respectively. Mean ratings with different letters indicate a significant difference at $p < 0.05$.

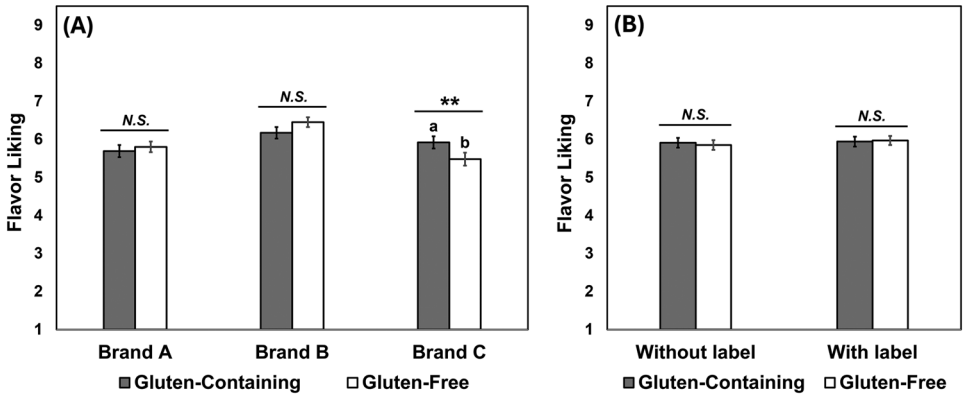

FIGURE 4 | **Mean comparisons (with error bars representing the standard error of the means) between gluten-containing and gluten-free cookies in terms of flavor liking, by brand (A) or label (B) conditions**. N.S. represents no significant difference at $p < 0.05$. ** represents a significance at $p < 0.01$. Mean ratings with different letters indicate a significant difference at $p < 0.05$.

TABLE 2 | Summary of the effects of brand, gluten, and label conditions, and their interactions, on absolute delta Just-About-Right scores of cookie samples with respect to chocolate flavor, sweetness, and hardness.

Category	Brand (B)	Gluten (G)	Label (L)	B × G	B × L	G × L	B × G × L
Chocolate flavor	48.40[a] (<0.001)	1.54 (0.22)	1.05 (0.31)	0.92 (0.40)	0.22 (0.80)	0.03 (0.87)	0.10 (0.90)
Sweetness	5.07 (0.007)	3.81 (0.05)	1.01 (0.32)	1.40 (0.25)	0.47 (0.63)	0.004 (0.95)	0.42 (0.66)
Hardness	8.93 (<0.001)	1.87 (0.17)	0.30 (0.59)	7.14 (<0.001)	1.31 (0.27)	0.67 (0.41)	1.05 (0.35)

[a]*F*-ratio (*p* value).

(mean ± SD = 0.37 ± 0.56), followed by Brand A's (0.54 ± 0.63) and Brand C's (0.80 ± 0.70), indicating that Brand B's cookies were closer to participants' ideal preferences. Similarly, Brand B's cookies (0.32 ± 0.52) were also rated as being closer to participants' JARs in sweetness compared to Brand A's (0.44 ± 0.60) and Brand C's (0.43 ± 0.60). However, for hardness, Brand B's cookies (0.82 ± 0.74) were rated as being farther from participants' JARs than Brand A's (0.66 ± 0.74) and Brand C's (0.61 ± 0.70).

The gluten condition did not have a significant effect on the JAR ratings for chocolate flavor, sweetness, and hardness (for all, $p > 0.05$). However, a significant interaction was observed between the gluten and brand conditions for hardness JAR ratings, indicating that the effect of gluten condition varied by brand (Table 3). Specifically, Brand C's gluten cookies (mean ± SD = 0.46 ± 0.65) were rated as closer to participants' JAR for hardness compared to Brand C's gluten-free counterparts

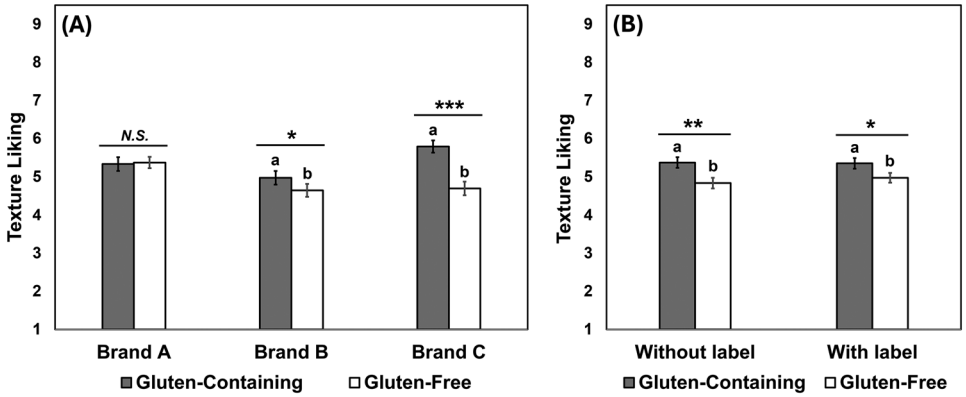

FIGURE 5 | **Mean comparisons (with error bars representing the standard error of the means) between gluten-containing and gluten-free cookies in terms of texture liking, by brand (A) or label (B) conditions**. N.S. represents no significant difference at $p < 0.05$. *, **, and *** represent a significance at $p < 0.05$, $p < 0.01$, and $p < 0.001$, respectively. Mean ratings with different letters indicate a significant difference at $p < 0.05$.

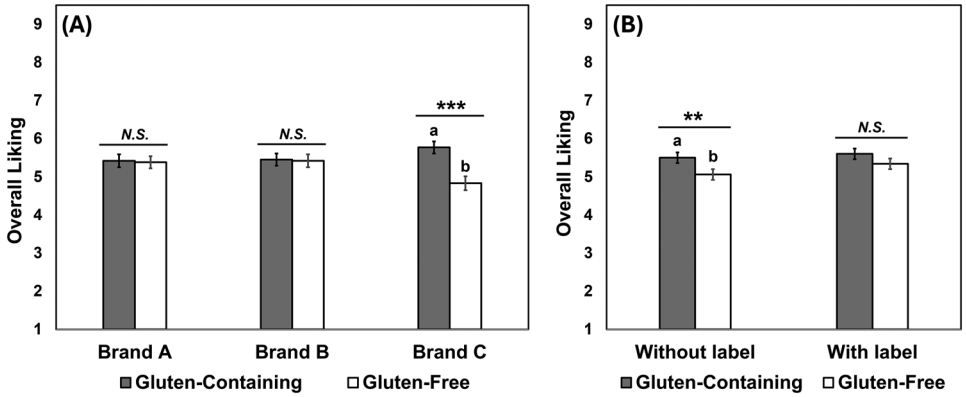

FIGURE 6 | **Mean comparisons (with error bars representing the standard error of the means) between gluten-containing and gluten-free cookies in terms of texture liking, by brand (A) or label (B) conditions**. N.S. represents no significant difference at $p < 0.05$. ** and *** represent a significance at $p < 0.01$ and $p < 0.001$, respectively. Mean ratings with different letters indicate a significant difference at $p < 0.05$.

TABLE 3 | Interactions between brand and gluten conditions with respect to absolute delta Just-About-Right (JAR) sores[a] for chocolate flavor, sweetness, or hardness.

JAR attribute	Brand	Gluten condition		*p* value
		Gluten-containing (C)	Gluten-free (F)	
Chocolate flavor	A	0.54[b] (±0.65)	0.54 (±0.61)	1.00
	B	0.42 (±0.59)	0.31 (±0.51)	0.48
	C	0.82 (±0.68)	0.79 (±0.72)	1.00
Sweetness	A	0.44 (±0.59)	0.43 (±0.62)	0.91
	B	0.27 (±0.49)	0.36 (±0.55)	0.64
	C	0.36 (±0.59)	0.49 (±0.61)	0.32
Hardness	A	0.71 (±0.76)	0.61 (±0.71)	0.76
	B	0.83 (±0.77)	0.82 (±0.72)	1.00
	C	0.46b[c] (±0.65)	0.75a (±0.72)	0.002

[a]The absolute delta JAR scores were computed by subtracting each JAR ratings from the JAR (i.e., 3).

[b]Mean score (±standard deviation).

[c]Mean scores with different letters within the same row indicate a significant difference at $p < 0.05$.

TABLE 4 | The effects of gluten and label conditions on participants' selection ratios for each emotion attribute by brand in gluten-containing (C) and gluten-free (F) cookie samples.

Brand	Emotion attribute	Blind condition		Labeled condition		*p* value
		C	F	C	F	
A	Active/Alert	0.19	0.14	0.16	0.13	0.66
	Energetic/Excited	0.06	0.07	0.08	0.12	0.51
	Enthusiastic/Inspired	0.08	0.10	0.10	0.06	0.80
	Happy/Satisfied	0.42	0.37	0.36	0.42	0.69
	Secure/At ease	0.31	0.29	0.30	0.36	0.70
	Relaxed/Calm	0.31	0.42	0.39	0.41	0.32
	Passive/Quiet	0.25	0.25	0.31	0.30	0.62
	Dull/Board	0.17	0.27	0.27	0.23	0.23
	Blue/Uninspired	0.14	0.18	0.14	0.16	0.87
	Unhappy/Dissatisfied	0.35	0.29	0.29	0.19	0.12
	Tense/Bothered	0.13	0.11	0.14	0.12	0.89
	Jittery/Nervous	0.07	0.04	0.02	0.02	0.30
B	Active/Alert	0.19	0.21	0.21	0.20	0.96
	Energetic/Excited	0.11	0.14	0.18	0.16	0.40
	Enthusiastic/Inspired	0.11	0.14	0.18	0.20	0.18
	Happy/Satisfied	0.36	0.36	0.36	0.44	0.43
	Secure/At ease	0.27	0.23	0.30	0.31	0.47
	Relaxed/Calm	0.33	0.35	0.32	0.30	0.89
	Passive/Quiet	0.23	0.20	0.19	0.19	0.88
	Dull/Board	0.25	0.16	0.16	0.20	0.21
	Blue/Uninspired	0.13	0.16	0.17	0.10	0.37
	Unhappy/Dissatisfied	0.27	0.33	0.24	0.26	0.45
	Tense/Bothered	0.17	0.12	0.13	0.13	0.75
	Jittery/Nervous	0.02	0.01	0.01	0.01	0.88
C	Active/Alert	0.16	0.14	0.24	0.17	0.22
	Energetic/Excited	0.17	0.16	0.16	0.13	0.91
	Enthusiastic/Inspired	0.19	0.10	0.17	0.12	0.12
	Happy/Satisfied	0.48a[a]	0.29b	0.43ab	0.33ab	0.004
	Secure/At ease	0.36	0.26	0.33	0.29	0.35
	Relaxed/Calm	0.26	0.32	0.30	0.33	0.57
	Passive/Quiet	0.21	0.13	0.21	0.16	0.31
	Dull/Board	0.20	0.19	0.19	0.17	0.91
	Blue/Uninspired	0.11	0.18	0.16	0.12	0.46
	Unhappy/Dissatisfied	0.19b	0.39a	0.27ab	0.39a	<0.001
	Tense/Bothered	0.08b	0.20ab	0.13ab	0.23a	0.02
	Jittery/Nervous	0.02ab	0.07a	0.02ab	0.00b	0.03

[a]Selection ratios with different letters within the same row indicate a significant difference at $p < 0.05$.

(0.75 ± 0.72). In contrast, no difference in hardness JAR ratings were found between C and F cookies for Brands A and B. Additionally, there were no significant interactions between the gluten and brand conditions in the absolute delta JAR scores for chocolate flavor or sweetness (Table 3).

Regarding the label condition, no significant effects were observed on JAR ratings for chocolate flavor, sweetness, and hardness (for all, $p > 0.05$). In addition, no interactions were found between the label condition and either the brand or gluten condition in JAR ratings for these attributes (Table 2).

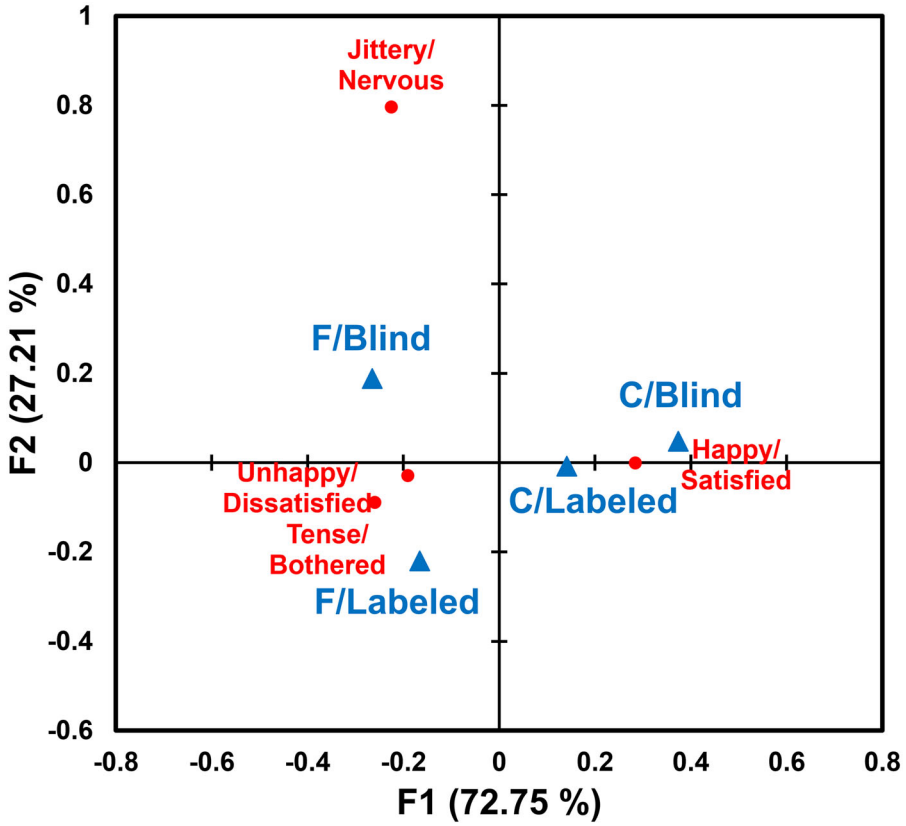

FIGURE 7 | A biplot of Correspondence Analysis (CA) based on the four emotion attributes from the Circumplex-inspired Emotion Questionnaire (CEQ) across Brand C's gluten-containing (C) and gluten-free (F) cookies under blind and labeled conditions.

3.3 | Emotional Responses to Cookies

Table 4 summarizes the results of Cochran's *Q*-tests, which analyzed differences in participants' selection ratios for individual emotion attributes on the basis of gluten-containing and gluten-free cookies under blind and labeled conditions for each brand. For Brands A and B, no significant differences were observed in the selection ratios of emotion attributes between gluten-containing and gluten-free cookies under blind and labeled conditions. In contrast, for Brand C, significant differences emerged between gluten-containing and gluten-free cookies under both blind and labeled conditions for four emotion attributes: "happy/satisfied," "unhappy/dissatisfied," "tense/bothered," and "jittery/nervous." Specifically, in the blind condition, gluten-containing cookies evoked "happy/satisfied" emotions more frequently and "unhappy/dissatisfied" emotions less frequently than gluten-free cookies. However, no such differences were observed in the labeled condition. Under the labeled condition, gluten-free cookies elicited "tense/bothered" emotions more frequently than gluten-containing cookies in the blind condition. Additionally, gluten-free cookies tasted under the blind condition evoked "jittery/nervous" emotions more frequently than when tasted under the labeled condition.

A biplot from the correspondence analysis revealed distinct differentiation patterns for Brand C's cookies (Figure 7). Gluten-containing (C) and gluten-free (F) cookies were separated along the *F*1 axis, which accounted for 72.75% of the total variation. The blind and labeled conditions were distinguished along the *F*2 axis, accounting for 27.21% of the total variation. The label effect (blind vs. labeled) was more pronounced for gluten-free cookies than for gluten-containing ones. Notably, gluten-free cookies were more strongly associated with "jittery/nervous" emotions in the blind condition compared to the labeled condition (Table 4 and Figure 7).

4 | Discussion

4.1 | Comparisons Between Gluten-Containing and Gluten-Free Cookies With Respect to Consumer Perception and Acceptance

This study compared consumer perception and acceptance between gluten-containing and gluten-free chocolate chip cookies across three brands, reflecting earlier research that gluten-free products often fall short in sensory and emotional responses, particularly for those available in the commercial marketplace (Capriles et al. 2023; Ervina 2023). Notably, this study involved three brands that produce both gluten-containing and gluten-containing cookie products, aiming to minimize significant variations across different manufacturers.

The impact of gluten condition on consumer perceptions and acceptance varied by brand (Tables 1 and 2). Interestingly, Brand A's gluten-containing cookies were favored for their appearance, whereas Brand B's gluten-free cookies received higher ratings of appearance liking. Brand C showed no significant difference

in appearance liking (Figure 3). These results align with prior research indicating that gluten-free cookies often receive lower appearance likings, largely due to differences in ingredients and processing methods, particularly in baked goods (Schober et al. 2003; Drabińska et al. 2016; Ervina 2023). However, our results also suggest that gluten-free cookies can achieve or exceed the appearance quality of gluten-containing cookies in certain cases, as observed with Brands B and C in this study.

Flavor liking results were mixed across brands. Brand C received higher ratings for its gluten-containing cookies, whereas Brands A and B showed no significant difference, suggesting that gluten condition did not markedly affect flavor liking. Furthermore, no significant differences were observed in the deviations from the expected chocolate flavor or sweetness in the JAR ratings between gluten-containing and gluten-free cookies (Tables 2 and 3).

The gluten condition significantly affected both the texture and overall liking of the cookies, aligning with previous studies showing higher likings of gluten-containing cookies than their gluten-free counterparts (Xu et al. 2020; Alencar et al. 2021; Capriles et al. 2023). Given the significant effect of gluten condition solely on texture liking, our findings suggest that food processors, product developers, and sensory professionals should prioritize enhancing the textural properties of gluten-free cookies over other sensory properties. An online survey using 205 Brazilian consumers with celiac disease also reported taste and texture as the most significant shortcomings of gluten-free food products available in the market (Alencar et al. 2021). Moreover, texture liking was brand-dependent, with Brands B and C showing a greater liking for gluten-containing cookies, particularly Brand C (Figure 5), which had notably smaller deviations in hardness JAR ratings for its gluten-containing options compared to its gluten-free counterparts (Table 3). This aligns with the result of the instrumental texture analysis: Brand C's gluten-containing cookies had significantly higher values for both maximum force and area under the force-distance curve, whereas no significant differences were observed between gluten conditions for the other two brands (Table S3). Previous studies on alternative ingredients and processing technologies have often highlighted the inferior sensory quality of many gluten-free foods, including cookies (Xu et al. 2020; Capriles et al. 2023; Ervina 2023). However, these studies have also identified certain gluten-free options that performed comparably to their gluten-containing counterparts in experimental settings (Ervina 2023). For example, Ervina (2023) reported that gluten-free cookies made from sorghum, peanut, mung bean, or sweet potatoes generally had lower sensory qualities than those made with wheat flour. In contrast, cookies made from taro flour exhibited sensory attributes comparable to wheat-based cookies, suggesting that the sensory quality of gluten-free foods can, in some cases, rival that of traditional formulations.

4.2 | Comparisons Between Gluten-Containing and Gluten-Free Cookies With Respect to Evoked Emotions

Our study found that emotional responses to gluten-containing and gluten-free cookies varied by brand. Although the gluten condition had a minimal impact on emotional responses, it did influence certain valence-related emotions ("happy/satisfied" and "unhappy/dissatisfied"). Specifically, Brands A and B showed no significant differences in emotional responses between their gluten-containing and gluten-free cookies, whereas Brand C exhibited a clear distinction. For example, gluten-containing cookies in Brand C evoked more positive emotions such as "happy/satisfied," whereas gluten-free options elicited more negative emotions such as "unhappy/dissatisfied." These findings are in agreement with sensory data indicating that participants liked the flavor, texture, and overall aspects of Brand C's gluten-containing cookies more than their gluten-free counterparts. These results support previous research suggesting a strong correlation between hedonic impressions and valence-related emotions (Wardy et al. 2018; Samant and Seo 2019; Spinelli and Jaeger 2019; Seo et al. 2023). Notably, in Brand C, the impact of gluten condition on emotional responses was more pronounced than that of label condition, suggesting that sensory acceptance plays a greater role in eliciting emotions than gluten-free claims.

4.3 | The Effects of Gluten-Free Labeling on Sensory and Emotional Responses to Cookies

Label claims such as "gluten-free," "free of gluten," "no gluten," and "without gluten" are critical for consumers who need to identify products containing less than 20 ppm of gluten for their health (e.g., those with celiac disease) (U.S. Food and Drug Administration 2023). The cookie market is trending toward choices labeled "healthier" or "gluten-free," driven by increasing health consciousness (Bashir et al. 2020). Previous research suggests a generally positive perception of gluten-free products even among those without celiac disease (Bashir et al. 2020; Cantrell et al. 2020). Consequently, we expected that gluten-free labeling could enhance consumer acceptance of chocolate chip cookies. Notably, gluten-free labels positively influenced consumer liking of the appearance of gluten-free cookies, resulting in no significant difference between gluten-containing and gluten-free cookies in the labeled condition. However, contrary to our expectations, the effect of gluten-free claims on hedonic ratings of flavor, texture, and overall impression across the three brands was minimal. These findings are consistent with those of Prada et al. (2019), who found that gluten-free labels did not affect the "expected" taste of various food products in an online survey. Our results extend this insight by demonstrating that gluten-free labels also have little to no effect on an actual "tasted" perception and acceptance of real food samples. Similar findings have been reported in studies examining sustainability-related labels; for example, labels such as "USDA Organic" showed no significant impact on consumer perceptions and acceptance of products such as chicken breast meat (Samant and Seo 2016a) and brewed coffee (Grunert et al. 2024).

The absence of a notable effect from gluten-free labeling on sensory ratings may be attributed to a mismatch between the positive impression associated with gluten-free claims and the actual sensory quality of the products, resulting in no assimilation effect (Sherif et al. 1958; Seo et al. 2008). Furthermore, the generally positive impression of gluten-free claims might be counteracted by a prevailing belief that gluten-free foods are inferior in flavor and texture compared to their gluten-containing counterparts. This conflict between health awareness and expectations of

sensory quality may help explain the minimal impact observed in this study. Future research should be conducted to test these assumptions.

Although our study did not directly assess participants' knowledge or understanding of gluten-free labels, previous research suggests that consumer awareness of such claims is generally low (Prada et al. 2019). Prior research has also shown that comprehension of label claims significantly affects consumer perception and acceptance of food products (Samant and Seo 2016a, 2016b). For example, Samant and Seo (2016a) found that sustainability label claims positively influenced consumer perception and acceptance only among participants who received educational sessions about the labels, in contrast to those in the control group who had not. This enhanced understanding also led to increased visual attention to labels and more favorable purchasing behaviors (Samant and Seo 2016b). Therefore, although our study did not measure label comprehension directly, the limited understanding of gluten-free claims reported in previous studies (Prada et al. 2019) may have contributed to the minimal effects observed. Future research that assesses consumers' understanding of gluten-free labeling could offer further insight into these findings.

Interestingly, although gluten-free labels did not significantly alter emotional responses to cookies in Brands A and B, they did have a positive effect on responses to gluten-free cookies in Brand C. Specifically, under labeled conditions, the unpleasant activation-related emotion "jittery/nervous" (Jaeger et al. 2019), which was evoked by gluten-free cookies in the blind condition, was reduced. This finding suggests that labeling may help mitigate negative emotional responses under certain conditions (e.g., Brand C), possibly due to the positive associations consumers have with gluten-free claims (Xhakollari et al. 2019; Cantrell et al. 2020). Given that emotional responses to food products play an important role in shaping consumer purchasing behavior (Samant and Seo 2020; Gurdian et al. 2022; Baranda et al. 2024), gluten-free labeling may act as a marketing tool to boost sales of gluten-free cookie products, particularly those requiring improvement in sensory quality.

As our study included gluten-containing cookies, individuals with celiac disease were excluded from participation. Although some studies have reported no significant differences in the sensory perception of gluten-free foods between individuals with and without celiac disease (Laureati et al. 2012), others have found notable differences (Giménez et al. 2015). It would therefore be valuable to investigate whether gluten-free labeling differentially affects sensory and emotional responses among individuals with celiac disease compared to those without the condition. Given their heightened awareness and deeper understanding of gluten-free claims due to medical necessity (Alencar et al. 2021), further research could examine whether this group exhibits greater sensitivity to the influence of gluten-free labeling on their perception and emotional responses to food products.

5 | Conclusions

This study examined how commercially available gluten-containing and gluten-free cookie products differ in consumer perception, acceptance, and emotional responses under both blind and labeled testing conditions. The findings indicate that individuals without celiac disease liked the texture and overall aspects of gluten-containing cookies more than their gluten-free counterparts within the same brand. Although the overall impact of gluten condition on emotional responses was minimal, brand-specific variations were observed. Notably, gluten-free labeling increased the appearance liking of gluten-free cookies but had limited influence on consumer perception and overall acceptance when comparing gluten-containing and gluten-free options. The effect of labeling on emotional responses also varied by brand. In conclusion, this comparative analysis across three cookie brands suggests that, whereas some gluten-free products are competitive in terms of consumer acceptance and emotional appeal, opportunities remain to enhance their sensory quality, especially textural properties.

Author Contributions

Eniola Ola: conceptualization, methodology, investigation, formal analysis, visualization, writing–original draft. **Han-Seok Seo**: conceptualization, methodology, formal analysis, supervision, resources, visualization, funding acquisition, writing–original draft, writing–review and editing.

Acknowledgments

The authors thank Nguyen Ngo and Natalia Calderon for their assistance in sensory evaluation.

Conflicts of Interest

The authors declare no conflicts of interest.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.