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Judging Cake by Its Cover: Sighted and Blind Evaluations of Gluten-Free Versus Conventional Cake

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ABSTRACT

There are preconceived notions about the sensory properties of gluten-free products that lead to their perceived inferiority to conventional products. But few studies have investigated how these perceptions are affected by visual cues and prior knowledge, rather than the sensory characteristics of the products themselves. The present study is designed to examine the effects of visual cues and preconceived notions on consumers' perceptions and preferences towards gluten-free and conventional cakes. The study is based on the multisensory perception of food and uses a within-subjects experimental design with 39 participants from one organisation. Descriptive statistics, Chi-square test and McNemar's test are used for analysing quantitative data, and thematic analysis for analysing qualitative responses. The results show that there were statistically significant differences between the participants' scores for texture and density, in favour of the gluten-free cake in the blind tasting. The shift between sighted preferences and blind texture judgements is consistent with an influence of visual cues on initial evaluations of products, although the fixed evaluation order and the confounding of cake type with plate colour mean that it cannot be attributed to visual information alone. Qualitative results indicate that participants' prior expectations were most often characterised by unfamiliarity, but these expectations were not statistically associated with blind preferences. The results suggest the potential role of multisensory perception in consumer assessments and emphasise the need to increase consumer awareness in addition to the development of gluten-free products with better sensory properties.

Keywords: *gluten-free products, visual cues, blind taste test, multisensory perception, consumer perception, preconceived beliefs*

INTRODUCTION

Consumer Perception of Food and Multisensory Flavour

Foraging and feeding are considered some of the most basic daily activities for which the human brain has evolved. This is supported by the great British biologist Young (1968, p. 21), who stated, “No animal can live without food.” In addition, Laan et al. (2011) found that the brain activity changes were most pronounced when hungry people were shown appetizing pictures of food. From this evidence, it could be suggested that the study of the human perception of food and beverages can give us some clues as to how

the human brain works. Despite its importance, flavour perception has received relatively little attention from psychologists and cognitive neuroscientists, in part because of the difficulty of controlling the delivery of the stimuli, the speed of adaptation of participants to the experimental stimuli and the longstanding view that taste and smell are "lower" and "common" sensations (Spence, 2015).

Food perception is inherently multisensory. The perception of food is mediated by receptors in the visual, olfactory, gustatory, somatosensory, and auditory systems, which interact to generate a holistic food perception (Foster et al., 2011; Lutomia et al., 2019; Xiong et al., 2025). In the past, scientists mainly studied the senses of taste and smell, and less attention was paid to the sense of touch, sight, and hearing. In contrast, recent studies have shown that chemical senses (taste and smell) and non-chemical senses (sound, colour and texture) are highly interrelated, and the area of food science has been interested in studying the food sensory processes in a more integrated way (Herrero and McCrea, 2023; Yu et al., 2017; Zepeda and Balaine, 2017).

Blind Tasting and the Role of Visual Cues in Food Perception

Moir (1936) was one of the first to show that changing the colour of food could affect individuals' perception of taste and flavour. This early discovery has led to over 150 studies examining the influence of visual clues on flavour perception. Most of this research has demonstrated that changing the hue and/or intensity of the colour of food and beverages can affect the perceived identity and perceived intensity of their flavour (Spence, 2015). However, this type of crossmodal effect has not been found in every study. Such discrepancies could be due to variations in taste and flavour preferences that people have for the same food colour (Spence et al., 2010).

People tend to look at food or drinks before eating them, which means that the visual information influences their expectations of the sensory experience that is to come. The expectations are then either validated or refuted when the food and/or beverage is tasted and evaluated. If the taste or flavour is similar to what they expected, they tend to consider the product to be as they expected. However, if the expected taste or flavour is very different from the actual taste or flavour, then people are more likely to have a disconfirmation of expectations (Spence & Piqueras-Fiszman, 2014). How much difference it takes to get this disconfirmation response is an important question to explore (Shankar et al., 2010).

Gluten, Celiac Disease, and Gluten-free Diets

Gluten is a protein found in wheat, barley, and rye, and acts as a glue, contributing to the unique flexibility of dough (Lebwohl et al., 2017). Celiac Disease, the most prevalent type of gluten sensitivity, is suffered by 1% of people worldwide and is an autoimmune response in the small intestine, triggered by gluten consumption. If not paid heed to, this may result in potential problems such as inflammation (Lebwohl et al., 2018). Non-celiac gluten sensitivity (NCGS) or non-celiac wheat sensitivity (NCWS) is a clinical condition with extra-intestinal and intestinal symptoms that are responsive to a gluten-free diet.

Gluten-free does not mean gluten-free, but rather means less than 20 ppm (parts per million) gluten, according to approved scientific methods (Food & Drug Administration, 2023). There is no treatment for celiac disease at the moment, just a gluten-free diet for life. Eliminating foods that contain wheat, barley, and rye enhances quality of life and even reduces mortality by the abatement of symptoms. There are, however, some difficulties in maintaining a gluten-free diet, such as the possibility of cross-contamination with gluten-containing foods, the high cost and scarcity of gluten-free products, and social and cultural issues related to food (Niewinski, 2008; Tack et al., 2010).

Sensory Characteristics and Challenges of Gluten-Free Products

Gluten-free products are becoming more popular due to the growing incidence of celiac disease (Bogue & Sorenson, 2008). However, many gluten-free products still have poor nutritional and technological properties when compared to their conventional wheat counterparts (Arendt et al., 2008; Mariotti et al., 2009). In addition, following a gluten-free diet can be difficult because of cross-contamination with gluten-containing foods, the high price and low availability of gluten-free foods, and the social and cultural aspects of food. Furthermore, the lack of acceptability and palatability of gluten-free products is a treatment barrier. (Niewinski, 2008; Tack et al., 2010).

Another major problem is the lack of diversity of gluten-free food products, leading to a lack of food choice and a lack of a diversified diet (Sverker et al., 2005). In addition, some studies have found that people with celiac disease are not satisfied with the quality, quantity, or price of gluten-free products, and that this is one of the most frequent problems experienced by people with celiac disease in various regions of the world (Araújo & Araújo, 2011; Bravo & Muñoz, 2011; Lamontagne et al., 2001; Zarkadas et al., 2006). The sensory properties of food products are also important in influencing consumer preferences (Guerrero et al., 2000).

Thus, while the use of alternative functional ingredients in the formulation of gluten-free products can improve the nutritional and technological properties, it is also essential that these products have desirable sensory properties, such as texture, taste, odour, and appearance. These properties are important for the acceptance of gluten-free foods by people with celiac disease (Pagliarini et al., 2010). In this context, food choice and intake are a complex process that is affected by marketing, psychological and sensory factors. Of these, the sensory attributes of a product can be important in influencing consumers' decisions (Guerrero et al., 2000).

Knowledge, Familiarity and Preconceived Beliefs about Gluten-Free Foods

The knowledge and awareness of consumers play a crucial role in shaping their perceptions of gluten-free products (Magano et al., 2022). Likewise, Paganizza et al. (2019) found that there was a high degree of ignorance and lack of knowledge among gluten-free consumers. Lack of knowledge is also found to play a role in the perception of better health of gluten-free products, although they do not have nutritional advantages over traditional products (Arslain et al., 2021). Similarly, Prada et al. (2019) reported that

image cues had an impact on consumers' perceptions of gluten-free products and highlighted the importance of providing consumers with accurate nutritional information to encourage informed food choices and alleviate common health misconceptions.

Furthermore, consumers' gluten-free product knowledge affects their buying choices. However, due to a lack of awareness, the participants trusted the verbal gluten-free claims on the packaging more than the non-verbal gluten-free symbols, being able to identify only three out of eight gluten-free labels (Sielicka-Rozynska et al., 2021). Likewise, Taşkin and Savlak (2021) found that there was a lack of knowledge about gluten-free products that did not depend on education level. Rather, participants found it hard to grasp the meaning of celiac disease and the 20 ppm limit for a product to be gluten-free. The results indicate that there is a need for increasing consumer knowledge about gluten-free products, both in terms of awareness and labelling, which will help them make informed food choices, follow a gluten-free diet more closely, and minimise the risk of accidental consumption of gluten (Myhrstad et al., 2021).

METHODOLOGY

Aims and Objectives

The present study aims to explore the perception and preference of gluten-free food products in comparison with conventional food products and the effect of visual presentation, sensory experience, and product awareness on food preference.

The aims of the study are:

- To compare the participants' visual preference for a gluten-free chocolate cake and a conventional chocolate cake.
- To compare sensory preferences of participants for both products after tasting them blindfolded.
- To explore gluten-free food taste, texture, mouthfeel, and acceptability perceptions.
- To determine if gluten-free information affects consumer preferences.
- To investigate the knowledge and experience of participants with gluten-free foods.

Hypotheses

H1: Under blind tasting conditions, participants will rate the gluten-free cake more favourably than the conventional cake on key sensory attributes, particularly texture and density.

H2: There will be a significant within-participant shift between participants' sighted plate preference and their blind texture judgement, such that participants who initially preferred the conventional cake under sighted conditions will be more likely to prefer the gluten-free cake under blind tasting conditions than vice versa.

Research Questions

RQ1: Do participants' initial visual preference between the gluten-free and conventional cake differ from chance?

RQ2: Does the removal of visual cues alter participants' reported likelihood of regularly consuming the gluten-free product?

RQ3: Do participants' prior expectations of gluten-free food (e.g., positive, negative, or unfamiliar) predict the strength or direction of their blind sensory preference?

Procedure

The study was conducted with 39 participants who were selected using convenience sampling in one organisation. Employees who were available and willing to participate were approached one-on-one and invited to participate in the study voluntarily. Participants were from different levels of gluten-free food knowledge, such as those who had heard of and eaten gluten-free foods, and those who had not. No participant was excluded due to previous knowledge of gluten-free foods. Demographic data were available for a subset of the sample (n = 21), which included 10 females and 11 males, with a mean age of 25.24 years (SD = 2.95) and a range of 22–34 years, with providing name, age and gender being optional for confidentiality.

The number of participants was set at 40. The final sample, however, was 39 participants, as the sampling was done through convenience sampling, voluntary participation and availability of the participants within the organisation. There was no priori power analysis to establish the desired sample size. Thus, while the final sample was close to the desired sample size, the study might have lacked the statistical power to detect small effects, especially with the number of significance tests performed.

The study employed an experimental research design with each participant tasting and evaluating both the gluten-free and conventional cake under the same conditions, although cake type was fixed to plate colour and the order of evaluation was not counterbalanced.

Participants were first given a consent form upon their arrival. Participants were asked to report any previously known food allergies, dietary restrictions or food sensitivities to the food products used in the study on the form. This information was gathered to ensure that each person in the study was safe and suitable to participate. Participants were asked to check the information they had read and understood and to accurately state any relevant allergies or dietary requirements in a short demographic section, which included name, age, and gender. The experiment was conducted with the participants for whom the products were deemed safe to consume.

Two identical pieces of chocolate cake were then placed side by side on two differently coloured plates:

- Plate A (White Plate): Gluten-Free Chocolate Cake
- Plate B (Black Plate): Conventional Chocolate Cake

Cake type was therefore fixed to plate colour, and the position of the cakes (e.g., left versus right) and the order of evaluation (sighted before blind) were likewise not counterbalanced or randomised. These design features are discussed in the Discussion and Limitations sections.

The participants were first asked to visually inspect both cakes and indicate which product they would prefer if they were allowed to taste it. They were observed, and their visual preference was recorded. The sighted evaluation was intentionally carried out before the blind tasting to allow the initial preference to be based on the visual appearance of the products, without tasting, smell, or direct oral sensory experience. The participants were then blindfolded to remove any visual bias. Blindfolded, they were asked to taste both samples of cake.

The chocolate cakes were made with the same ingredients: vegetable oil, sugar, yogurt, milk, cocoa powder, baking powder and baking soda. The only difference between the two products was the flour used. The traditional cake was made with wheat flour, while the gluten-free cake was made with gluten-free oat flour and almond flour. The amount of each ingredient, the baking method, the portion size, and the serving conditions were all the same, except for the flour, so that any differences in perception that were observed could primarily be attributed to the difference in flour.

Participants tasted both cake samples and were then asked to take their blindfolds off and were given a Post-Tasting Evaluation Questionnaire. The questionnaire contained eight questions to compare the two products on different sensory attributes and to find out the perception of gluten-free food by the participants.

The participants judged the products on the following characteristics: texture, chewiness, mouthfeel, visual presentation, density, ease of eating, and their likelihood of eating the preferred product regularly (Plate A, Plate B, or No Difference/No Preference, as appropriate). Participants were also asked to explain their overall impression of the taste of gluten-free food before being told what it was.
The questionnaire was filled in before the participants knew which of the products was gluten-free, so that their answers only referred to their sensory experiences and perceptions, but not to the identity of the products.

After participants had finished the questionnaire, they were fully debriefed about the purpose of the study. Participants were told that the cake served on the white plate (Plate A) was the gluten-free chocolate cake and the cake served on the black plate (Plate B) was the conventional chocolate cake. They were also informed about the aims of the experiment and given information about gluten-free foods and the significance of gluten-free foods to people with celiac disease and other gluten-related disorders. This debriefing was the end of the experimental procedure.

Instrumentation

Questionnaire: The data for the study were obtained by a structured post-tasting questionnaire for all the participants following the sensory evaluation. The questionnaire consisted of eight questions to evaluate the preference and perception of the two cake samples with respect to different sensory attributes such as texture, chewiness, mouthfeel, visual presentation, density, ease of eating, and likelihood of regular consumption. It also contained a question asking about participants' general perception of gluten-free food before learning the identity of the products.

Ethical Considerations

Ethical issues were followed throughout the study. All participants signed a consent form and provided any known food allergies, food restrictions or food sensitivities before participation to ensure that participation was safe and appropriate. The study was voluntary, and participants were told that they could withdraw from the study and request the withdrawal of their data at any point during the study, including following the debrief, without penalty. Because this study was an experimental sensory evaluation in which the names of the products were withheld for a period of time, all participants were debriefed at the end of the experiment. They were told about the purpose of the study, what the gluten-free and conventional products were and the research goals during the debriefing. There was no monetary incentive, compensation or reward for participation.

Analysis Employed

Quantitative analyses were conducted using IBM SPSS Statistics Version 25 and proceeded in three steps. First, for each of the eight categorical items, chi-square goodness-of-fit tests were used to determine whether the distribution of Plate A versus Plate B responses departed from an even 50/50 split; neutral responses (“no difference”/“no preference”) were excluded from these tests, consistent with standard treatment of ties in forced-choice preference data. Effect sizes are reported as Cohen’s g (the absolute deviation of the observed proportion from .50) alongside 95% Wilson confidence intervals for the proportion favouring Plate A. Second, McNemar’s test (McNemar, 1947), which is appropriate for paired categorical data from the same respondents, was used to compare each participant’s sighted plate preference to their own blind judgments (texture and likelihood of regular consumption), directly testing for a within-person shift between sighted and blind evaluation. Third, the open-ended prior-expectation item was analyzed using Braun and Clarke’s (2006) six-phase reflexive thematic analysis: (1) familiarization with the full set of responses, (2) generation of initial codes capturing the content of each response, (3) collating codes into candidate themes, (4) reviewing themes against the full data set for coherence and distinctiveness, (5) defining and naming each theme, and (6) producing the thematic report presented below. Coding was conducted by a single analyst at the semantic (explicit content) level; as such, the resulting themes should be understood as one coherent, defensible reading of the data set rather than an exhaustive or uniquely correct classification. To integrate the qualitative and quantitative strands,

a continuous blind-preference index was computed for each participant as the mean of +1 (Plate A chosen) and −1 (Plate B chosen) codes across the six blind sensory/evaluative items, with "no difference" responses excluded; this index ranges from −1 (consistent preference for the regular product) to +1 (consistent preference for the gluten-free product). A Kruskal-Wallis test was used to examine whether this index differed across the thematic categories identified in the qualitative analysis.

RESULTS

Quantitative Analysis

Table 1

Frequency Distribution and Chi-Square Tests for Sighted and Blind Preference Measures

Measure	Plate A n	Plate B n	Neutral n	% Plate A [95% CI]	$\chi^2(1)$	p	g
Sighted plate preference	17	22	0	43.6% [29.3, 59.0]	0.64	.423	0.06
Texture (blind)	26	9	4	74.3% [57.9, 85.8]	8.26	.004*	0.24
Chewiness (blind)	17	13	9	56.7% [39.2, 72.6]	0.53	.465	0.07
Mouthfeel (blind)	21	13	5	61.8% [45.0, 76.1]	1.88	.170	0.12
Attractiveness of presentation	18	18	3	50.0% [34.5, 65.5]	0.00	1.000	0.00
Density (blind)	23	9	7	71.9% [54.6, 84.4]	6.12	.013*	0.22
Ease of eating (blind)	17	13	9	56.7% [39.2, 72.6]	0.53	.465	0.07
Likelihood of regular consumption	20	11	8	64.5% [46.9, 78.9]	2.61	.106	0.14

Note. Neutral responses ("no difference" or "no preference") were excluded from chi-square tests and from the percentage calculations. g = Cohen's g (absolute deviation of the observed proportion from .50). CI = confidence interval.

* $p < .05$.

Table 1 presents the frequency distribution of Plate A (gluten-free, white plate) and Plate B (regular, black plate) responses across all eight measures, along with chi-square goodness-of-fit tests comparing each distribution to an even 50/50 split. Sighted plate preference did not differ significantly from chance, $\chi^2(1, N = 39) = 0.64$, $p = .423$, and if anything trended toward Plate B (56.4%) over Plate A (43.6%). Ratings of the attractiveness of presentation were exactly evenly split (50.0% vs. 50.0%), consistent with this item reflecting a purely visual, sighted judgment unaffected by taste.

In marked contrast to the sighted-preference results, blind sensory ratings favoured the gluten-free product (Plate A) on every one of the six blind measures. This preference reached statistical significance for texture, with 74.3% of participants rating Plate A more favourably, $\chi^2(1, N = 35) = 8.26$, $p = .004$, $g = 0.24$, and for density, with 71.9% favouring Plate A, $\chi^2(1, N = 32) = 6.12$, $p = .013$, $g = 0.22$. Mouthfeel (61.8% Plate A), likelihood of regular consumption (64.5% Plate A), chewiness (56.7% Plate A), and ease of eating (56.7% Plate A) all trended in the same direction but did not reach conventional significance thresholds, though the consistency of direction across all six blind measures is itself notable.

Table 2

McNemar Tests Comparing Sighted Plate Preference to Blind Judgments

Comparison	Concordant n	Sighted A → Blind B	Sighted B → Blind A	p (exact)
Sighted preference vs. blind texture judgment	19	3	13	.021*
Sighted preference vs. likelihood of regular consumption	14	5	12	.143

Note. Values in the discordant-pair columns represent the number of participants whose sighted preference and blind judgment disagreed, split by direction of disagreement. Concordant pairs (sighted and blind judgment in agreement) are shown for reference but are not used in the McNemar test statistic.
* $p < .05$.

To test directly whether this sighted-to-blind divergence reflected a genuine within-person reversal rather than two independent distributions that happened to differ, McNemar's test was used to compare each participant's sighted plate preference to their own blind judgments (Table 2). The comparison between sighted preference and blind texture judgment was significant: of the 16 participants whose sighted and blind judgments were discordant, 13 preferred Plate B by sight but rated Plate A better on texture once blindfolded, compared to only 3 who showed the reverse pattern, $p = .021$ (exact). The comparison between sighted preference and likelihood of regular consumption showed the same directional pattern (12 vs. 5 discordant pairs favouring a shift toward Plate A) but did not reach significance, $p = .143$.

Qualitative Analysis: Thematic Analysis of Prior Expectations

Table 3

Themes Identified in Participants' Prior Expectations of Gluten-Free Food Taste

Theme	Definition	n	%	Illustrative response(s)
Unfamiliarity / lack of prior exposure	Responses stating the participant had no direct experience with gluten-free food and therefore could not characterize its taste.	12	30.8%	"I don't think I have had anything gluten-free before"; "I have never had gluten-free food"
Positive or neutral sensory anticipation	Responses describing gluten-free food using favorable or non-negative sensory language, or as broadly comparable to regular food.	10	25.6%	"Softer, chewy, a bit sweeter"; "Very similar to the usual ones"
Negative sensory anticipation	Responses describing gluten-free food using unfavorable sensory language (e.g., dry, bland, crumbly) or expressing reluctance to consume it.	9	23.1%	"Oily, dry or too crumbly (in a bad way)"; "Eh. Blah. Won't willingly eat gluten-free food"
Conditional / quality-dependent evaluation	Responses framing the taste of gluten-free food as contingent on preparation quality, or explicitly contrasting expectation with a prior tasting experience.	3	7.7%	"If made well, gluten-free food can be healthier and tasty as well"; "Not as good as original is but after tasting, they were pretty good"
Disengagement / indifference	Responses indicating the participant had not formed, or did not hold, any particular view about gluten-free food's taste.	3	7.7%	"No specific thought"; "Honestly, wouldn't really pay attention to the difference in taste"

Non-response	Item left blank or answered with a placeholder character.	2	5.1%	(no response provided)

Note. N = 39. Percentages are rounded and sum to 100%.

Responses to the open-ended item ("Before being informed about the products, how would you describe the taste of gluten-free food in general?") were analyzed following Braun and Clarke's (2006) six-phase reflexive thematic analysis procedure. Familiarization with the full set of 39 responses and generation of initial codes produced a set of candidate codes capturing unfamiliarity, valenced sensory description, conditionality, and disengagement.

Unfamiliarity or Lack of Prior Exposure

The most prevalent theme, accounting for just under one third of responses (30.8%), reflected an explicit lack of prior experience with gluten-free food. Participants coded under this theme did not offer a sensory description at all, instead reporting that they had "never tried gluten-free food" or "did not think" they had encountered it before. A subset of these responses combined unfamiliarity with openness to the experience (e.g., "Have no idea how gluten-free food would taste, but love to experiment"), suggesting that unfamiliarity did not uniformly imply reluctance.

Positive or Neutral Sensory Anticipation

The second most common theme (25.6%) comprised responses that characterized gluten-free food using favourable or non-negative sensory language, such as "softer, chewy, a bit sweeter," "feels fresh," "airy," or "spongy." Several responses in this theme explicitly framed gluten-free food as comparable to its regular counterpart ("very similar to the usual ones"), while one participant went further, stating a clear existing preference for gluten-free food based on a perceived denser texture.

Negative Sensory Anticipation

Approximately one quarter of responses (23.1%) described gluten-free food in unfavourable sensory terms, most commonly as dry, bland, crumbly, oily, or bitter, or expressed explicit reluctance to consume it ("Eh. Blah. Won't willingly eat gluten-free food"). One response in this theme linked a negative sensory expectation to a specific prior experience with gluten-free bread that had discouraged further trial, illustrating how a single negative exposure may generalise into a broader avoidance expectation.

Conditional or Quality-Dependent Evaluation

A smaller theme (7.7%) captured responses that framed the taste of gluten-free food as contingent on preparation quality rather than as an inherent property of gluten-free food itself ("If made well, gluten-free food can be healthier and tasty as well"). Notably, this theme also included the only response

that explicitly described a revision of expectation following direct tasting experience ("Not as good as original is but after tasting, they were pretty good"), reflecting the sighted-to-blind reversal observed in the quantitative results.

Disengagement or Indifference

A further small theme (7.7%) reflected an absence of any particular view, with participants reporting "no specific thought" or stating they would not attend to differences in taste at all. This theme is conceptually distinct from unfamiliarity: participants coded here did not necessarily lack exposure to gluten-free food, but reported not holding, or not attending to, an expectation about it.

Non-response

Two responses (5.1%) consisted only of a placeholder character and were coded as non-responses. These were retained in the theme count for transparency but excluded from illustrative quotation.

Table 4

Mean Blind-Preference Index by Thematic Category

Theme	n	M blind-preference index	SD
Conditional / quality-dependent	3	0.76	0.21
Non-response	2	0.67	0.00
Positive or neutral anticipation	10	0.29	0.73
Negative sensory anticipation	8	0.28	0.70
Unfamiliarity / lack of prior exposure	12	0.23	0.60
Disengagement / indifference	3	−0.09	0.67

Note. The blind-preference index is the mean of +1 (Plate A/gluten-free chosen) and −1 (Plate B/regular chosen) codes across the six blind sensory/evaluative measures, with "no difference" responses excluded; positive values indicate a lean toward the gluten-free product. Kruskal–Wallis $H(4) = 2.71$, $p = .607$ (non-response category excluded, $n = 2$).

To examine whether participants' prior expectations were systematically associated with the strength or direction of their blind taste preference, the mean blind-preference index (ranging from −1, consistent preference for the regular product, to +1, consistent preference for the gluten-free product) was compared across the six thematic categories (Table 4). Descriptively, every theme except disengagement/indifference showed a mean index in the positive range, indicating a lean towards the gluten-free product regardless of participants' stated prior expectations, including among participants whose open-ended responses expressed clearly negative anticipations (M = 0.28) or explicit unfamiliarity (M = 0.23). A Kruskal–Wallis test comparing the blind-preference index across the five thematic categories with sufficient data (excluding non-response, n = 2) was not statistically significant, $H(4) = 2.71$, $p = .607$, indicating no reliable evidence that participants' prior expectations, as captured qualitatively, predicted the strength of their blind sensory preference. The descriptive differences in theme means in Table 4 should therefore not be interpreted as evidence of a statistically reliable relationship between prior expectations and blind preference, particularly as the theme groups were small and unequal (n = 3 to 12).

Taken together, the quantitative and qualitative strands are descriptively consistent with the interpretation: participants' blind sensory preference for the gluten-free product was not confined to a subgroup who already expected to prefer it. The preference for the gluten-free cake's texture and density was observed across participants who described gluten-free food positively, negatively, with uncertainty, or not at all before tasting.

DISCUSSION

There was no significant difference between the initial sighted plate preference of the gluten-free and conventional cakes, as shown in Table 1. Likewise, there were no statistically significant differences between the two products in their preference for chewiness, mouthfeel, visual presentation, ease of eating, or likelihood of regular consumption, indicating that these two products were perceived similarly in these sensory attributes. But differences were noted in texture and density that were statistically significant. 74.3% of participants liked the gluten-free cake more regarding its texture, and 71.9% liked the gluten-free cake more regarding its density.

The results suggest that participants had similar perceptions of both cakes, but the gluten-free cake was significantly more positively perceived in terms of texture and density under blind tasting conditions. This result is different from what Manzatti (2021) found in the studies, where the two most common areas where the purchased gluten-free products were lacking were taste and texture. Similarly, a study conducted by Alencar et al. (2021) on gluten-free bread found a number of sensory parameters that should be taken into account during the creation of new gluten-free products, highlighting the need to improve their texture and taste by making them softer and moister. Similarly, Potter et al. (2014), who also studied gluten-free bread, found that the expectations of consumers were never met and were always disappointing.

The conflicting results could be due to the gluten-free product used in this study. The gluten-free cake used in this experiment was made with a mixture of oat flour and almond flour, and all other ingredients, amounts, baking methods, serving sizes, and conditions were identical to those used in the other cake recipes discussed in previous research. This recipe might have given a more desirable texture, making the gluten-free cake more palatable to participants and thus more positively rated. The observed results, however, might be due to the order of evaluation (fixed: sighted then blind), the limited number of samples, or the recipe and baking procedure.

Table 2 shows that there was a statistically significant difference between the sighted preference and blind texture judgement of the participants, suggesting that the sighted preference changed after the blind texture judgement of the cakes. In particular, 13 of the 16 participants preferred to switch from Plate B to Plate A during the blind texture evaluation, while only 3 of the 16 participants preferred to switch from Plate A to Plate B during the blind texture evaluation.

These findings should be interpreted in light of two design confounds. First, the gluten-free cake was always served on the white plate and the conventional cake on the black plate, so cake type was confounded with plate colour, contrast, and presentation. The sighted preference may therefore reflect these presentation effects rather than the appearance of the cakes alone, and the same applies to the position of the cakes (e.g., left versus right), which was not counterbalanced. Second, all participants completed the sighted evaluation before the blind tasting, so the shift from sighted to blind judgements may reflect order effects, learning, or repeated exposure to the products rather than only the removal of visual cues. The observed shift is therefore not attributed solely to visual information, and plate colour, cake position, and evaluation order should be counterbalanced or randomised in future research.

This suggests that the gluten-free cake was more favourably rated in terms of texture when the participants were blind-tasting, although this shift cannot be attributed solely to the removal of visual cues (see the limitations noted above). This result aligns with Magano et al. (2022), who found that consumers' lack of knowledge of gluten-free products contributes to their attitudes towards gluten-free products. In a similar study, Sielicka-Rozynska et al. (2021) examined the impact of consumers' gluten-free label literacy on purchasing gluten-free foods and found that consumers were more likely to trust verbal gluten-free claims on the package than non-verbal gluten-free symbols. In addition, Taşkin and Savlak (2021) found that there was a lack of knowledge that was not related to the level of education. Rather, it pointed out that the participants found it hard to understand the meaning of the word ‘celiac' and the criteria for a gluten-free product, such as the gluten-free threshold of 20 ppm, which may lead to preconceived ideas about the gluten-free product.

However, when the same participants were compared with their regular consumption, no statistically significant difference was seen between the participants' sighted preference and their likelihood of regular consumption, although 12 participants changed their preference from Plate B to Plate A and 5 participants changed their preference from Plate A to Plate B. These results indicate that the blind tasting did not

significantly affect the participants' intention to regularly consume the gluten-free product, but did affect their perception of the texture.

One possible explanation for this finding is that the participants could more objectively assess the products based on their sensory attributes, but the likelihood that they would eat the gluten-free product on a regular basis was likely still affected by their current eating habits, familiarity with the conventional products, and preconceived notions about gluten-free foods. That is, consumers seemed to be willing to accept the positive sensory characteristics of the gluten-free cake in the blind tasting, but this positive sensory experience was not enough to alter their long-term preferences for the gluten-free cake. This implies that other factors besides sensory characteristics, including previous experience, familiarity and perceptions of gluten-free products, might have a significant impact on the decision to consume gluten-free products regularly.

Familiarity or no prior exposure was the most common theme in Table 3, with 30.8% of the participants reporting this. Many of the participants reported not having much or any previous experience with gluten-free food, and therefore were unable to describe or evaluate the taste. The second most common theme was positive or neutral sensory anticipation, where participants reported that gluten-free food would taste the same as regular food or that they had positive expectations about the taste of gluten-free food. Conversely, 23.1% of participants had negative sensory anticipation, believing that gluten-free food would be dry, bland, crumbly or just less enjoyable than regular food.

A lesser percentage of participants gave conditional or quality-based ratings, indicating that the flavour of gluten-free food would be influenced by how it was prepared or the quality of the recipe. An equal proportion showed disengagement or indifference, meaning that they did not have a definite opinion or did not notice much taste difference. Lastly, 5.1% of respondents refused to answer.

In general, the qualitative results indicated that many of the participants had no firsthand experience with gluten-free food before participating in the study and that their prior expectations varied widely. However, these expectations were not statistically associated with blind preferences (Kruskal–Wallis $H(4) = 2.71$, $p = .607$), so any influence of prior knowledge on preferences is descriptive rather than statistically demonstrated. The results are similar to those found by Prada et al. (2019), who investigated consumers' perception of the main purpose of gluten-free products, which revealed that consumers were not very knowledgeable about gluten-free products. Likewise, Paganizza et al. (2019) identified that the knowledge of celiac patients was limited, as they used associations, reasoning, social media and the internet to support their diet, which affected their perception of some products. Furthermore, Sylvester et al. (2016) noticed how people tend to overestimate their adherence to gluten-free diets due to lack of knowledge, leading them to consume uncalled-for levels of gluten, believing they are strongly adherent.

In extension of these findings, the present study suggests, descriptively, that participants' perceptions of gluten-free food varied with their prior knowledge and preconceived beliefs, although the Kruskal–Wallis test did not provide evidence that prior expectations predicted blind preferences. The large percentage of

participants who reported that they had not heard of gluten-free products suggests that many participants had limited exposure to gluten-free products and made assumptions about what they thought gluten-free products would taste like. Overall, the results indicate that gluten-free food perception is highly variable and that positive and negative perceptions exist, depending on the individual's awareness and prior experience. In conclusion, the results show that there is a need to increase consumer awareness and education about gluten-free products. This increased familiarity could help alleviate misconceptions and allow consumers to make their own judgments, instead of relying on assumptions based on sensory experiences.

CONCLUSION

This study investigated the effect of visual cues and preconceived notions on consumers' gluten-free and conventional cake evaluations in sighted and blind tasting conditions. The participants did not show any significant difference in visual preference between the two products, but the gluten-free cake was significantly more favoured in terms of texture and density in the blind tasting. The results indicate that consumers' perceptions of gluten-free foods may be affected by their sensory properties as well as by their previous experience and expectations, although the role of prior expectations was not statistically supported in this study, which may not be representative of the sensory properties of the product.

The study adds to the existing literature on multisensory food perception by suggesting that consumers' perception of gluten-free products may shift when visual information is removed, although order effects and the plate-colour confound preclude attributing this shift to visual information alone. The results of this study are important for understanding the psychological factors that influence consumer acceptance, and are useful for future research on consumer perception and gluten-free product development, as demand for gluten-free products rises.

Limitations

1. Very few experiments have been conducted to date to provide a solid theoretical basis for the present study when a comparison between gluten-free and conventional products was made. In doing so, the experimental design could have been further strengthened had there been more previous research studies available to inform the research gaps and the methodology.
2. The research was largely group-oriented, and demographic factors like age, gender and other individual factors were not explored in detail. Considering all these factors might have yielded a more comprehensive idea of whether people's attitudes and preferences for gluten-free products varied among the demographic groups.
3. The present study was designed in one cultural context and compared no participants from different cultural and/or geographical contexts. Food preferences and dietary behaviours, as well as gluten-free awareness, can differ from one culture to the next, so a cross-cultural comparison would have broadened the scope and applicability of results.

4. Convenience sampling was used to select the sample for the study from a single organisation. As such, the findings may not be extrapolated to the general population, as participants may not be representative of the general population in terms of occupation, level of education, or region.
5. This experiment was performed in a conference room of the organisation, not in a controlled laboratory setting. All attempts were made to reduce the amount of disturbance and noise in the area, but this was not possible to the same extent as achieved in a laboratory. As a result, the environment may have influenced some participants' responses and the experimental conditions to a small degree.
6. The order of the sighted evaluation and blind tasting was set so that all participants did the sighted evaluation first, followed by the blind tasting. However, the observed differences between sighted and blind evaluations could have been due to not only the lack of visual cues, but also order effects, such as familiarity, learning, or prior exposure to the products. The observed changes should therefore not be attributed solely to visual information.
7. Cake type was confounded with plate colour: the gluten-free cake was always served on the white plate and the conventional cake on the black plate. Sighted preferences may therefore reflect plate colour, contrast, or presentation effects rather than the appearance of the cakes alone. The position of the cakes (e.g., left versus right) was likewise not counterbalanced or randomised.
8. The Kruskal–Wallis test relating prior expectations to blind preference was not statistically significant, $H(4) = 2.71$, $p = .607$, and the thematic groups were small and unequal. Descriptive differences between groups should not be read as evidence of a reliable relationship between prior expectations and blind preferences.
9. A priori power analysis was not conducted to determine the target sample size. The study may have been underpowered to detect small effects, due to the number of statistical tests conducted compared to the final sample of 39 participants.
10. One analyst coded the data, and there were no independent codings or interrater reliability checks of the qualitative data. As a result, the qualitative data analysis could be subjective to one researcher's point of view.

Future Recommendations

1. A standardised scale to measure consumers' awareness, knowledge, perceptions and preferences on gluten-free products may be developed and validated in the future. It would enable more uniformity in the measurement of these foods across studies and aid in understanding the factors affecting the acceptance of gluten-free foods.
2. Further research could include comparisons across nations and among cultural sub-groups to assess the awareness, perceptions and preferences of gluten-free products. This would help to give a wider picture of how cultural, dietary and social factors affect consumers' attitudes and enhance the generalisability of research.
3. The results of the present study demonstrated that a gluten-free cake was preferred in terms of texture and density under masked tasting conditions, indicating that a well-formulated gluten-free product is as acceptable, or even preferred, as the conventional product. As such, the food

industry, bakery producers, and other businesses should keep innovating the taste and texture of gluten-free foods, as well as continue to educate consumers about the health benefits and suitability of gluten-free foods for people with celiac disease or gluten sensitivity. An increase in product quality and consumer education may lead to broader acceptance and uptake of gluten-free products.

4. Further research should involve a greater number and variety of participants from various age groups, genders, education levels, professions and geographic locations. The findings would be more generalisable if they were more representative and gave a better understanding of the impact of demographic factors on consumers' perceptions and acceptance of gluten-free products.
5. Future studies could examine consumer perceptions of a wider variety of gluten-free food products instead of one specific product, such as bread, biscuits, pasta, pizza, or snacks. This would enable us to know if the results obtained from the present study follow the criteria for different food categories and would give a wider picture of the acceptance of gluten-free products by the consumer.
6. To reduce possible order effects, future studies should randomise or balance the order of evaluations between sighted and blind evaluators. This would enable consumers' responses to the visual cue to be separated and a more robust evaluation of consumers' sensory preferences.
7. Future studies should counterbalance or randomise plate colour and cake type, as well as the position of the cakes (e.g., left versus right), so that visual preferences can be separated from plate colour, contrast, and presentation effects.

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