STIMULUS-ORGANISM-RESPONSE MODEL OF PURCHASE INTENTION TOWARD MICROALGAE-BASED GLUTEN-FREE FUNCTIONAL FOOD

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Abstract

Background: The increasing consumption of ultra-processed foods and growing attention to healthy eating are driving innovation in high nutritional value gluten-free functional foods. Microalgae, particularly Spirulina, have the potential to serve as a fortification ingredient due to their richness in protein, vitamins, minerals, antioxidants, and fiber.
Purpose: This study aims to analyze the effect of multi-sensory experience, perceived novelty, perceived health benefit, and environmental concern on purchase intention through perceived value and attitude toward product within the Stimulus-Organism-Response (SOR) framework.
Design/methodology/approach: The study was conducted in East Java from September to November 2025, involving 457 purposively selected respondents. Data were collected through face-to-face surveys after respondents sampled the product, and were analyzed using descriptive statistics and Exploratory Structural Equation Modeling (ESEM) with Maximum Likelihood Robust (MLR) estimation and target rotation.
Findings/Result: Multi-sensory experience, perceived health benefit, and environmental concern positively and significantly influenced perceived value, whereas perceived novelty showed a significant negative effect. Perceived value strongly affected attitude toward product, which in turn had a strong positive effect on purchase intention.
Conclusion: Purchase intention is formed through a sequential pathway from stimulus, value assessment, attitude formation, to buying intention. Education and increased product familiarity are needed so that novelty is perceived as added value rather than a risk.
Originality/value (State of the art): The novelty of this study lies in the integration of the SOR framework and ESEM to explain purchase intention toward microalgae based gluten-free functional food in a more realistic manner, particularly for a product that is still relatively new.

Keywords: ESEM, microalgae, purchase intention, gluten-free functional food, SOR

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INTRODUCTION

Non-communicable diseases, such as cardiovascular disease, type 2 diabetes, and cancer, remain among the leading causes of global mortality, partly driven by unhealthy dietary patterns and increasing consumption of ultra-processed foods (UPFs) (Chen et al. 2020). Several systematic reviews have shown that UPF consumption is associated with obesity, metabolic syndrome, hypertension, dyslipidemia, and an increased risk of mortality (Liang et al. 2025; Lv et al. 2024; Shu et al. 2023; Vitale et al. 2024). This concern is increasingly relevant in Indonesia. Recent national health data show that adult obesity increased from 21.8% in 2018 to 23.4% in 2023, while the prevalence of diabetes among people aged ≥ 15 years reached 11.7% based on blood glucose examination (KEMENKES, 2019; Sakir et al. 2024)analyze the sociodemographic factors associated with food consumption, and determine the associations between food consumption/ dietary intake and the prevalence rates of obesity, type 2 diabetes (T2D. Simultaneously, highly processed foods and beverages high in sugar, salt, saturated fat, and trans-fat, such as sugar-sweetened beverages, savoury snacks, and instant noodles, have become increasingly popular because they are affordable, widely available, and intensively marketed (WHO Indonesia, 2026). These trends indicate that Indonesia's dietary transition is moving toward greater exposure to convenient, but nutritionally imbalanced, food products. This highlights the urgency of developing healthier, nutrient-rich food products that align with the needs of modern consumers.

One growing segment is gluten-free functional food, particularly because the "gluten-free" claim is often perceived as a signal of health, safety, and product quality (Andrade-Bustamante et al. 2025). However, this perception should be interpreted critically, as gluten-free labels do not automatically indicate better nutritional quality than their gluten-containing counterparts. Previous studies have shown that many commercial gluten-free products may contain lower levels of protein and dietary fiber, while having higher levels of carbohydrates, saturated fat, salt, or sugar than comparable gluten-containing products (Melini & Melini, 2019; Myhrstad et al. 2021)a chronic systemic autoimmune disorder caused by a permanent intolerance to gluten proteins in genetically susceptible individuals. The diet entails the substitution of gluten-containing products with gluten-free-rendered products. However, over recent decades the nutritional profile of gluten-free (GF. This issue is relevant in Indonesia, where wheat-based food consumption is high, domestic wheat production remains limited, and demand is largely met through imports, which reached 11.5 million metric tons in 2023/2024 (USDA, 2024). Gluten-free products are defined as products that do not contain gluten (Bastiawan et al. 2022), and in Indonesia, such claims must be supported by valid scientific evidence in accordance with the BPOM Regulation No. 1 of 2022. Therefore, the development of gluten-free products should not rely merely on ingredient substitution but should also be directed toward improving the nutritional quality of the product.

Microalgae, particularly Spirulina, have potential as fortification ingredients because they are rich in proteins, minerals, vitamins, lipids, antioxidants, dietary fibers, and other bioactive compounds (Bernaerts et al. 2019; Qazi et al. 2022)such as gluten-free (GF. Spirulina is also considered a relevant sustainable food source because it can be cultivated on nonagricultural land and has high productivity (Lafarga, 2019; Maehle & Skjeret, 2022; Zaidi et al. 2025)and it is therefore necessary to understand the determinants influencing consumers' behaviour for microalgae-based food. The current study explores the influence of various factors on consumers' attitude, purchase intention and willingness to pay for two microalgae-based products (bread and beer. Cookies were selected as the product focus because they are popular, practical snacks with the potential to be developed as nutrient-dense snacks (Batista et al. 2017; Zaidi et al. 2025). Previous studies have shown that Spirulina fortification can improve the nutritional content of food products while maintaining sensory acceptability at certain levels (Batista et al. 2017; Lucas et al. 2020)richness in bioactive compounds, and because they are considered a sustainable protein source for the future. The aim of this work was to evaluate microalgae (Arthrospira platensis F & M-C256, Chlorella vulgaris Allma, Tetraselmis suecica F & M-M33 and Phaeodactylum tricornutum F & M-M40, although excessive concentrations may reduce consumer acceptance owing to changes in color, taste, texture, and overall acceptability (Hussein et al. 2025).

Although Spirulina-based gluten-free cookies have potential as functional foods, their nutritional advantages do not necessarily translate into purchase intention. Microalgae-based products remain relatively new to many Indonesian consumers; therefore, their

green color, distinctive aroma, unfamiliar taste, and innovative product images may generate both interest and hesitation (Putra et al. 2024). Thus, the key issue in this study lies not only in product formulation but also in how consumers evaluate sensory experience, product novelty, perceived health benefits, product value, attitude toward the product, and environmental concern before forming purchase intention.

To address this problem, this study applies the Stimulus-Organism-Response (SOR) framework (Liu & Zheng, 2019) as the theoretical basis for explaining consumers' purchase intention toward microalgae-based gluten-free functional food. In this framework, multisensory experience, perceived novelty, perceived health benefits, and environmental concerns are positioned as stimulus factors. Perceived value and attitude toward the product represent consumers' internal evaluations, whereas purchase intention serves as the response. This approach is appropriate because consumer acceptance of innovative functional foods is not determined solely by nutritional advantages but also by sensory perception, perceived novelty, health-related evaluation, environmental concern, perceived value, and attitude toward the product.

This study aimed to analyze the formation of consumers' purchase intention toward microalgae-based gluten-free functional food, particularly Spirulina-fortified cookies. The novelty of this study lies in examining consumer acceptance of Spirulina-fortified gluten-free cookies as a relatively unfamiliar microalgae-based food product in Indonesia by integrating multisensory experience, perceived novelty, perceived health benefits, environmental concern, perceived value, attitude toward the product, and purchase intention within a stimulus–organism–response framework. Specifically, this study examines the effects of multisensory experience, perceived novelty, perceived health benefits, and environmental concerns on perceived value and attitudes toward the product, as well as the subsequent effects of perceived value and attitudes toward the product on purchase intention. Although Spirulina fortification has been reported to improve the nutritional quality of gluten-free products while maintaining consumer acceptability (Putra et al. 2024), few studies have explained the factors shaping Indonesian consumers' acceptance and purchase intention toward this product category. The findings are expected to contribute to the consumer behavior literature on functional foods while offering practical implications for developing Spirulina-based gluten-free products that better align with market preferences.

METHODS

This study used a quantitative cross-sectional survey design to examine the formation of consumers' purchase intention toward microalgae-based gluten-free functional food within the Stimulus-Organism-Response (SOR) framework (Muhajirin et al. 2024; Sofya et al. 2024; Waruwu et al. 2025)observation, analysis, finding solutions, and hypothesis testing. one of the research methods that will be discussed in this study is a survey, namely explanatory survey and cross sectional. Explanatory surveys are used to identify and confirm cause-and-effect relationships between variables, as well as predict changes or variations in relation to other variables. While cross sectional is a study that studies the correlation between exposure or risk factors (independent. The study was conducted in East Java, Indonesia, specifically in Malang and Madura, from September to November 2025. These locations were selected purposively because of their diverse consumer characteristics, agribusiness relevance, and growing interest in healthy food consumption (Rokhma et al. 2024; Runtunuwu et al. 2022).

This study used both primary and secondary data. Primary data were collected through face-to-face surveys using a structured questionnaire administered after the respondents participated in a product-tasting session. Before completing the questionnaire, respondents were asked to taste the microalgae-based gluten-free cookies so that their evaluations were based on a direct multisensory experience with the product. This procedure also enabled the researchers to ensure that respondents had tasted the product before providing their assessments, while helping to reduce the potential misinterpretation of the questionnaire items. Secondary data were collected from journals, books, government reports, and other relevant publications to support the theoretical framework, research background, and methodological justification (Sulung & Muspawi, 2024).

Respondents were selected using purposive sampling method. The inclusion criteria were age $\geq$ 15 years, willingness to taste the product, no allergies or dietary restrictions related to the tested ingredients, ability to communicate in Bahasa Indonesia, and willingness

to complete the questionnaire. The sample size was determined using Krejcie and Morgan's (1970) formula based on the East Java population reported by the BPS (2024). A minimum sample of 385 respondents was increased by 20% to anticipate incomplete responses, resulting in a target sample of 457 respondents (Subhaktiyasa, 2024). Although the population of East Java is very large, the Krejcie and Morgan formula remains relevant because, for very large populations, the minimum required sample size becomes relatively stable and converges to approximately 384. Therefore, the minimum sample of 385 respondents was considered adequate, while the final sample of 457 respondents provided an additional margin to account for potentially incomplete responses.

Primary data were collected through face-to-face interviews. Before completing the questionnaire, respondents received a brief explanation of the study, provided informed consent, and tasted the microalgae-based gluten-free cookies. The study was conducted with the permission of the Universitas Brawijaya Institutional Research Board. Because the study involved food product tasting, the data collection procedure followed ethical safeguards, including voluntary participation, informed consent, respondent anonymity, and prior screening for allergies or dietary restrictions related to the tested ingredients. Respondents were also informed that they could refuse or withdraw from participation at any stage, without any consequences.

The questionnaire used a five-point Likert scale to measure multisensory experience, perceived novelty, perceived health benefits, environmental concerns, perceived value, attitude toward the product, and purchase intention. The measurement items were adapted from previous studies on consumer behavior, functional food acceptance, perceived value, product attitude, and purchase intention. The questionnaire consisted of five items for multisensory experience, three items for perceived novelty, four items for perceived health benefits, four items for environmental concern, three items for perceived value, three items for attitude toward the product, and four items for purchase intention. Prior to the main survey, the instrument was contextually adjusted, reviewed for content validity, and pilot-tested to ensure that the items were clear, relevant, and understandable to respondents in the context of microalgae-based gluten-free cookies. The pilot test results were used to refine the wording of several items to reduce ambiguity and potential misinterpretations.

Data were analyzed using descriptive statistics and Exploratory Structural Equation Modeling (ESEM). Descriptive analysis was used to summarize the respondent characteristics and variable responses (Sofwatillah et al. 2024). ESEM was applied because it combines the flexibility of Exploratory Factor Analysis and the confirmatory strength of CFA, allowing realistic cross-loadings among related indicators (Prokofieva et al. 2023).

The model was estimated using Weighted Least Squares Mean and Variance Adjusted (WLSMV), which is appropriate for ordinal Likert-scale data and is reported in lavaan as Diagonally Weighted Least Squares (DWLS). Model fit was evaluated using the Chi-square, CFI, TLI, RMSEA, and SRMR. Construct validity was evaluated based on standardized factor loadings and cross-loading patterns, and internal consistency was assessed using standardized Cronbach's alpha. This approach was considered appropriate for ESEM because the model allows theoretically plausible cross-loadings among conceptually related indicators rather than assuming a strictly zero cross-loading structure, as in conventional CFA.

The structural model tested the effects of multisensory experience, perceived novelty, perceived health benefits, and environmental concerns on perceived value; the effect of perceived value on attitude toward the product; and the effect of attitude toward the product on purchase intention. Hypotheses were evaluated using standardized path coefficients, standard errors, and p-values, with $p < 0.05$ indicating significance of the results. Indirect effects were examined through the sequential structural pathways estimated in this model. Set-ESEM was used to improve model realism by allowing cross-loadings only among conceptually related constructs (Marsh & Alamer, 2024). The set refers to predefined groups of theoretically related constructs in which cross-loadings are permitted only within the same conceptual set. Cross-loadings between unrelated construct sets are restricted, allowing the model to remain theoretically guided while accounting for measurement overlap among closely related variables.

The framework of this study is based on the stimulus-organism-response (SOR) model. Multisensory experience, perceived novelty, perceived health benefits, and environmental concerns were positioned as stimulus factors. Perceived value and attitude toward the product function as consumers' internal evaluations, whereas purchase intention represents the consumer response.

This framework (Figure 1) explains that consumers' purchase intention toward microalgae-based gluten-free functional foods is formed through a sequential evaluation process. Product- and consumer-related stimuli, including multisensory experiences, perceived novelty, perceived health benefits, and environmental concerns, influence consumers' perceived value. Perceived value shapes attitudes toward a product, which subsequently determines purchase intention.

The hypotheses in this study were developed based on the SOR framework, which explains that external stimuli influence consumers' internal evaluations and subsequently shape their behavioral responses. In the context of innovative functional foods, multisensory experience, perceived novelty, perceived health benefits, and environmental concerns are assumed to influence consumers' perceived value because they affect how consumers evaluate the usefulness, attractiveness, health relevance, and broader meaning of the product. Furthermore, perceived value is expected to shape attitudes toward the product, while a favorable attitude is expected to strengthen purchase intention. The hypotheses tested in this study are as follows: H1: Multisensory experience positively affects perceived value; H2: Perceived novelty positively affects perceived value; H3: Perceived health benefits positively affect perceived value; H4: Environmental concern positively affects perceived value; H5: Perceived value positively affects attitude toward the product; and H6: Attitude toward the product positively affects purchase intention.

RESULTS

Respondent Characteristics

This study obtained 457 valid responses from consumers who participated in the product tasting session and completed the questionnaire. The sample size exceeded the minimum requirement of 385 respondents and was considered adequate for Exploratory Structural Equation Modeling (ESEM), which requires stable parameter estimation because of the possibility of cross-loadings among indicators.

The respondent profile shows that 56% of respondents were female and 44% were male. This composition indicates that female respondents were slightly more dominant in the sample than male respondents. Gender is relevant in consumer food studies because men and women may differ in their food preferences, health considerations, and consumption behavior (Horovitz, 2024). Based on age, most respondents were in the 15-24 age group, accounting for 94% of the total sample, while the remaining 6% were distributed across the 25-34, 35-44, and 45-54 age groups. This composition suggests that the findings mainly represent young consumers' perceptions of microalgae-based gluten-free functional foods. The dominance of respondents aged 15–24 should be acknowledged as a limitation in terms of generalizability, as this highly concentrated age composition means that the findings reflect the characteristics of young consumers more strongly than those of broader age groups. Thus, the results remain relevant for explaining young consumers' perceptions, evaluations, and purchase intentions, but they cannot be fully generalized to the entire Indonesian consumer population. Young consumers tend to be more open to food innovation and novel food experiences, which may influence their responses to functional and gluten-free food products (Hazley et al. 2022; Mellor et al. 2022; Wasserman et al. 2020).

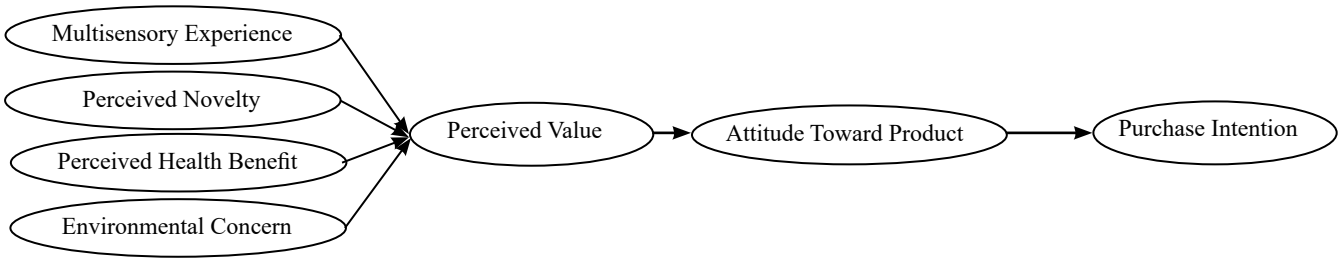

Figure 1. A sequential stimulus-organism-response conceptual framework

In terms of domicile, 57% of the respondents came from Malang, while approximately 42% came from Pamekasan. The dominance of respondents from Malang may be related to its role as an educational center in East Java, where young consumers are more exposed to food innovation, lifestyle trends, and health-related information (Bhanuwati & Ulum, n.d.). Regarding occupation, the sample was largely composed of university and school students, representing 48% and 42% of respondents, respectively. This pattern was consistent with the age distribution, which was dominated by adolescents and young adults. Educational environments may expose consumers to information about health, sustainability, and product innovation, which can shape their internal evaluations and purchase intention (Asgar et al. 2023; Knežević et al. 2024; Maehle & Skjeret, 2022).

The income profile shows that 60% of respondents had a monthly income of less than or equal to Rp1,000,000. This reflects the dominance of students in the sample, whose income commonly comes from parental allowance, scholarships, or part-time work (Aziz, 2019). This indicates that product affordability may be important in shaping purchase intention, particularly because gluten-free products are often more expensive than conventional products (Rayesa & Ali, 2022). Therefore, improving the affordability of food-grade microalgae products is important for expanding consumer access (Azimatun Nur, 2014).

Based on education level, 55% of respondents had completed senior high school as their highest level of education. This pattern is consistent with the dominance of young respondents who were still in school or pursuing higher education (Soler-Gallart et al. 2025). Education level is relevant because it may influence consumers' ability to understand nutritional information, health claims, and product labels (Baker et al. 2022). Previous research also suggests that knowledge can strengthen consumer attitudes and willingness to try microalgae-based alternatives (Kasana et al. 2025). Overall, the respondent characteristics indicate that this study primarily captures the perceptions of young, educated consumers with relatively limited income toward microalgae-based gluten-free functional foods.

Descriptive Analysis

Data were analyzed using quantitative descriptive statistics and Exploratory Structural Equation Modeling (ESEM), which combines EFA and CFA within the SEM framework while allowing small cross-loadings (Prokofieva et al. 2023)CFA assumes all indicators/ items should load uniquely on their allocated latent dimensions. To address this weakness, Exploratory Structural Equation Modeling (ESEM. The model followed the Stimulus-Organism-Response (SOR) framework, with multisensory experience, perceived novelty, perceived health benefit, and environmental concern as stimulus variables; perceived value and attitude toward the product as organism variables; and purchase intention as the response variable. Parameter estimation used Weighted Least Squares Mean and Variance Adjusted (WLSMV), reported in lavaan as Diagonally Weighted Least Squares (DWLS), with target rotation. Model fit was assessed using χ^2, CFI, TLI, RMSEA, and SRMR, while construct validity and reliability were evaluated using standardized factor loadings, cross-loading patterns, and standardized Cronbach's alpha. Structural relationships were tested using path coefficients (β) at $p < 0.05$.

Table 1 presents the descriptive results, showing that the item mean scores ranged from 3.69–4.49. At the construct level, the average scores were 4.03 for multisensory experience, 4.15 for perceived novelty, 4.32 for perceived health benefits, 4.28 for environmental concern, 4.28 for perceived value, 4.31 for attitude toward product, and 3.87 for purchase intention. These results suggest that respondents generally perceived the gluten-free microalgae product as sensorially pleasant, novel, healthy, environmentally aligned, and valuable (Leyva-Hernández et al. 2025; Martínez-Ruiz et al. 2025; Xiao et al. 2025). Perceived value and attitude toward the product were also high, confirming their important role in shaping consumer responses (García-Salirrosas et al. 2025; Pan & Wu, 2024; E. S.-T. Wang & Chu, 2021). However, purchase intention showed the lowest construct-level mean, indicating that positive evaluations did not fully translate into buying intention, possibly due to practical barriers such as taste, aroma, price, and product accessibility (Knežević et al. 2024; Li et al. 2025). At the item level, the highest mean score was found for nutritional value (M1.1 = 4.49), whereas the lowest was observed for intention to buy (Y2 = 3.69).

Table 1. Descriptive statistics of research variables in the stimulus–organism–response model of purchase intention toward microalgae-based gluten-free functional food

Variables	Mean	Minimum	Maximum	Standard Deviation
Multisensory Experience (X1)				
Visual Appeal (X1.1)	3.921	1	5	0.940
Texture Suitability (X1.2)	4.089	1	5	0.828
Appearance Attractiveness (X1.3)	4.015	1	5	0.906
Taste Suitability (X1.4)	4.144	1	5	0.906
Pleasant Aftertaste (X1.5)	3.989	1	5	0.928
Perceived Novelty (X2)				
Product Uniqueness (X2.1)	3.888	1	5	0.931
New Experience (X2.2)	4.326	1	5	0.749
Curiosity (X2.3)	4.223	1	5	0.852
Perceived Health Benefits (X3)				
Healthy Microalgae (X3.1)	4.472	1	5	0.769
Essential Nutrients (X3.2)	4.216	1	5	0.765
Protein Content (X3.3)	4.450	2	5	0.748
Nutritional Fulfillment (X3.4)	4.146	2	5	0.796
Environmental Concern (X4)				
Environmental Support (X4.1)	4.146	1	5	0.696
Sustainable Snack (X4.2)	4.387	2	5	0.784
Environmentally Friendly Choice (X4.3)	4.286	2	5	0.715
Contribution to Environmental Preservation (X4.4)	4.299	2	5	0.734
Perceived Value (M1)				
Nutritional Value (M1.1)	4.492	1	5	0.716
Price–Benefit Suitability (M1.2)	4.124	1	5	0.775
Self-Image (M1.3)	4.216	1	5	0.768
Attitude Toward Product (M2)				
Nutritional Advantage (M2.1)	4.275	1	5	0.745
Product Safety (M2.2)	4.461	1	5	0.760
Consumption Satisfaction (M2.3)	4.192	1	5	0.844
Purchase Intention (Y)				
Willingness to Buy (Y1)	3.921	1	5	0.872
Intention to Buy (Y2)	3.689	1	5	0.954
Regular Consumption (Y3)	3.947	1	5	0.916
Purchase Plan (Y4)	3.905	1	5	0.935

Measurement Model Evaluation

Table 2 presents the validity testing results, which were first conducted to ensure that each indicator appropriately represented its corresponding construct within the SOR framework. The initial screening used r.drop, with values above 0.30 being considered acceptable (Altunoz & Aygün, 2025; Raharjanti et al. 2022). All indicators met this threshold, indicating that all items were valid for further analyses. Higher r.drop values were observed for multisensory experience and perceived health benefits, while perceived novelty showed relatively lower but still acceptable values. Purchase intention demonstrated the strongest consistency. As ESEM was applied in the main analysis, these results served as a preliminary validity check before factor structure testing with target rotation (Gu et al. 2020; Van Zyl & Ten Klooster, 2022).

As shown in Table 3, reliability was assessed using the standardized Cronbach's alpha (α), where values above 0.60 indicate acceptable internal consistency (Anselmi et al. 2019; Yang et al. 2025). All constructs met the minimum reliability criterion ($\alpha > 0.60$), indicating that

the indicators within each construct were sufficiently consistent and suitable for further analyses. Purchase Intention showed the highest reliability (α = 0.91), followed by Multisensory Experience (α = 0.83), Perceived Health Benefits (α = 0.81), Environmental Concern (α = 0.77), and Perceived Value (α = 0.74). Meanwhile, Perceived Novelty (α = 0.61) and Attitude Toward Product (α = 0.63) had the lowest reliability values. Although these values remained above the acceptable threshold, they indicate relatively lower internal consistency than the other constructs, suggesting that the items may capture more diverse aspects of novelty perception and product attitude.

Table 2. Construct validity testing in the stimulus-organism-response model of purchase intention toward microalgae-based gluten-free functional food

Indicator	R-Drop (>0.30)	Validity
Multisensory Experience (X1.1)	0.59	Valid
Multisensory Experience (X1.2)	0.58	Valid
Multisensory Experience (X1.3)	0.66	Valid
Multisensory Experience (X1.4)	0.65	Valid
Multisensory Experience (X1.5)	0.65	Valid
Perceived Novelty (X2.1)	0.35	Valid
Perceived Novelty (X2.2)	0.48	Valid
Perceived Novelty (X2.3)	0.42	Valid
Perceived Health Benefit (X3.1)	0.59	Valid
Perceived Health Benefit (X3.2)	0.65	Valid
Perceived Health Benefit (X3.3)	0.63	Valid
Perceived Health Benefit (X3.4)	0.62	Valid
Environmental Concern (X4.1)	0.56	Valid
Environmental Concern (X4.2)	0.46	Valid
Environmental Concern (X4.3)	0.68	Valid
Environmental Concern (X4.4)	0.63	Valid
Perceived Value (M1.1)	0.45	Valid
Perceived Value (M1.2)	0.64	Valid
Perceived Value (M1.3)	0.63	Valid
Attitude Toward Product (M2.1)	0.49	Valid
Attitude Toward Product (M2.2)	0.36	Valid
Attitude Toward Product (M2.3)	0.49	Valid
Purchase Intention (Y1)	0.78	Valid
Purchase Intention (Y2)	0.78	Valid
Purchase Intention (Y3)	0.79	Valid
Purchase Intention (Y4)	0.81	Valid

Table 3. Construct reliability testing in the stimulus-organism-response model of purchase intention toward microalgae-based gluten-free functional food

Variables	Std.alpha (>0.60)	Reliability
Multisensory Experience	0.83	Reliable
Perceived Novelty	0.61	Reliable
Perceived Health Benefit	0.81	Reliable
Environmental Concern	0.77	Reliable
Perceived Value	0.74	Reliable
Attitude Toward Product	0.63	Reliable
Purchase Intention	0.91	Reliable

Structural Model Evaluation

As shown in Table 4, the path coefficient results indicate that multisensory experience (X1) has a significant positive effect on perceived value (M1) (β = 0.251), indicating that superior taste, aroma, color, and texture experiences elevate perceived value. This is particularly important because the acceptance of microalgae products is often sensitive to sensory aspects (Abdolmohamad Sagha et al. 2022; Matos et al. 2022; Verni et al. 2023). Perceived novelty (X2), however, had a significant negative effect on perceived value (β = -0.081; p = 0.018), suggesting that novelty can trigger a sense of unfamiliarity and risk perception, thereby suppressing value judgments (Baker et al. 2022; Hopkins et al. 2023). In contrast, perceived health benefit (X3) had a significant positive effect (β = 0.275; p < 0.001), and environmental concern (X4) emerged as the strongest predictor of value (β = 0.356; p < 0.001), indicating that health benefits and sustainability orientation reinforce value assessments (Arslan, 2025; Baker et al. 2022). Furthermore, perceived value strongly shapes attitude toward the product (M1→M2: β = 0.917; p < 0.001), and attitude directly drives purchase intention (M2→Y: β = 0.904; p < 0.001), making the SOR pathway clearly discernible: stimulus → perceived value → attitude → purchase intention (Zheng et al. 2024).

The coefficient of determination (R^2) was used to assess how much variance in the endogenous constructs could be explained by the predictors in the model, and remained relevant even when the analysis employed ESEM, which allowed for cross-loadings (Prokofieva et al. 2023; Van Zyl & Ten Klooster, 2022). The results yielded R^2 M1 = 0.972, R^2 M2 = 0.959, and R^2 Y = 0.541, indicating that the model accounts for 97.2% of the variation in perceived value, 95.9% of the variation in attitude toward the product, and 54.1% of the variation in purchase intention. However, the very high R^2 values for perceived value and attitude toward the product should be interpreted cautiously. Values approaching 1.0 may not only indicate high explanatory power but may also reflect conceptual overlap among predictors, potential multicollinearity, or model overfitting. In the context of ESEM, this does not necessarily indicate that the model is problematic because ESEM is designed to accommodate theoretically plausible cross-loadings and measurement overlap among closely related constructs. Therefore, the high R^2 values in this study may reflect the close conceptual proximity among consumers' evaluative processes within the SOR framework, particularly between stimulus-related perceptions, perceived value, and attitude toward the product. Thus, these findings suggest a strong explanatory capacity for the organism constructs, but they should be discussed proportionately rather than interpreted solely as evidence of superior model performance. Meanwhile, the more moderate R^2 value for purchase intention indicates that buying intention is also shaped by other practical considerations beyond the internal evaluative pathway, such as taste acceptance, aroma, price, and product accessibility (Jeong et al. 2022; Pereira et al. 2024).

The goodness-of-fit test yielded CFI = 0.987 and TLI = 0.983, both exceeding the conventional thresholds, along with SRMR = 0.070, which falls below 0.08, indicating relatively small standardized residuals and an acceptable approximation of the model-implied covariance structure to the observed data (Yang et al. 2025). However, RMSEA = 0.086 exceeded the commonly used 0.08 benchmark, suggesting that the approximate model fit was not fully satisfactory. Moreover, the robust fit indices showed a substantial decline in model fit, with a Robust CFI = 0.857 and Robust RMSEA = 0.109. Because the robust CFI was below the commonly recommended threshold of 0.90 and the robust RMSEA exceeded the acceptable range, these results indicate that the model specification was not yet optimal after robust correction. Therefore, the fit results should be interpreted cautiously and acknowledged as a limitation of this study. This limitation may be related to the complexity of the ESEM specification, the presence of cross-loadings among conceptually related constructs, and the potential overlap among consumer evaluation variables within the SOR framework (Handtke & Bögeholz, 2023).

Results of Exploratory Structural Equation Modeling (ESEM)

The SOR framework was employed to explain purchase intention toward gluten-free microalgae products: stimuli (X1-X4) shape the organism constructs (M1-M2), which in turn influence purchase intention (Y) (Feng et al. 2025). The measurement model was analyzed using ESEM because indicators for relatively novel products tend to overlap, making it necessary to accommodate cross-loadings to yield more realistic and unbiased measurements (Prokofieva et al. 2023).

Table 4. Path estimates of the stimulus-organism-response model of purchase intention toward microalgae-based gluten-free functional food

Path	Coefficient Estimation	Standar Error	Z-Value	P-Value	Description
X1 → M1	0.251	0.066	3.823	0.000	Significant, positive effect
X2 → M1	-0.081	0.034	-2.361	0.018	Significant, negative effect
X3 → M1	0.275	0.069	4.011	0.000	Significant, positive effect
X4 → M1	0.356	0.060	5.893	0.000	Significant, positive effect
M1 → M2	0.917	0.043	21.149	0.000	Significant, positive effect
M2 → Y	0.904	0.042	21.312	0.000	Significant, positive effect

The ESEM results indicate that the Multisensory Experience construct (X1) is highly robust, as evidenced by the positive, strong, and significant loadings of indicators X1.1-X1.5 (±0.54-0.83), confirming that taste, color, texture, and aroma experiences constitute the core of this construct. Consistent with the nature of innovative products, the Perceived Novelty indicators (X2.1-X2.3) also exhibited significant cross-loadings onto X1 (±0.22-0.37), suggesting that the sense of "newness" largely emerges through sensory experience. This type of cross-loading pattern is precisely the reason ESEM was adopted, as it does not force cross-loadings to zero, thereby reducing estimation bias (Prokofieva et al. 2023). Nevertheless, the structure of Perceived Novelty appears less stable, as X2.1 and X2.3 loaded more strongly onto X1 and/or X4 than onto X2, while X3.2 (within the Perceived Health Benefit block) loaded very highly onto X2 (0.845) and remained high on X3 (0.684), suggesting that in terms of content, X3.2 may be capturing the "uniqueness" of the product rather than pure health benefit. Despite this, the Perceived Health Benefit construct generally showed a strong role in the ESEM model, particularly through the large and significant loading of X3.1 (0.825). The cross-loading of X3.2 remains acceptable because ESEM allows indicators to load onto more than one construct. However, the standardized loading of X3.3, which exceeded 1.0 (1.071), should be interpreted with caution because it may indicate an estimation anomaly such as a Heywood case or multicollinearity. Thus, health benefits can still be understood as an important dimension in consumers' evaluation of microalgae-based functional food, consistent with Martínez-Ruiz et al. (2025), who showed that consumers' understanding and awareness of the health benefits of microalgae are associated with a more positive intention to consume these products. Nevertheless, the result for X3.3 should be acknowledged as a technical limitation of this measurement model. Environmental Concern also demonstrated strong loadings through X4.1 (0.730), X4.3 (0.876), and X4.4 (0.955); however, X4.2 was weak and non-significant on X4 (0.190) while loading more strongly onto X3 (0.611), suggesting that this item is more closely aligned with health considerations than with pure environmental concern (Martínez-Ruiz et al. 2025). On the organism side, Perceived Value (M1) was highly cohesive (Std.all ±0.779-0.835), supporting its role as a stimulus-response mediator (García-Salirrosas et al. 2025), while Attitude Toward Product (M2) was adequate (±0.641-0.786) as an evaluative mechanism leading to purchase intention (Mirzaei-Fard et al. 2025). The Purchase Intention construct (Y) demonstrated very high strength (Std.all ±0.872-0.896), indicating that the response indicators were formed consistently and stably (Feng et al. 2025).

Direction of Cross-Loadings in Exploratory Structural Equation Modeling (ESEM) on the Stimulus Constructs

The ESEM results for the stimulus constructs revealed overlaps across dimensions, particularly between perceived novelty and multisensory experience. The sense of "newness" in gluten-free microalgae products is largely shaped by the unusual taste, aroma, texture, and appearance of the product, meaning that novelty does not stand independently but is embedded within the sensory experience (Spence, 2020)I review the literature concerning what happens when flavours, ingredients, and/or culinary techniques are deliberately combined in a dish, drink, or food product. Sometimes the result is fusion but, if one is not careful, the result can equally well be confusion instead. In fact, blending, mixing, fusion, and flavour pairing all provide relevant examples of how the elements in a carefully-crafted multi-element tasting experience may be combined. While the aim is sometimes to obscure the relative contributions of the various elements to the mix (as in the case of blending. Furthermore, several perceived health benefit indicators also loaded onto perceived

novelty, indicating that the health benefits of unfamiliar functional foods are often understood simultaneously as part of the product's novelty (Baker et al. 2022). Overlap also emerged between environmental concern and perceived novelty, as environmentally conscious consumers tend to be more receptive to new products perceived as eco-friendly, causing sustainability value and novelty to be read in tandem (Chang et al. 2025; Ma & Chang, 2022). In the results, environmental concern additionally loaded onto perceived health benefits, and vice versa, suggesting that some respondents associated being "environmentally friendly" with being "safer, more natural, or healthier" when evaluating microalgae products (Uliano et al. 2024; Wang et al. 2020). Overall, this cross-loading pattern reflects the way consumers simultaneously process product stimuli across sensory, novelty, health, and environmental dimensions before forming evaluations and purchase intentions within the SOR framework

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Indirect Effects of Stimuli Through the Organism Constructs on the Response

The indirect effects test indicates that purchase intention is primarily formed through the sequential pathway of perceived value (M1) → attitude toward product (M2) → purchase intention (Y): stimuli first shape perceived value, value shapes attitude, and attitude drives purchase intention (Ma & Chang, 2022). Multisensory experience (X1) and perceived health benefits (X3) exerted positive indirect effects by enhancing perceived value and strengthening attitude, whereas perceived novelty (X2) exerted a negative indirect effect because novelty is more often interpreted as uncertainty, thereby suppressing perceived value and weakening attitude (Ampofo & Abbey, 2022; Białek-Dratwa et al. 2022; Imtiyaz et al. 2021). Environmental concern (X4) emerged as the strongest lever, yielding the largest indirect effect (0.295), indicating that environmental concern elevates perceived value, including moral and sustainability value, reinforces attitude, and ultimately increases purchase intention (Martínez-Ruiz et al. 2025; Simanjuntak et al. 2023).

Hypothesis Testing

The hypothesis testing results presented in Table 5 indicate that multisensory experience has a significant positive effect on perceived value (H1 supported; $\beta = 0.251$, $p < 0.001$). Although perceived novelty significantly affected perceived value, the relationship was negative rather than positive ($\beta = -0.081$; $p = 0.018$). Thus, H2 should be rejected in the hypothesized positive direction. This result indicates that novelty in microalgae-based gluten-free functional foods may be perceived as unfamiliar or uncertain rather than a value-enhancing innovation. Furthermore, perceived health benefits (H3; $\beta = 0.275$; $p < 0.001$) and environmental concern (H4; $\beta = 0.356$; $p < 0.001$) both increased perceived value, with the largest effect attributable to environmental concern. At the organism-to-response stage, perceived value strongly shaped attitude toward the product (H5 supported; $\beta = 0.917$; $p < 0.001$), and attitude served as a direct driver of purchase intention (H6 supported; $\beta = 0.904$; $p < 0.001$). Overall, the SOR pathway is clearly discernible: stimuli increase or, in the case of novelty, decrease perceived value; value shapes attitude; and attitude subsequently drives purchase intention.

Implikasi manajerial

The findings indicate that Spirulina-based gluten-free cookies should not be marketed merely by emphasizing product novelty, because perceived novelty negatively affects perceived value. Novelty should be translated into familiarity through benefit education, safety information, product tasting, familiar flavor variants, and easy-to-understand packaging. Because environmental concern was the strongest predictor of perceived value, product communication should emphasize concrete sustainability benefits, such as resource efficiency and the relevance of microalgae as a future food source. Commercialization strategies should also consider respondents' limited purchasing power, particularly because the sample was dominated by young and low-income consumers. Small package sizes, trial prices, campus-based promotions, and accessible distribution channels may help reduce the barriers to purchase. These implications are relevant not only for producers but also for retailers, educational institutions, and food policy stakeholders in improving consumer literacy regarding microalgae-based functional foods.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This study demonstrates that purchase intention toward gluten-free microalgae-based functional foods is formed through a stimulus-organism-response

(SOR) mechanism, in which multisensory experience, perceived health benefit, and environmental concern enhance perceived value, while perceived novelty tends to diminish it. Subsequently, perceived value plays a critical role in strengthening attitudes toward the product, which ultimately drives purchase intention. These findings indicate that product acceptance cannot solely rely on nutritional content, health claims, or sustainability messages. Since the respondents were predominantly young consumers, students, and low-income groups, positive perceived value and attitude may not automatically translate into strong purchase intention unless practical barriers are addressed. Therefore, product education and familiarity-building should be implemented by specific stakeholders: food producers and MSME-based functional food developers need to improve sensory acceptability, especially taste and aroma; marketers and retailers should provide trial-based promotion, clearer product information, and easier product access; universities, nutrition educators, and public health institutions can strengthen consumer understanding of the health, safety, and environmental value of microalgae-based foods; and local government and food-related agencies can support affordability, market introduction, and consumer awareness programs targeted at young consumers.

Recommendations

Based on the ESEM results and study limitations, future product development should prioritize sensory improvement, particularly taste, aroma, texture, and appearance, because multisensory experiences contribute positively to perceived value. Producers should also strengthen health benefits and sustainability communication through specific and credible claims rather than generic promotional messages. Since perceived novelty had a negative effect, education, product trials, ingredient transparency, and serving suggestions should be used to reduce unfamiliarity and perceived risks. Future studies should involve more diverse respondents in terms of age, income, occupation, and region and include variables such as food neophobia, familiarity, trust, willingness to pay, and price sensitivity. Experimental or longitudinal designs are also needed to examine whether perceived value, attitude, and purchase intention remain stable after repeated exposure or a more intensive consumption experience.

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Table 5. Hypothesis testing according to the sequential stimulus-organism-response framework

Hypothesis	Coefficient Estimate	P-Value	Hypothesis Accepted/Rejected
H1: X1 → M1	0.251	0.000	Accepted (significant positive)
H2: X2 → M1	-0.081	0.018	Accepted (significant negative)
H3: X3→ M1	0.275	0.000	Accepted (significant positive)
H4: X4→ M1	0.356	0.000	Accepted (significant positive)
H5: M1 → M2	0.917	0.000	Accepted (significant positive)
H6: M2 → Y	0.904	0.000	Accepted (significant positive)

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