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RESEARCH PAPER

Modeling consumer purchase intention for upcycled okara products using PLS-sem

Siti Susanti[1], Nobel Kristian Tripandoyo Tampubolon[2], Mutia Intan Savitri Herista[2], Siswanto Imam Santoso[2]

1 *Food Technology, Department of Agriculture, Faculty of Animal Husbandry and Agriculture, Diponegoro University, Semarang, 50275, Indonesia*
2 *Agribusiness, Department of Agriculture, Faculty of Animal Husbandry and Agriculture, Diponegoro University, Semarang, 50275, Indonesia*

Corresponding author: Siti Susanti (sitisusanti@live.undip.ac.id)

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Abstract

Upcycling tofu dregs, or okara, offers potential health, economic, and environmental advantages; however, evidence linking its nutritional value, circular economy relevance, and consumer acceptance remains fragmented. This study aims to address this gap by developing and empirically testing a Triple Sustainability-Driven Behavioral Intention Model that links Perceived Health Benefit (PHB), Economic Value Perception (EVP), Environmental Concern (EC), Attitude (ATT), and Purchase Intention (PI). Following literature-based model development, a cross-sectional survey was conducted with 365 consumers from five selected subdistricts in Semarang, Indonesia. The data were analyzed using partial least squares structural equation modeling (PLS-SEM) in SmartPLS 4, with reflective measurement assessment based on indicator loadings, Cronbach's alpha, rho_A, composite reliability, average variance extracted, discriminant validity, and bootstrapped path coefficients. The measurement model demonstrated sufficient reliability and convergent validity, with indicator loadings ranging from 0.79 to 0.89, reliability coefficients from 0.89 to 0.93, and AVE values from 0.69 to 0.73. In the structural model, Attitude emerged as the strongest proximal predictor of Purchase Intention ($\beta = 0.472$, $p < 0.001$). Economic Value Perception exerted the strongest influence on Attitude ($\beta = 0.512$, $p < 0.001$) and also directly affected Purchase Intention ($\beta = 0.284$, $p < 0.001$), indicating partial mediation. Environmental Concern positively affected Attitude ($\beta = 0.245$, $p = 0.003$) and had an indirect effect on Purchase Intention, whereas Perceived Health Benefit influenced both Attitude ($\beta = 0.171$, $p = 0.009$) and Purchase Intention ($\beta = 0.117$, $p = 0.032$). These findings suggest that consumers evaluate okara-based upcycled foods mainly through value-for-money and perceived health benefits, while environmental concern strengthens attitude formation rather than replacing functional and economic evaluations. Early market introduction should therefore integrate credible health claims, transparent value-for-money communication, and concise environmental messaging. Future studies should validate the model across broader consumer demographics, product contexts, and actual purchase behavior.

Keywords

Tofu dregs, sustainable food consumption, triple sustainability, behavioral intention, upcycled food

Introduction

Indonesia continues to face significant challenges with municipal waste management, particularly in large cities where food consumption and household garbage are concentrated. An appropriate context for examining the relationship between circular economy policies and food consumption practices is Semarang, the capital of Central Java and a major metropolitan economic centre. National waste-management statistics reveal that garbage creation continues to be a significant developmental issue in Indonesia, with Semarang exacerbating the urban waste challenge in Central Java (SIPSN 2024; SIPSN 2025). Circular food innovation

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presents a means to diminish food-processing waste while generating value-added goods that are acceptable to consumers (Ali and Choe 2022; Korsunova et al. 2022).

One important by-product of the manufacture of tofu and soy-based foods is okara, also known as tofu dregs. Okara has potential as an upcycled food ingredient despite being typically regarded as a low-value by-product since it contains dietary fiber, protein, and functional components that can improve the nutritional profile of food items (Philip et al. 2022; Zhang et al. 2023). Prior research indicates that tofu and soy by-products may be converted into value-added food ingredients, facilitating waste reduction and product innovation (Caponio et al. 2012; Verni and Casanova 2022). This possibility is particularly pertinent in tofu production environments, where ongoing by-product development poses an environmental challenge and presents a chance for valorization (Susanti et al. 2023). Semarang exemplifies the fragility of environmental advancement when consumer-oriented procedures are inadequately comprehended or incorporated (Font Vivanco et al. 2022; Vargas-Merino et al. 2023). Evidence from Semarang's green shopping context indicates that pro-environmental understanding does not consistently result in corresponding purchasing behavior, suggesting that behavioral dynamics may either enhance or diminish the benefits of programs and campaigns (Tampubolon et al. 2025). This gap is significant for circular food innovations, as adoption needs to be repeated, habitual, and socially integrated to endure over time. Thus, pinpointing the most significant factors of enduring intention is crucial for connecting innovation to long-term waste reduction (Hidayati et al. 2021; Flores and Jansson 2022).

The sustainability potential of okara-based upcycled foods cannot be realized just through technology advancements or nutritional enhancements. The success of upcycled food items relies on consumer acceptance, favorable product assessment, and readiness to buy. Consumers may endorse food-waste reduction conceptually, but they often hesitate to purchase food items derived from by-products due to apprehensions of flavor, safety, quality, price, or unfamiliarity. Prior studies on upcycled and sustainable foods demonstrate that customer reactions are influenced by environmental factors, perceived value, anticipated product quality (Ghazanfar et al. 2022; Miolla et al. 2023; Moshtaghian et al. 2024).

In behavioral research of sustainable food consumption, attitude is frequently seen as a crucial psychological process that connects consumer attitudes to purchasing intentions. Three belief aspects are particularly significant for okara-based upcycled foods. Perceived Health Benefit (PHB) denotes the degree to which consumers perceive that okara-based upcycled foods offer nutritional or functional benefits. Economic Value Perception (EVP) indicates whether customers regard the product as justifiable in price and economically viable relative to alternative food options. Environmental Concern (EC) denotes customers' cognizance toward food-waste mitigation, circular economy principles, and ecological preservation. The three variables encompass health, economic, and environmental assessments that collectively influence attitudes and purchase intentions about okara-based upcycled foods (Le and Nguyen 2022; Alam et al. 2023; Biasini et al. 2023).

Despite increasing interest in the valorization of okara and sustainable food consumption, the behavioral mechanisms influencing consumer acceptability of okara-based upcycled meals are little elucidated. Current research predominantly focuses on the nutritional content, functional attributes, and technical applications of okara, with limited investigation into consumer perceptions of okara-based products as viable food alternatives in the market. Moreover, prior sustainable food research frequently analyzes health motivation, economic value, and environmental concern in isolation, rather than synthesizing them into a cohesive behavioral framework. This establishes a theoretical and empirical void in comprehending whether the desire to purchase okara-based upcycled meals is predominantly influenced by perceived health advantages, value-for-money factors, environmental concerns, or their cumulative effect through attitude.

The following research topics are addressed in this study in light of this gap. First, how do customers' attitudes on okara-based upcycled meals become influenced by perceived health benefits, perceived economic value, and environmental concerns? Second, how do customers' attitudes, economic value perceptions, and perceived health benefits affect their intention to buy okara-based upcycled foods? Third, is there a link between sustainability-related assessments and purchase intention that is mediated by attitude?

This study develops and experimentally assesses a Triple Sustainability-Driven Behavioral Intention Model for okara-based upcycled meals in order to address these research concerns. Within a PLS-SEM framework, the model integrates Perceived Health Benefit, Economic Value Perception, Environmental Concern, Attitude, and Purchase Intention. In particular, this study looks at how PHB, EVP, and EC directly affect Attitude and Purchase Intention, as well as how Attitude mediates the relationship between these sustainability-related perceptions and Purchase Intention. By analyzing customers from certain Semarang subdistricts and elucidating how health, economic, and environmental assessments influence consumer intention toward okara-based upcycled meals, this study advances the field of circular food innovation research.

Literature Review

Theory of planned behavior and attitude as a mediating mechanism

A theoretical foundation for understanding how consumers assess sustainable food items prior to generating purchase intentions is provided by behavioral intention models (Lin and Dong 2023). In the Theory of Planned

Behavior, attitude is typically seen as a direct determinant of intention since it encapsulates consumers' comprehensive positive or negative assessment of an action or product (Dupont et al. 2022; Li et al. 2023). In the realm of okara-based upcycled foods, customer attitude is crucial as it encompasses evaluations of the product's environmental impact, perceived health advantages, economic worth, safety, quality, and familiarity. Prior research on sustainable and food-related consumption indicates that perceived value, environmental concern, and health considerations can enhance purchase intention by initially fostering a positive product attitude (Chen 2022; Kovacs and Keresztes 2022; Miftari et al. 2022).

The function of attitude necessitates additional investigation regarding upcycled food products, as consumers may acknowledge the environmental benefits of reducing food waste yet remain reluctant to buy items deemed unusual, unconventional, or potentially risky. Research on upcycled food reveals that this category has problems regarding public acceptance, with consumer reactions influenced by ethical considerations, perceived healthiness, sensory appeal, pricing, familiarity, and natural composition. In the context of sustainable (Moshtaghian et al. 2024) novel foods, sensory appeal, cost, safety, health, and unfamiliarity have been recognized as significant elements influencing customer expectations and purchasing intentions (Chen 2022). Furthermore, research on substandard food indicates that favorable environmental attitudes do not consistently correlate with the willingness to pay or purchasing behavior, as consumers may encounter ambivalence when assessing items linked to food-waste reduction (Puteri et al. 2022). This study identifies attitude as the primary mediating variable that connects perceived health benefit, economic value perception, and environmental concern to purchase intention.

Perceived Health Benefit and consumer evaluation of okara-based upcycled foods

Perceived Health Benefit (PHB) that a food product might offer functional or nutritional benefits that promote health and well-being is known as perceived health benefit, or PHB. Because okara provides dietary fiber, PHB is especially important when it comes to recycled meals made from okara (Susanti et al. 2023), protein and other useful elements that might improve food items' nutritional value (Temple 2022). Previous studies on food by-products and functional ingredients indicate that by-products can be transformed into value-added food components with potential health-promoting properties (Minervini et al. 2022; Verni and Casanova 2022). Studies on functional foods enhanced with food byproducts also shown that when consumers are aware of the additional ingredient's functional and health advantages, their acceptance of the product can be increased (Miolla et al. 2023). Therefore, consumers may view okara-based upcycled foods as nutritionally significant and palatable culinary innovations rather than just waste-derived goods due to anticipated health advantages.

However, buying intention is not always correlated with perceived health benefits. Consumer acceptability of by-product-based functional meals is contingent not only on the existence of advantageous chemicals but also on consumers' perceptions of the product as familiar, safe, and acceptable as well as their comprehension of the ingredient's health benefits (Miolla et al. 2023). Research on biofortified vegetables also indicates that when a stated advantage is evident and significant to consumers, nutrition and health claims may boost the likelihood of a purchase (Welk et al. 2023). Therefore, PHB may influence purchase intention both directly and indirectly through attitude. When consumers perceive okara-based upcycled foods as beneficial for health, they are more likely to develop a favorable attitude toward the product, which may subsequently strengthen their purchase intention. Based on this reasoning, the following hypotheses are proposed:

H1: Perceived Health Benefit positively influences Attitude toward okara-based upcycled foods.
H2: Perceived Health Benefit positively influences Purchase Intention toward okara-based upcycled foods.
H6: Attitude positively influences Purchase Intention toward okara-based upcycled foods.
H7: Attitude mediates the relationship between Perceived Health Benefit and Purchase Intention toward okara-based upcycled foods.

Environmental concern and attitude toward okara-based upcycled foods

Consumers' knowledge of and concern about environmental issues, such as food waste, resource inefficiency, and the effects of food production on the environment, is referred to as environmental concern (EC). EC is especially pertinent when it comes to okara-based upcycled meals as they are closely linked to circular economy and food waste reduction strategies. Reusing food by-products in food production can promote circular economy principles and lessen the environmental burden of disposal, but they are frequently viewed as trash, which has negative effects on the environment, the economy, and society (Miolla et al. 2023). Food waste and by-products have also been identified as a sustainability concern; yet, their value as novel food ingredients might enhance resource efficiency and facilitate the shift to a circular economy (Minervini et al. 2022). Because okara-based goods turn tofu production leftovers into food with additional value, customers who are more concerned about the environment may see these items more favorably.

However, buying intentions are not always directly correlated with environmental concerns. Although consumers may be in favor of reducing food waste in theory, they may be reluctant to buy upcycled food items if they believe they contain inferior ingredients or have unclear

advantages. Environmental concerns can influence consumer judgment and intention in novel and sustainable food situations, although their impact may vary depending on factors such as price, unfamiliarity, safety, health, and sensory appeal (Chen 2022). Research on less-than-ideal food also demonstrates that while understanding of food waste and environmental issues might promote more favorable views, ambivalence may still limit willingness to pay and buy behavior (Puteri et al. 2022). This illustrates the larger value-action gap in consumer food-waste behavior, where concern and knowledge may not always translate into appropriate action (Marwood et al. 2023). Therefore, this study anticipates that EC will primarily affect purchase intention by fostering a positive attitude about upcycled meals made from okara. Based on this reasoning, the following hypotheses are proposed:

H3: Environmental Concern positively influences Attitude toward okara-based upcycled foods.
H8: Attitude mediates the relationship between Environmental Concern and Purchase Intention toward okara-based upcycled foods.

Economic Value Perception and value-for-money in okara-based upcycled food adoption

Economic Value Perception (EVP) refers to consumers' assessment of whether a product offers fair benefits in relation to its cost, quality, and anticipated utility. EVP is crucial when it comes to okara-based upcycled meals since customers are unlikely to embrace circular food products only on the basis of ethical or environmental factors. They may also assess the product's usefulness, affordability, comparability to traditional alternatives, and value. Price, sensory appeal, healthfulness, familiarity, ethical concern, and value for money are important elements influencing consumers' reactions to upcycled food items, according to research on upcycled food choice (Moshtaghian et al. 2024). Perceived value and willingness to pay are directly linked to consumers' product evaluation and purchase intention in sustainable food context (Kovacs and Keresztes 2022). Consumers' economic and functional assessment is still crucial in the adoption of sustainable foods, as evidenced by study on organic food consumption, which demonstrates that perceived value may considerably increase ongoing buy intention (Qi et al. 2023).

EVP may have a direct and indirect impact on buying intention through attitude. Customers are more likely to have a positive opinion of okara-based upcycled meals and think about buying them if they believe the product offers good value for the money. Because high cost, unfamiliarity, sensory expectations, safety, and perceived health value might affect customer acceptance and intention, this is especially important for innovative and sustainable food items (Chen 2022). Research on biofortified vegetables also indicates that when the perceived nutritional advantage is evident and significant, consumers would be prepared to pay more (Welk et al. 2023). Therefore, if consumers do not view okara-based upcycled foods as useful and economically justifiable, circularity may not be enough to encourage adoption. The following theories are put out in light of this logic:

H4: Economic Value Perception positively influences Attitude toward okara-based upcycled foods.
H5: Economic Value Perception positively influences Purchase Intention toward okara-based upcycled foods.
H9: Attitude mediates the relationship between Economic Value Perception and Purchase Intention toward okara-based upcycled foods.

Synthesis of the proposed behavioral intention model

Okara-based repurposed meals offer a pertinent setting for investigating the relationship between consumer purchase intention and circular food innovation. Okara, a by-product of the manufacture of soy milk and tofu, has nutritional value and the potential to be valued; nevertheless, its commercial adoption is contingent upon consumers' perceptions of its economic viability, environmental significance, and healthfulness. According to earlier research (Gao et al. 2022; Minervini et al. 2022; Verni and Casanova 2022; Jaouhari et al. 2023), okara and other food by-products may be converted into value-added substances with nutritional, functional, and circular economy importance. This study conceptualizes Perceived Health Benefit (PHB), Environmental Concern (EC), and Economic Value Perception (EVP) as three sustainability-related assessments that may influence customers' Attitude and Purchase Intention toward okara-based upcycled meals based on previous research. EVP covers consumers' evaluation of value-for-money, pricing justice, and economic rationale; EC highlights customers' concern for food waste reduction and circular economy practices; and PHB represents the perceived nutritional and functional value of okara-based goods.

According to the suggested model, attitude serves as the primary psychological mechanism that connects these assessments of sustainability to purchase intention. This need is crucial because, although consumers may acknowledge the economic, environmental, or health benefits of okara-based upcycled foods, these assessments are more likely to promote purchase intention when they initially produce a positive product attitude. As a result, the model looks at both attitude-mediated and direct channels. In particular, EC is anticipated to have an indirect impact on Purchase Intention through Attitude, whereas PHB and EVP are anticipated to have a direct and indirect impact. Furthermore, being the model's closest evaluative mechanism, Attitude is anticipated to have a direct impact on Purchase Intention..

The basic foundation of the suggested PLS-SEM model for okara-based upcycled meals is shown in Fig. 1.

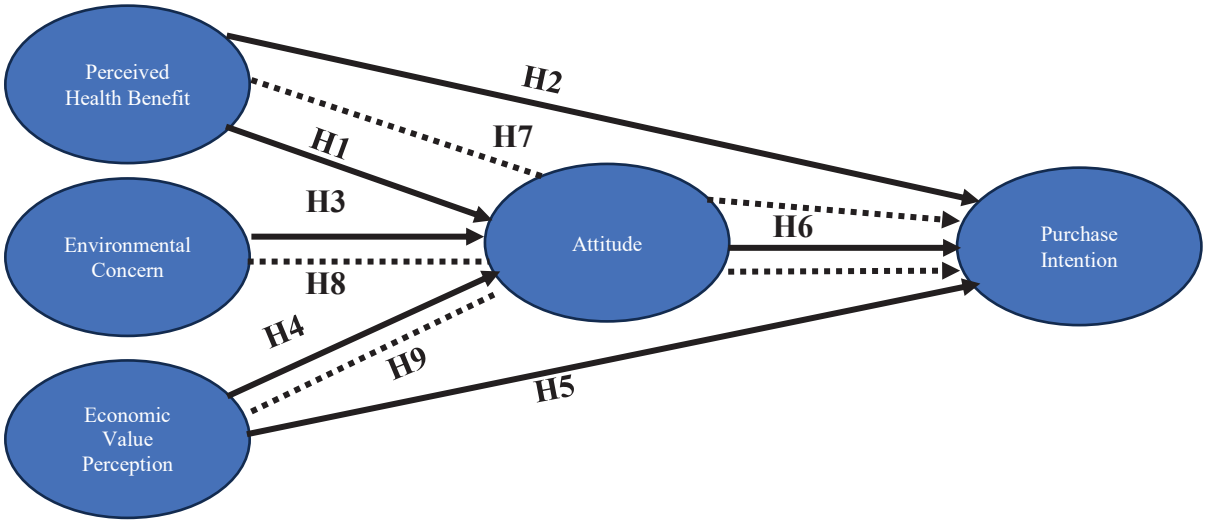

Figure 1. Conceptual framework of the proposed PLS-SEM model for purchase intention toward okara-based upcycled foods.

Five latent constructs such as PHB, EC, EVP, Attitude, and Purchase Intention are shown in the framework. The proposed direct effects of PHB, EC, and EVP on Attitude; the direct impacts of PHB, EVP, and Attitude on Purchase Intention; and the indirect effects of PHB, EC, and EVP on Purchase Intention through Attitude are all represented by the structural routes. As a result, the framework makes clear how consumer attitude and purchase intention are likely to be influenced by economic, environmental, and health assessments. The direct and mediation hypotheses examined in this investigation are included in Table 1.

Method

Research design and study setting

In order to investigate consumers' purchasing intentions about okara-based upcycled meals in Semarang City, Central Java, Indonesia, this study used a cross-sectional survey approach. Because the study used a PLS-SEM framework, which is frequently used to estimate relationships among latent constructs in prediction-oriented behavioral research, to evaluate the relationships among consumers' perceptions, attitudes, and purchase intentions at a single point in time, this design was deemed appropriate (Hair et al. 2022). Future longitudinal studies are advised to investigate the stability of the suggested correlations over time and across real-world purchase scenarios, as this design does not provide the inference of temporal changes or causal development in consumer behavior. Semarang was chosen as the research location because it reflects an urban food consumption context where circular food innovation, tofu production byproducts, and municipal waste management challenges converge. The 2024 Semarang City subdistrict population distribution, shown in Table 1, was used to determine the study environment.

Table 1. Total population in Semarang City in 2024.

Subdistrict	Population by Gender (People)		
	Male	Female	Total
Mijen	46420	46668	93088
Gunung Pati	50735	50842	101577
Banyumanik	70861	72885	143746
Gajah Mungkur	27600	28734	56334
Semarang Selatan	30224	31794	62018
Candisari	37317	38125	75442
Tembalang	100313	101508	201821
Pedurungan	97609	99859	197468
Genuk	68709	68647	137356
Gayamsari	35019	35369	70388
Semarang Timur	32280	34195	66475
Semarang Utara	58229	59636	117865
Semarang Tengah	26454	28754	55208
Semarang Barat	73355	75972	149327
Tugu	17054	17038	34092
Ngaliyan	72998	73630	146628
Semarang City	845177	863656	1708833

Based on table 1, five subdistricts such as Pedurungan, Tembalang, West Semarang, Banyumanik, and Ngaliyan—were chosen using area-based purposive sampling because they are among Semarang's major urban population centers and offer access to a variety of consumer groups pertinent to an early market evaluation of okara-based upcycled foods. Therefore, rather than claiming complete statistical representativeness of all Semarang inhabitants, Table 1 was utilized to illustrate the population structure of Semarang City and to support the selection of main urban survey regions. As a result, the results should be considered as an empirical evaluation of consumers from certain metropolitan subdistricts; the subsequent subsection describes the specific sample phases, respondent eligibility requirements, and online data collecting methods.

The results should be regarded as an empirical evaluation of customers from certain metropolitan subdistricts. The various sample phases, eligibility conditions for respondents, and online data collection methods are explained in the following sections. No offline replies were included in the final dataset; all responses were gathered via the dissemination of an online questionnaire.

Sampling procedure and participants

The five chosen subdistricts were subjected to a multistage online sampling process. Initially, the chosen subdistricts listed in Section 3.1 were used to define the survey areas. Second, because online surveys can effectively reach digitally connected respondents in behavioral research, the questionnaire link was disseminated through online communication channels connected to locals, students, community networks, and potential customers within those areas (Van Gelder et al. 2010; Ebert et al. 2023). Third, eligibility criteria were used to screen respondents: they had to be Semarang residents or active consumers, fall within the eligible consumer age range, be willing to participate, and comprehend the idea of okara-based upcycled meals after being given a brief product description. Because consumer knowledge might affect how functional or innovative food items are evaluated and accepted, a product description was added (Baker et al. 2022). Respondent selection was carried out at the individual level by online distribution rather than probability-based household sampling because the study did not employ a household-listing technique. For analysis, 365 genuine online replies in total were kept. Only those who completed the key measuring items, gave informed consent, and comprehended the product idea were included. Because the sample size exceeded typical minimal criteria for a model with a maximum of three predictors of an endogenous construct, it was deemed sufficient for PLS-SEM (Hair et al. 2022).

The results should be evaluated cautiously and may not be extrapolated as totally representative of all Semarang inhabitants, especially customers with restricted internet access, as all responses were gathered online. Because the study used area-based purposive sampling and online distribution rather than probability-based household sampling, confidence level and precision level were not used to estimate statistical representativeness of the Semarang population. Instead, sample adequacy was justified based on the requirements of PLS-SEM model complexity, the number of predictors in the structural model, and the final number of valid responses.

Measurement development and construct operation

Reflective indicators were used to test each latent construct on a 5-point Likert scale, with 1 denoting strongly disagree and 5 denoting strongly agree. Five dimensions were assessed using the questionnaire: Purchase Intention (PI), Attitude (ATT), Economic Value Perception (EVP), Environmental Concern (EC), and Perceived Health Benefit (PHB). The items were contextually modified for the okara-based upcycled foods scenario after being adapted from earlier peer-reviewed research. The perceived functional and nutritional advantages of okara-based products were represented in PHB items (Temple 2022; Miolla et al. 2023; Welk et al. 2023). Concerns of reducing food waste, the circular economy, and environmental sustainability in food consumption were captured by EC items (Chen 2022; Puteri et al. 2022; Marwood et al. 2023). Value-for-money, price equity, and economic rationale for product uptake were all represented by EVP items (Kovacs and Keresztes 2022; Qi et al. 2023; Moshtaghian et al. 2024). The ATT and PI items were modified from attitude-intention frameworks that are often employed in studies on food-related and sustainable buying behavior (Hashmi et al. 2012; Dupont et al. 2022; Le and Nguyen 2022; Miftari et al. 2022; Lin and Dong 2023).

Because the indicators were viewed as expressions of underlying psychological perceptions, attitudes, or intentions rather than as separate elements that made up the construct, all constructions were designated as reflective. Accordingly, it was anticipated that respondents with greater PHB, EC, EVP, ATT, or PI would consistently exhibit higher agreement across the respective items (Hair et al. 2022). This problem is recognized as a methodological constraint because a formal expert review and pilot test were not carried out prior to the main survey. The measuring questions were reexamined for concept relevance, readability, and language consistency throughout article revision in order to address the reviewer's issue regarding item clarity. While maintaining the original construct meaning, the English phrasing presented in Table 2 was standardized by substituting simpler terms like "I believe" and "I intend" for repetitious and unduly formal formulations like "I assert" and "I contend." Table 2 displays the final build codes and measurement items.

Data analysis (SEM Procedures)

A reflecting measurement model and a structural model made up the two halves of the PLS-SEM model. Perceived Health Benefit (PHB), Environmental Concern (EC), Economic Value Perception (EVP), Attitude (ATT), and Purchase Intention (PI) were identified as reflecting latent components in the measurement model. The structural model identified ATT as the mediating construct, PI as the ultimate endogenous construct, and PHB, EC, and EVP as exogenous constructs. The mediation hypotheses H7–H9 were tested by the indirect routes via ATT, while H1–H6 were tested by the direct structural paths. In this study, no moderation hypothesis was put out. Because the theoretical focus was on psychological assessment mechanisms, demographic factors were not included as control variables in the basic PLS-SEM model, but they

Table 2. Indicators of variables.

Variable	Source(s)	Indicator(s)	Code
Perceived Health Benefit (PHB)	Moshtaghian et al. 2024; Zhou et al. 2022	I believe that okara-based upcycled foods can support my overall health.	PHB1
		I believe that okara-based upcycled foods provide beneficial nutrients.	PHB2
		I believe that okara-based upcycled foods can support weight management.	PHB3
		I believe that okara-based upcycled foods may help support disease-risk reduction.	PHB4
		I believe that okara-based upcycled foods can support a healthier diet.	PHB5
Environmental Concern (EC)	Miftari et al. 2022; Zhang et al. 2022	Purchasing okara-based upcycled foods aids in mitigating food waste	EC1
		Purchasing okara-based upcycled foods can contribute to a reduction in carbon footprint	EC2
		Purchasing okara-derived upcycled foods promotes a circular economy	EC3
		Purchasing okara-based upcycled foods contributes to the mitigation of environmental pollution	EC4
		Opting for okara-based upcycled foods constitutes an environmentally sustainable decision	EC5
Economic Value Perception (EVP)	Lou et al. 2022	The caliber of okara-derived upcycled foods justifies the cost	EVP1
		Okara-based upcycled foods are priced competitively in relation to analogous products	EVP2
		Okara-derived upcycled foods provide excellent cost-effectiveness	EVP3
		Opting for okara-based upcycled foods constitutes a financially astute decision for me	EVP4
		In summary, the investment in okara-based upcycled foods is justified by the advantages I obtain	EVP5
Attitude (ATT)	Miftari et al. 2022; Lin and Dong 2023; Zhang et al. 2022	In general, I maintain a favorable disposition towards okara-based upcycled foods	ATT1
		I consider okara-based upcycled foods to be an appealing concept	ATT2
		I believe that upcycled foods derived from okara would be pleasurable to eat	ATT3
		I believe that upcycled foods derived from okara align with contemporary consumer preferences	ATT4
		I believe that the consumption of okara-based upcycled foods promotes a sustainable lifestyle	ATT5
Purchase Intention (PI)	Hashmi et al. 2012	I intend to buy okara-based upcycled foods in the near future.	PI1
		I intend to try different okara-based upcycled food products.	PI2
		I intend to recommend okara-based upcycled foods to others.	PI3
		I intend to buy okara-based upcycled foods regularly.	PI4
		I intend to choose okara-based upcycled foods as a sustainable alternative when available.	PI5

were utilized to address sample constraints and define the respondent profile.

PLS-SEM, or partial least squares structural equation modeling, was used in SmartPLS 4 to evaluate the data. With Perceived Health Benefit (PHB), Environmental Concern (EC), and Economic Value Perception (EVP) as exogenous constructs, Attitude (ATT) as the mediating construct, and Purchase Intention (PI) as the final endogenous construct, the structural model was defined in accordance with the suggested behavioral framework. Using outer loadings, internal consistency reliability, convergent validity, and discriminant validity, the measurement model was initially evaluated for reflected indicator quality. The primary criteria for measurement adequacy were indicator loadings over 0.70, Cronbach's alpha and composite reliability values above 0.70, average variance extracted (AVE) above 0.50, and appropriate HTMT values (Raykov and Marcoulides 2015; Hair et al. 2022). Standardized path coefficients, bootstrapped t-statistics, p-values, R^2 modified R^2, and f^2 effect sizes were used to assess the structural model in accordance with the PLS-SEM path modeling technique after the measurement model was verified (Hair et al. 2022). H1–H6 were tested using direct effects, while H7–H9's mediating function was investigated using bootstrapped specific indirect effects with a two-tailed significance level of $p < 0.05$. This study does not provide a moderation hypothesis. Because the theoretical focus was on psychological assessment mechanisms, demographic factors were not included as control variables in the basic PLS-SEM model, however they were used to address sample constraints and characterize the respondent profile. Q^2 and PLSpredict, including Q^2_predict, RMSE, and MAE where appropriate, were used to evaluate predictive relevance and out-of-sample predictive performance (Shmueli et al. 2016; Hair et al. 2022).

Result and discussion

Respondent's profile

In order to contextualize the sample makeup and make the interpretation of the PLS-SEM results more clear, the demographic profile was analyzed prior to model estimation. To illustrate the coverage and possible constraints of the respondent group, the profile is displayed by gender, age, subdistrict, and occupation/education status. The demographic data is utilized to describe the sample rather than to assert complete statistical representativeness of the total urban population of Semarang because the study employed online sampling within certain subdistricts.

Table 3 Shows that women constituted 62.7% of the sample (229/365), whereas men represented 37.3% (136/365). The age distribution was predominantly youthful, with individuals aged 20–29 years accounting for 47.7% (174/365) and those aged 15–19 years comprising 41.9% (153/365), leaving only 10.4% aged 30 or older. This profile is analytically significant as women consistently

Table 3. Respondent's profile.

Gender	Respondents
Male	136
Female	229
Total	365
Age	**Respondents**
15-19	153
20-29	174
30-39	31
40-49	6
>50	1
Total	365
Subdistricts	**Respondents**
Ngaliyan	151
Banyumanik	28
Pedurungan	62
Semarang Barat	40
Tembalang	84
Total	365
Works	**Respondents**
Civil servant /Government employee	10
Lecturer/Instructor	21
Entrepreneur/Self-employed	19
Upper-Secondary Student (Senior High/Vocational)	71
Diploma Student (Associate degree: D1/D2/D3)	5
Undergraduate Student (Bachelor's degree)	180
Postgraduate Student (Master's/Doctoral)	8
Private-Sector Employee	41
Homemaker (Housewife)	10
Total	365

prioritize health-related food factors and often incorporate sustainability themes into their daily food choices, thereby enhancing the variance in perceived health benefits and environmental concerns (Bärebring et al. 2020; Grzymisławska et al. 2020; Gaspar et al. 2023). Similarly, young adults are at a developmental stage where lasting consumption patterns emerge, and where social influence and sustainability-focused preferences may be significant, rendering them a compelling demographic for examining value–health–environment trade-offs in purchasing intentions (Arnoldussen et al. 2022; Ludwig-Borycz et al. 2023; Xie and Madni 2023).

The occupational and educational distribution reveals that the data predominantly represent student demographics: undergraduates comprised 49.3% (180/365) and upper-secondary students 19.5% (71/365), with smaller proportions of working adults, including private-sector employees (11.2%, 41/365) and lecturers/instructors (5.8%, 21/365). This concentration is pertinent to an upcycled-food context as higher education settings correlate with enhanced environmental literacy and increased involvement in sustainability issues, while students frequently face stricter budget limitations that amplify "value-for-money" considerations (Baungaard et al. 2023; Hu and Liao 2023). Concurrently, data regarding student food insecurity and resource limitations underscores the significance of economic value perception as a prominent motivator in student populations (Conrad et al. 2022). Furthermore, youth and student demographics are consistently recognized as crucial stakeholders in fostering sustainable consumption practices that integrate social, environmental, and economic factors (Renzi et al. 2022).

Respondents were geographically distributed across five subdistricts of Semarang: Ngaliyan (41.4%, 151/365), Tembalang (23.0%, 84/365), Pedurungan (17.0%, 62/365), Semarang Barat (11.0%, 40/365), and Banyumanik (7.7%, 28/365), demonstrating coverage across various urban areas with a notable predominance of Ngaliyan. Focusing fieldwork on a specific subset of subdistricts is methodologically justifiable when the objective is to efficiently capture heterogeneity within realistic resource limitations, as the sampling strategy should align with the research question, target population, and operational feasibility rather than adhering to a "must-cover-all-areas" principle (Schneider 2013; Muñoz-Cancino et al. 2023). In urban environments, spatial and behavioral instruments, such as GIS-based delineation of sample domains, are frequently employed to facilitate pragmatic and economical sampling choices, particularly when comprehensive random coverage is challenging to execute (Bluemke et al. 2017; Ngom Vougat et al. 2019). Therefore, rather than representing the entire age and occupational structure of Semarang's metropolitan population, the results should be regarded as reflecting a youth-heavy, student-oriented, and digitally connected consumer sector. This sample makeup restricts the findings' applicability to older consumers, non-student groups, and consumers with restricted internet access, but it may be helpful for understanding younger customers' early reactions to okara-based upcycled meals.

Measurement model results

Outer model of structural equation modelling

Since all constructions were defined as reflecting, outer loadings were the main method used to evaluate indicator quality as proof of indicator dependability. Because they show that the indicators appropriately reflect their respective latent constructs, outside loadings in PLS-SEM of around 0.70 or higher are often regarded as acceptable (Hair et al. 2022). All maintained indicators in the current model were higher than this cutoff, indicating that each component made a sufficient contribution to its construct. Threshold compliance by itself, however, should not be seen as definitive proof of item quality. Therefore, the outer loading evaluation was utilized not only to support the preservation of the indicators but also to find comparatively weaker indications that could need to be improved in further research. This diagnostic interpretation is crucial since measurement quality depends on respondent comprehension, construct relevance, and phrasing clarity in addition to statistical adequacy (Smith and Cribbie 2013; Raykov and Marcoulides 2015; Guiné et al. 2023) (Fig. 2).

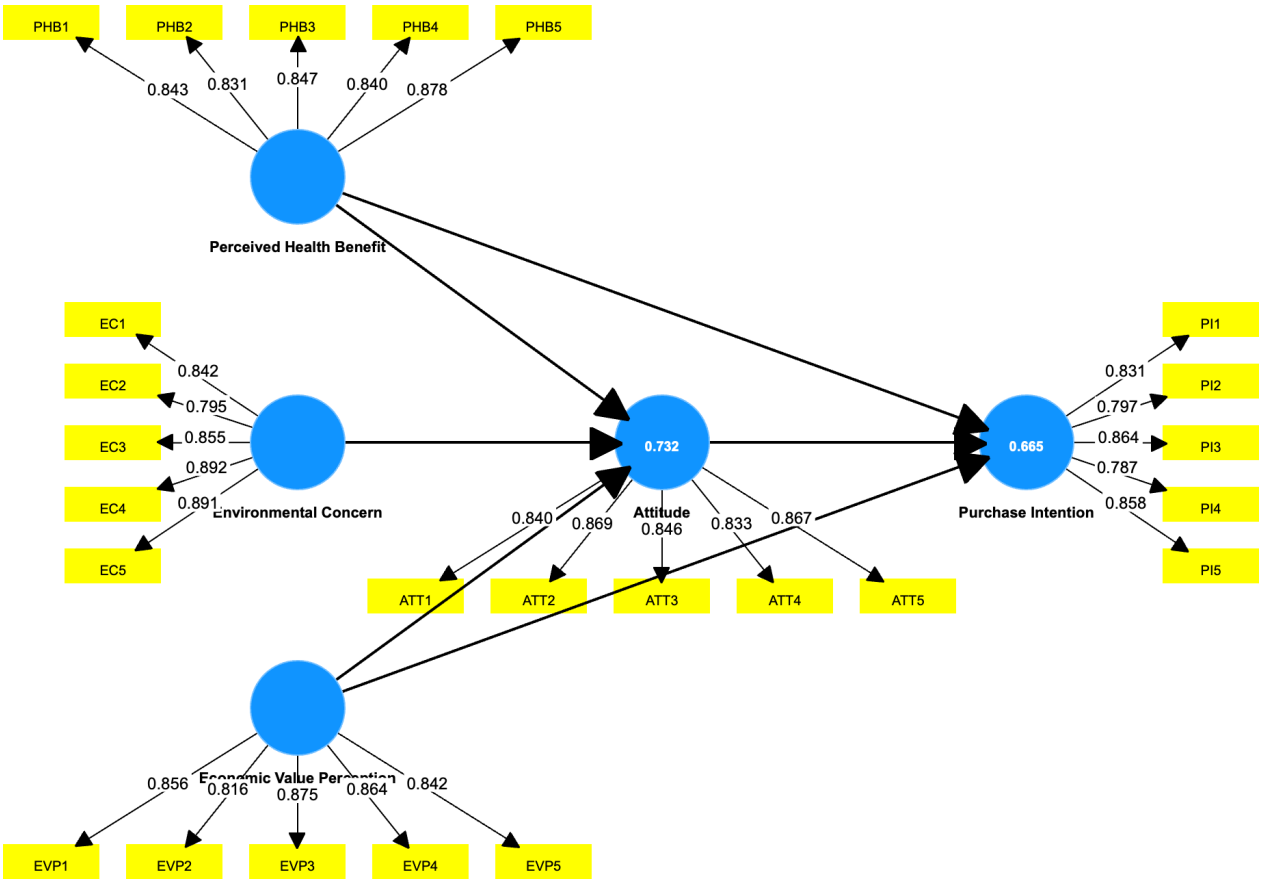

Figure 2. Outer model

With values ranging from 0.787 to 0.892, Table 4 demonstrates that all indicators loaded significantly on their corresponding structures. The loadings of attitude markers were constant (ATT1–ATT5 = 0.833–0.869), suggesting that respondents' perceptions of okara-based upcycled meals were largely steady. Additionally, Economic Value Perception demonstrated high indicator performance (EVP1–EVP5 = 0.816–0.875), indicating a tight alignment between the economic assessment construct and price, quality, and value-for-money items. Although EC2 had a comparatively lower score than other EC items, Environmental Concern showed the largest range of loadings (EC1–EC5 = 0.795–0.892), suggesting that respondents may have read carbon-footprint-related language less consistently. Additionally, the model's perceived health benefit indicators (PHB1–PHB5 = 0.831–0.878) were good, demonstrating the importance of perceptions of health and nutritional benefits.

Although purchase intention indicators need to be interpreted more carefully, they were kept since they surpassed the suggested loading level (PI1–PI5 = 0.787–0.864). Because okara-based upcycled foods are still relatively new and may not yet be widely available in the market, the comparatively lower loading of PI4 indicates that regular purchase intention may be more challenging for respondents to assess than trial, recommendation, or general purchase intention. Therefore, future research should further improve item wording, carry out formal pilot test-

Table 4. Outer loading.

	Attitude	Economic value perception	Environmental concern	PHB	Purchase intention
ATT1	0.840				
ATT2	0.869				
ATT3	0.846				
ATT4	0.833				
ATT5	0.867				
EC1			0.842		
EC2			0.795		
EC3			0.855		
EC4			0.892		
EC5			0.891		
EVP1		0.856			
EVP2		0.816			
EVP3		0.875			
EVP4		0.864			
EVP5		0.842			
PHB1				0.843	
PHB2				0.831	
PHB3				0.847	
PHB4				0.840	
PHB5				0.878	
PI1					0.831
PI2					0.797
PI3					0.864
PI4					0.787
PI5					0.858

ing, and investigate whether routine-purchase indicators remain stable across broader and more diverse consumer groups, even though the outer model supports the retention of all indicators for reliability, validity, and structural model testing (Hair et al. 2022; Guiné et al. 2023).

Reliability and validity test

Cronbach's alpha (α), composite reliability (ρA and ρC), and Average Variance Extracted (AVE) were used to evaluate construct reliability and convergent validity. Although Cronbach's alpha is frequently used to evaluate internal consistency, it has drawbacks due to its reliance on item equivalency assumptions and sensitivity to item quantity and similarity (Dunn et al. 2014; Taber 2018). Consequently, it was also said that composite reliability offered a supplementary evaluation of build dependability. By calculating the percentage of indicator variation explained by each concept in relation to measurement error, AVE was utilized to assess convergent validity. Reliability values over 0.70 and AVE values above 0.50 were deemed acceptable for reflected measurement models in accordance with standard PLS-SEM standards (Taber 2018; Hair et al. 2022).

According to Table 5, every concept satisfied the suggested standards for convergent validity and internal consistency. The composite reliability values (ρA = 0.889–0.911; ρC = 0.916–0.932) and Cronbach's alpha values (0.885–0.908) were also good. Each construct explained more than half of the variance in its indicators, with AVE values ranging from 0.686 to 0.732. Environmental Concern had the greatest reliability and AVE values among the constructs, indicating that the environmental items in this sample were highly aligned. Purchase Intention had the lowest dependability and AVE values, but it was still acceptable. This might be because buy intention components, such as trial, suggestion, frequent purchase, and sustainable decision, are more diversified. Because okara-based upcycled meals are very new and respondents may assess trial intention more readily than regular purchase intention, this difference seems reasonable.

Overall, these findings validate the measurement model's convergent validity and dependability for the current dataset. AVE and reliability coefficients, however, shouldn't be taken as definitive proof of measurement validity. High reliability does not eliminate the necessity for content validation, pilot testing, or replication across several consumer groups; it may also indicate similarity across items. Thus, while future research should further verify the instrument utilizing larger samples, improved item wording, and a rigorous pre-testing approach, the current results show measurement sufficiency for further structural model testing (Dunn et al. 2014; Taber 2018).

Discriminant validity test

To ascertain if theoretically different notions might be empirically distinguished from one another, discriminant validity was evaluated. Because it is frequently advised in PLS-SEM for identifying possible overlap among latent constructs, the heterotrait–monotrait ratio (HTMT) was employed. While results below 0.90 are sometimes understood as acceptable under a more liberal standard in behavioral research, HTMT scores below 0.85 are generally seen as conservative evidence of discriminant validity (Hair et al. 2022). Because they can suggest conceptual closeness or potential measurement overlap across notions, values that approach or surpass these thresholds call for diagnostic caution (Riou et al. 2016).

Table 6 demonstrates that the majority of HTMT values stayed below or around the widely accepted cutoff, indicating a satisfactory degree of discriminant validity for the measurement model. Nonetheless, the HTMT value between attitude and economic value perception was 0.907, which was just higher than the liberal 0.90 threshold. At 0.880, the HTMT score between Attitude and Purchase Intention was likewise comparatively high. These findings show that although the constructs are conceptually different, several of them are closely connected in terms of how respondents assessed upcycled dishes made from okara. This trend makes sense since overall product attitude may be significantly influenced by value-for-money assessments, and behavioral intention models predict a substantial relationship between attitude and purchase intention.

Table 5. Construct reliability and validity.

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Attitude	0.905	0.905	0.929	0.725
Economic value perception	0.904	0.906	0.929	0.724
Environmental concern	0.908	0.911	0.932	0.732
Phb	0.902	0.903	0.927	0.719
Purchase intention	0.885	0.889	0.916	0.686

Table 6. Discriminant validity.

	Attitude	Economic value perception	Environmental concern	PHB	Purchase intention
Economic value perception	0.907				
Environmental concern	0.841	0.837			
Phb	0.806	0.801	0.841		
Purchase intention	0.880	0.843	0.729	0.742	

As a result, rather than being unqualified proof of total construct separation, the discriminant validity results should be read cautiously. Because EVP indicates economic evaluation, Attitude reflects total product appraisal, and Purchase Intention reflects behavioral motivation, Economic Value Perception, Attitude, and Purchase Intention continue to be conceptually distinct. However, the comparatively high HTMT values indicate that future research should use other samples, improved item wording, HTMT confidence ranges, and measurement invariance testing to further confirm construct uniqueness. The measurement model satisfied reliability and convergent validity requirements, the structural model was intended to investigate theoretically grounded relationships among closely related consumer evaluation constructs, and the constructs were kept for the current study because their theoretical boundaries were clearly defined (Riou et al. 2016; Hair et al. 2022).

Structural model result

In PLS-SEM, adjusted R^2 takes model complexity into consideration, whereas R^2 shows the percentage of variation in an endogenous construct explained by its predictors. Particularly in behavioral research that employ latent variables and Likert-type survey data, these values are helpful for assessing explanatory power in variance-based modelling (Monecke and Leisch 2012; Hair et al. 2022). In addition to R^2, f2 was used to estimate how much the explained variance changes when a particular predictor is eliminated from the model in order to evaluate the relative effect size of each predictor. According to accepted standards, modest, medium, and large impacts are indicated by f^2 values of 0.02, 0.15, and 0.35, respectively (Hair et al. 2022).

According to Table 7, a significant amount of the variation in Attitude (R^2 = 0.732; adjusted R^2 = 0.730) and Purchase Intention (R^2 = 0.665; adjusted R^2 = 0.662) was explained by the model. After accounting for the number of predictors, the explanatory power appears to have been rather steady, as indicated by the little difference between R^2 and adjusted R^2. PHB, EC, and EVP together have excellent explanatory relevance for consumers' overall assessment of okara-based upcycled meals, according to the R^2 value for Attitude. Although almost one-third of the variation is still unexplained, the R^2 value for Purchase Intention shows that Attitude, PHB, and EVP explain a significant chunk of intention. This implies that future research might enhance the explanation of purchase intention by include other variables as perceived danger, food neophobia, subjective norm, product availability, flavor anticipation, or perceived behavioral control (Monecke and Leisch 2012; Hair et al. 2022).

Table 7. R^2 and F^2 value.

R^2	R-square	R-square adjusted
Attitude	0.732	0.730
Purchase Intention	0.665	0.662
F^2	**Attitude**	**Purchase Intention**
Attitude		0.191
Economic Value Perception	0.364	0.070
Environmental Concern	0.074	
PHB	0.041	0.017

The f^2 findings show that the predictors' contributions to the model were not equal. Value-for-money reasoning was the biggest factor in the creation of attitudes in this sample, according to Economic Value Perception, which had the largest impact size on Attitude (f^2 = 0.364). This conclusion has theoretical significance because, although consumers may favor circular or upcycled foods in theory, their overall assessment is likely to be heavily influenced by whether they believe the product is reasonably priced, practical, and worth its cost. PHB (f^2 = 0.041) and environmental concern (f^2 = 0.074) had less of an impact on attitude, suggesting that assessments pertaining to health and the environment served as supporting rather than dominant factors in the construction of attitudes (Yoon and Klasen 2018; Hair et al. 2022).

As the most significant proximal evaluative mechanism in the model, Attitude had a modest impact size (f^2 = 0.191) for Purchase Intention. The direct effect sizes of PHB (f^2 = 0.017) and EVP (f^2 = 0.070) on purchase intention were less, indicating that a large portion of the impact of sustainability-related assessments functions through the development of a positive attitude rather than through direct motivation alone. The suggested behavioral logic that health, environmental, and economic assessments are translated into purchase intentions primarily when they improve customers' general perceptions of okara-based upcycled meals is supported by this trend. However, these structural correlations should be seen as explanatory associations rather than causative effects because the study's methodology was cross-sectional.

Inner model of structural equation modelling

The structural model was evaluated to look at the suggested connections between the latent components once adequate measurement quality was confirmed. Standardized path coefficients (β) in PLS-SEM show the strength and direction of associations, and bootstrapping with a two-tailed significance criteria is typically used to assess statistical inference. In this study, the mediation hypotheses H7–H9 were tested using particular indirect effects through attitude, whereas H1–H6 were tested using direct effects. Using established PLS-SEM procedures for hypothesis testing and mediation analysis, this specification enabled the model to assess whether Attitude serves as the psychological mechanism connecting Perceived Health Benefit, Environmental Concern, and Economic Value Perception to Purchase Intention (Hair et al. 2022) (Fig. 3).

To ensure transparent hypothesis testing, the bootstrapping results are presented in Table 8, detailing the original standardized estimates (β), their sampling variability (STDEV), and the corresponding t-statistics and p-values for both direct hypotheses (H1–H6) and indirect (mediated) hypotheses (H7–H9).

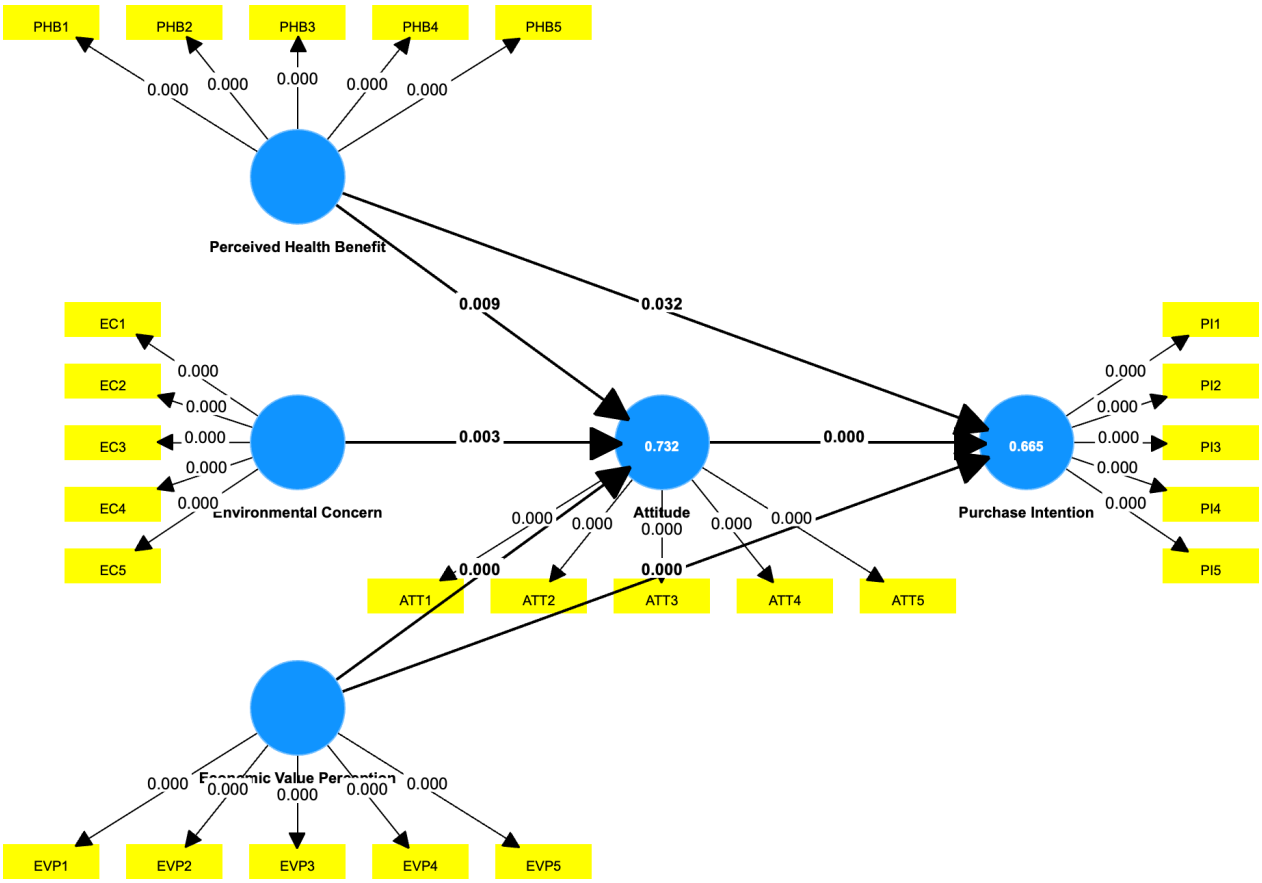

Figure 3. Inner model

Table 8. Path coefficient.

Direct hypothesis	Path coefficient	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
H1	PHB -> Attitude	0.171	0.168	0.066	2.595	0.009
H2	PHB -> Purchase Intention	0.117	0.120	0.054	2.147	0.032
H3	Environmental Concern -> Attitude	0.245	0.261	0.082	2.973	0.003
H4	Economic Value Perception -> Attitude	0.512	0.499	0.081	6.317	0.000
H5	Economic Value Perception -> Purchase Intention	0.284	0.284	0.063	4.529	0.000
H6	Attitude -> Purchase Intention	0.472	0.469	0.069	6.796	0.000
Indirect hypothesis	**Path Coefficient**	**Original sample (O)**	**Sample mean (M)**	**Standard deviation (STDEV)**	**T statistics (|O/STDEV|)**	**P values**
H7	PHB -> Attitude -> Purchase Intention	0.081	0.079	0.034	2.388	0.017
H8	Environmental Concern -> Attitude -> Purchase Intention	0.115	0.121	0.040	2.868	0.004
H9	Economic Value Perception -> Attitude -> Purchase Intention	0.241	0.234	0.054	4.441	0.000

The bootstrapping results (Hair et al. 2022), including standardized estimates, standard deviations, t-statistics, and p-values for the direct and indirect pathways, are shown in Table 8. The findings support Attitude's function as the model's proximal predictor of intention by demonstrating its positive and substantial effect on Purchase Intention (H6: $\beta = 0.472$, $t = 6.796$, $p < 0.001$). Economic Value Perception had the highest path coefficient toward attitude development (H4: $\beta = 0.512$, $t = 6.317$, $p < 0.001$), followed by Perceived Health Benefit (H1: $\beta = 0.171$, $t = 2.595$, $p = 0.009$) and Environmental Concern (H3: $\beta = 0.245$, $t = 2.973$, $p = 0.003$). This pattern implies that customers' attitudes on okara-based upcycled foods are mostly shaped by their assessment of value for money.

Positive and statistically significant findings were also found for the direct influence on purchase intention. Purchase intention was strongly impacted by economic value perception (H5: $\beta = 0.284$, $t = 4.529$, $p < 0.001$), whereas perceived health benefit had a lesser but still significant direct effect (H2: $\beta = 0.117$, $t = 2.147$, $p = 0.032$). These results demonstrate that economic and health-related assessments may have a direct impact on intention; nevertheless, the greater impact of attitude indicates that product appraisal is still a crucial process in transforming consumer assessments into buy intention.

Additional theoretical explanation is provided by the mediation results. Purchase intention was significantly influenced indirectly by perceived health benefit (H7: $\beta = 0.081$, $t = 2.388$, $p = 0.017$) and economic value perception (H9: $\beta = 0.241$, $t = 4.441$, $p < 0.001$). These findings suggest partial mediation as PHB and EVP both maintained strong direct effects on Purchase Intention. Purchase intention was significantly impacted indirectly by environmental concern through attitude (H8: $\beta = 0.115$, $t = 2.868$, $p = 0.004$). However, this conclusion should be taken as an attitude-mediated pathway rather than proof of full mediation because the model did not define a straight EC →PI connection. Overall, the findings in this sample confirm H1–H9 and indicate that attitude plays a significant role in the conversion of economic, environmental, and health assessments into purchase intention. However, these links should be understood as explanatory associations rather than causative effects because the study was cross-sectional and only available online.

Conclusion and suggestion

In order to explain customers' purchasing intentions toward okara-based upcycled meals in certain Semarang subdistricts, this study created and tested a Triple Sustainability-Driven Behavioral Intention Model. The results imply that the interplay of economic, attitudinal, health-related, and environmental assessments shapes consumers' intentions. In this sample, Purchase Intention was directly impacted by Economic Value Perception, which also seems to be the largest driver to Attitude. This suggests that value-for-money, price justice, product quality, and benefit-price justification may need to be highlighted in early market communication. Additionally, Purchase Intention was directly and indirectly impacted by Perceived Health Benefit through Attitude, indicating that when paired with acceptable sensory quality, realistic and believable nutrition-related messaging, including fiber and protein content, may enhance customer assessment. Purchase Intention through Attitude was influenced by Environmental Concern, suggesting that environmental marketing may be more successful when it enhances favorable product assessment rather than depending only on green claims.

Okara-based upcycled foods products may be launched for early market activation through channels including educational settings, reasonably priced retail channels, and internet advertising that are accessible to young, tech-savvy customers. However, given the sample was wholly online, student-focused, and predominately young, this advice should be taken with caution. First-trial obstacles relating to unfamiliarity, taste expectations, and perceived safety may be lessened with the use of trial-based tactics such product demonstrations, tasting sessions, and explicit product descriptions. Therefore, by integrating messaging about health, affordability, and circularity, product communication should continue to be straightforward, believable, and fair.

Methodological improvement should be a top priority for future research. First, to increase representativeness across age groups, vocations, and subdistricts, larger and more evenly distributed samples are required. Second, measurement invariance and multi-group variations among demographic segments—such as gender, student vs non-student groups, and younger versus older consumers—should be examined in future research. Third, it is advised to use experimental or longitudinal designs to see if the identified intention patterns hold true over time and translate into real purchasing behavior. To properly explain why positive attitudes may or may not result in routine purchase behavior, future models may additionally incorporate perceived risk, food neophobia, subjective norm, perceived behavioral control, product availability, and sensory assessment.

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Additional information

Conflict of interest
The authors have declared that no competing interests exist.

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No ethical statement was reported.

Artificial Intelligence (AI) use
The authors accept full responsibility for the content of the manuscript, including the disclosure of any use of AI.
Regarding the use of AI in the preparation of this manuscript, the authors declare the following: GPT
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The authors acknowledge the use of AI-assisted tools, including ChatGPT for supporting text structuring and interpretation, SciSpace for literature search, QuillBot for paraphrasing, and Napkin AI for graphical support. These tools were used exclusively for language refinement, literature organization, and visualization. No AI was used in data collection, data processing, or statistical analysis, and the authors are fully responsible for the interpretations and conclusions

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Author contributions
Siti Susanti: Supervision, conceptualization, validation, writing – review and editing, project administration. Nobel Kristian Tripandoyo Tampubolon: Conceptualization, methodology, investigation, data curation, formal analysis, writing – original draft. Mutia Intan Savitri Herista: Investigation, resources, data curation, writing – review and editing. Siswanto Imam Santoso: Supervision, validation, methodology, writing – review and editing. All authors have read and agreed to the published version of the manuscript.

Author ORCIDs
S. Susanti https://orcid.org/0000-0001-6046-0381
N.K.T. Tampubolon https://orcid.org/0009-0004-2943-5216

Data availability
All of the data that support the findings of this study are available in the main text.