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The Impact of Consumer Characteristics, Product Attributes, and Food Type on Polish University Students' Willingness to Pay More for Sustainable Insect-Based Foods

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Abstract

As part of urban sustainable food strategies, reducing land and emission footprints motivates interest in edible insects (EI) as a sustainable protein source. However, research on the determinants of young consumers' acceptance and willingness to pay for insect-based foods in Central and Eastern Europe remains limited. This study assessed whether Polish students are willing to pay more for foods containing EI when production is environmentally friendly. The analysis focused on identifying socio-demographic and product-related factors influencing willingness to pay a higher price. Data were collected in November 2023 through a nationwide Computer-Assisted Web Interview (CAWI) conducted via Google Forms among 947 Polish university students. A logistic regression model was applied to determine socio-demographic predictors, while exploratory factor analysis was used to identify latent dimensions of product attributes and food categories. Results revealed that gender and place of residence significantly affected willingness to pay, with women and urban residents showing higher readiness. Attributes related to convenience, availability, sensory appeal, health and nutrition claims, and CO_2 reduction benefits were the strongest positive correlates. The findings suggest pragmatic pathways for introducing insect-based foods into sustainable urban food systems and highlight the role of education in fostering environmentally responsible consumer behavior.

Keywords: urban food systems; edible insects; low-carbon land use; willingness to pay; sociodemographic approach

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1. Introduction

Urban food systems are a rapidly growing area within urban and regional planning, as cities face the dual challenge of ensuring food security and reducing the land footprint of food production [1–3]. Strictly controlled indoor vertical farming systems in urban agriculture show a high likelihood of economic viability [4,5]. Advances in urban food systems are making cities important sites of food production [6,7] reducing transport needs

and carbon dioxide emissions. Increasing urban self-sufficiency also enhances resilience during natural disasters, political conflicts, or epidemics [8].

Development efforts in urban agriculture should consider the interdependence of sustainability goals, identify key drivers and barriers and use local productivity potentials to improve livelihoods [8]. Rapid urbanization creates additional pressure on rural land, affecting food security. Ensuring food supply therefore depends not only on protecting arable land but also on improving soil quality, reducing agricultural pollution and enhancing resource efficiency [2]. Vertical systems can contribute to climate-resilient production by reducing land and water use, as well as pesticide and fertilizer emissions [9–11].

Urban agriculture combined with circular-economy protein sources is increasingly recognized as a key strategy for integrating food production into cities and strengthening urban–rural linkages [12]. Conventional livestock farming is one of the most land- and carbon-intensive sectors, constraining sustainable urban development [13,14]. In this context, sustainable food consumption emphasizes alternative protein sources that meet nutritional needs while minimizing environmental harm [15,16]. Edible insects (EI), endorsed by the FAO and scientific communities, offer high feed-to-protein efficiency and can be reared in vertically integrated facilities that require minimal space and resources. Integrating insect farming into urban systems through rooftop and indoor facilities can therefore support compact, low-carbon, and resilient food networks [8,17].

The European Union addressed the need for sustainable protein alternatives by adopting the Novel Foods Regulation 2015/2283 [18]. Under this framework, the Commission established a list of authorized novel foods [19], including *Tenebrio molitor* (yellow mealworm), *Locusta migratoria* (migratory locust), *Acheta domesticus* (house cricket), and the larvae of *Alphitobius diaperinus* (lesser mealworm), as reflected in the Union list and its amendments through 2023 [19]. Poland operates within this regulatory framework.

Studies show growing interest in incorporating edible insects into human diets, both as whole insects and as processed ingredients such as powders and flours. Insect flour has a favorable environmental profile and high nutritional value, and is increasingly used in foods such as bread [20–24], sponge cakes [25,26], shortbread biscuits [27], crackers [28], snack bars [29,30], extruded snacks [31–33], yogurts [34,35], ice cream [36], and meat substitutes such as burgers [37].

Despite these advantages, psychological barriers remain the main limitation to EI consumption among Polish consumers [38,39]. Disgust, fear and awareness of insect origin are strong deterrents [40]. Similar patterns were observed among students in Italy, Chile, Turkey and Saudi Arabia [15,41–43]. However, Polish Generation Z consumers appear more open to novel insect-based foods than older generations [44]. Education and income influence the perception of these products as healthy and environmentally friendly [45]. For environmental reasons, Generation Z tends to accept "hidden entomophagy," meaning insect ingredients incorporated into familiar processed foods rather than visible whole insects [38,39,44,46].

Market segmentation studies among Polish students indicate that psychological factors such as food neophobia, safety concerns and sustainability awareness, together with sensory attributes such as taste and aroma, are the strongest determinants of acceptance, while socio-demographic characteristics play a marginal role [47]. To improve acceptance, researchers recommend promoting processed insect-based products, improving education and labeling transparency, and highlighting environmental and health benefits [38,40,46,48].

Food-security challenges linked to urban expansion underscore the need for sustainable food production in both cities and rural areas. Vertically integrated urban insect production could help meet protein demand while reducing environmental pressure. Understanding whether consumers, especially students, are willing to pay more for envi-

ronmentally friendly insect-based foods is therefore essential for market development. Acceptance of hidden insect ingredients in familiar products could accelerate large-scale domestic production and reduce prices over time. Against this background, the present study links sustainable food consumption with urban development and land use efficiency. The aim of the present study was to address a gap in current research by examining the willingness of Polish Generation Z students to pay a higher price for foods containing EI, provided that these products are produced with reduced environmental impact. This work builds on prior research on consumer acceptance of EI, with a particular focus on younger cohorts, and tests whether perceived environmental benefits in the production process influence students' willingness to pay a price premium. The study had an exploratory character and was designed to identify preliminary patterns in consumers' willingness to pay rather than to empirically test a fully specified theoretical model.

The study tested the following hypotheses:

H1: *Socio-demographic characteristics (gender, place of residence, field of study, self-assessed financial situation) are associated with the level of willingness to pay a higher price for environmentally friendly insect-based foods.*

H2: *Perceptions of selected product attributes are associated with the willingness to pay a higher price for foods containing EI that are produced in an environmentally sustainable way.*

H3: *The type of insect-based product is associated with willingness to pay a higher price.*

2. Materials and Methods

2.1. Data Collection and Sample Characteristics

To assess the willingness of young consumers in Poland, specifically Generation Z, to pay a higher price for foods containing edible insects (EI), we conducted a survey among students at higher education institutions nationwide. The study protocol was reviewed and approved by the University Ethics Committee for Scientific Research at the Krakow University of Economics (KEBN/71/0044/D24/2023). A non-probability purposive sampling strategy was used, yielding a final sample of 947 participants. An empirical study was conducted in November 2023 using the Computer-Assisted Web Interview (CAWI) method via the Google Forms online platform. All respondents provided informed, voluntary consent and made aware of any potential risks associated with participation the CAWI survey.

The survey was conducted among Polish university students representing Generation Z, as this cohort is expected to capture an increasingly significant share of global consumer markets by 2030. Currently, Generation Z constitutes approximately 40% of the global consumer population and is shaping emerging market trends that will define products and services in the near future [49]. Their collective spending power is projected to reach around USD 12 trillion by 2030, positioning them as one of the most influential consumer groups in history [50]. Moreover, Generation Z already demonstrates faster growth in expenditure compared with older generations [51]. As this generation matures and enters its peak earning years, its importance as a consumer group will continue to grow, particularly in markets driven by innovation, sustainability, and novel food technologies. A high level of digital engagement, a strong value orientation (e.g., environmental awareness and ethical consumption), and openness to innovative products make Generation Z a strategically important group for studying willingness to pay for sustainable insect-based foods.

The research instrument was an online questionnaire administered via a CAWI platform and comprised two main sections. The first section collected data on quantitative

variables, including willingness to pay a higher price for new, innovative foods containing EI, provided that production is environmentally sustainable. Respondents also indicated their readiness to consume such foods across product forms, including burgers and other processed meat products, ready-to-eat meals such as soups, pasta, or pancakes, baked products including bread, rolls, and pizza, and confectionery such as cakes, cookies, chocolate-coated insects, or sweet pastries. Additional categories included snack bars, crisps and other snacks, post-workout beverages and high-protein supplements, dairy products such as yogurts and cheese, sauces and mayonnaise, as well as items produced with crickets, mealworm larvae (*Tenebrio molitor*), or migratory locusts (*Locusta migratoria*) in frozen, dried, or powdered forms [44].

The survey further examined how selected product attributes shape purchasing decisions for insect-based foods. Considered attributes included sensory characteristics such as taste, aroma, and appearance, high nutritional value, market availability and variety, popularity, affordable price, and packaging appeal. Functional qualities such as ease of use, health and nutrition claims, reduced carbon emissions, and the availability of recipes on blogs and websites were also included [46].

Participants rated their agreement with each statement on a five-point Likert scale, where 1 meant "definitely no," 2 "no," 3 "I do not know/no opinion," 4 "yes," and 5 "definitely yes" [52].

To assess willingness to pay a higher price for EI foods produced in an environmentally friendly manner, respondents were grouped by their average response scores. The classification used the mean (X) and standard deviation (SD): low willingness (scores $\leq X - SD$), moderate willingness ($X - SD <$ scores $< X + SD$), and high willingness (scores $\geq X + SD$). According to this categorization, 25.67% of respondents were highly willing to pay more, 29.78% showed moderate willingness, and 44.55% reported low willingness to pay a premium, conditional on environmentally sustainable production.

The second section gathered sociodemographic data, including gender, place of residence, and a subjective assessment of financial situation. To improve the clarity of statistical comparisons and ensure adequate cell sizes, selected categories were aggregated. For field of study, disciplines with relatively small counts were grouped into two broader categories. The Natural Sciences category included medical and health sciences, agricultural sciences, and natural and physical sciences, reflecting their emphasis on empirical research and applied learning. The Social Sciences and Humanities sciences combined social sciences and humanities, which focus on social, cultural, and psychological phenomena.

For place of residence, respondents from cities with 150,000–500,000 inhabitants and those from cities with more than 500,000 inhabitants were combined into a single category of cities over 150,000 residents. This grouping reflects the comparable characteristics of large urban environments and supports balanced analytical subgroups.

For perceived economic status, responses were consolidated into two groups. Individuals who rated their situation as "insufficient" or "sufficient" were classified as lower economic status, while those reporting a "very good" situation or a "exceptionally high status" were classified as higher economic status. This aggregation facilitates clearer interpretation and reduces bias arising from underrepresented subgroups.

2.2. Statistical Analyses

To achieve the study objectives, we applied a three-stage analytical procedure. The primary aim was to assess how socio-demographic variables relate to the willingness of Polish students to pay a higher price for foods containing edible insects (EI) in the context of sustainable production.

In the first stage, an ordinal logistic regression model based on the proportional odds assumption was applied to identify socio-demographic determinants of respondents' willingness to pay a higher price for food products containing edible insects (EI). The dependent variable represented three ordered levels of willingness: low, moderate, and high. Explanatory variables included gender, field of study, place of residence, and self-assessed economic status.

The model was estimated using maximum likelihood estimation within the OrderedModel framework of Python's (version 3.11) statsmodels library, employing a logit link function. For categorical predictors, reference categories were set as follows: men for gender, engineering and technical sciences for field of study, rural areas for place of residence, and lower economic status for self-assessed material situation. Model performance was evaluated both in-sample and through five-fold stratified cross-validation. In-sample model accuracy was 0.444, with a mean absolute error (MAE) of 0.815 and a quadratic weighted Cohen's kappa of 0.010, indicating moderate ordinal alignment between predicted and observed categories. Cross-validation produced comparable results (Accuracy = 0.436, MAE = 0.830), suggesting limited generalization capacity. The overall model significance was confirmed by the omnibus likelihood-ratio test ($\chi^2 = 18.1$, df = 7, $p = 0.012$). Although the model exhibited only moderate classification performance, such outcomes are typical for exploratory ordinal regression analyses involving attitudinal data, where the primary aim is to identify statistically significant associations rather than to achieve high predictive precision. In the second step, predictors for the ordered-outcome model were derived by conducting an exploratory factor analysis (EFA) on items measuring acceptance of EI product formats and purchase attributes. Because the items were ordinal, original five-point Likert responses (1 "definitely no," 2 "no," 3 "I do not know/no opinion," 4 "yes," 5 "definitely yes") were recoded to a three-category scale by collapsing 1–2 into "no" and 4–5 into "yes." EFA was performed on polychoric correlation matrices with oblimin rotation, given a priori expectations that factors may correlate. Sampling adequacy was confirmed as excellent, with KMO = 0.921 for product categories (all MSA $\geq$ 0.851) and KMO = 0.945 for purchase attributes (all MSA $\geq$ 0.899). Bartlett's tests were significant for both instruments ($p < 0.001$), supporting factorability. For product categories, a four-factor solution fit the data and explained 80.8% of variance (SS loadings: 2.79, 2.99, 1.53, 1.57). For purchase attributes, a three-factor solution explained 73.5% of variance (SS loadings: 3.42, 3.50, 2.62). The following composites were obtained: Whole/Visible Insects; Processed Staples and Basics; Sweet Snacks and Confectionery; Dairy and Sauces; and Sensory Appeal; Market Access and Convenience; Claims (Health/Nutrition/CO_2). Item responses were first z-standardized and then combined into weighted composite scores using factor loadings. Weights were renormalized on a row-wise basis when any indicator was missing. The resulting composites were re-standardized (M = 0, SD = 1) so that regression coefficients reflect a one standard deviation increase. Two-indicator factors (Sweet Snacks and Confectionery; Dairy and Sauces) were retained as weighted scores but interpreted with caution.

In the third step, willingness to pay a higher price for foods containing edible insects was modeled as a three-category ordered outcome (low, moderate, high) using the full sample (n = 947). The seven standardized composites derived in the second step were entered as predictors. A cumulative logit proportional-odds model including all seven composites converged without issues (n = 947; AIC = 1711.08). Per-predictor nominal tests indicated no violations of proportional odds. Estimated thresholds were ordered and well separated (low | moderate = -0.295; moderate | high = 1.424), which supports a coherent latent continuum.

3. Results

The analysis included 947 university students, of whom 568 were women (60.0%) and 379 were men (40.0%). Clear gender patterns emerged across fields of study: men were predominantly enrolled in engineering and technical sciences (57.00%), while women were more frequently represented in social and humanities sciences (49.30%) and also showed a stronger presence in the natural sciences (20.24%).

The residential structure was broadly similar across genders. The largest share of respondents came from rural areas (about 36–37%), followed by those living in small and medium-sized towns (approximately one-third overall), and large cities (27–32%).

In terms of self-reported economic status, most participants described their situation as good (around 53%), while smaller proportions reported lower (23–27%) or higher (20–23%) status. Gender differences in this regard were minimal (Table 1).

Table 1. Sample characteristics after category consolidation by gender.

Variable	Men		Women	
	N	%	N	%
Gender	379	40.00	568	60.00
Field of study				
Engineering and technical sciences	216	57.00	173	30.46
Social and humanities sciences	132	34.83	280	49.30
Natural sciences	31	8.17	115	20.24
Place of residence				
Rural area	137	36.15	212	37.33
Town (up to 50,000 inhabitants)	66	17.41	101	17.78
Town (50,000–150,000 inhabitants)	56	14.78	101	17.78
City (>150,000 inhabitants)	120	31.66	154	27.11
Self-reported economic status				
Lower economic status	88	23.22	154	27.11
Good economic status	202	53.30	300	52.82
Higher economic status	89	23.48	114	20.07

3.1. Socio-Demographic Factors and Willingness to Pay for EI Foods

Based on the results of the ordinal logistic regression model two socio-demographic factors, gender and place of residence, emerged as statistically significant predictors of respondents' willingness to pay a higher price and to consume foods containing edible insects (Table 2). Women demonstrated a significantly higher likelihood of expressing greater willingness compared to men (β = 0.388, p = 0.003), corresponding to an odds ratio of 1.47. This indicates that the odds of reporting a higher level of willingness were approximately 47% greater for women than for men. A similar upward trend was observed for place of residence. Respondents living in large cities (>150,000 inhabitants) showed a 1.48-fold increase in the odds of higher willingness relative to those living in rural areas (β = 0.389, p = 0.012). For individuals residing in medium-sized towns (up to 150,000 inhabitants), the effect was positive but did not reach statistical significance (p = 0.095) (Table 2). Neither field of study nor self-assessed economic status showed a statistically significant relationship with willingness.

Table 2. Socio-demographic predictors of willingness to pay and consume EI foods.

Predictor	Coef.	SE	z	*p*	95% CI	OR
Female (vs. male)	0.388	0.130	2.976	0.003	(0.133–0.645)	1.474
Social and humanities sciences (vs. engineering and technical sciences)	−0.216	0.139	−1.556	0.120	(−0.489–0.056)	0.806
Natural sciences (vs. engineering and technical sciences)	−0.016	0.188	−0.085	0.932	(−0.386–0.352)	0.984
Town up to 150,000 inhabitants (vs. rural area)	0.246	0.147	1.672	0.095	(−0.042–0.535)	1.279
City > 150,000 inhabitants (vs. rural area)	0.389	0.154	2.525	0.012	(0.087–0.691)	1.475
Good economic status (vs. lower)	0.129	0.145	0.891	0.373	(−0.154–0.414)	1.138
High economic status (vs. lower)	0.275	0.177	1.549	0.121	(−0.072–0.622)	1.316

3.2. Exploratory Factor Analysis of EI Product Categories and Purchase Attributes

For product categories (Table 3), a four-factor structure was obtained. Loadings within factors were robust, typically 0.511–0.980, with no substantive cross-loadings. The factors correspond to Whole/Visible Insects, Processed Staples and Basics, Sweet Snacks and Confectionery, and Dairy and Sauces.

Table 3. Factor loadings of food products containing edible insects.

Product	F1 *	F2	F3	F4
Burgers and processed meat products		0.862		
Ready-to-eat meals (soups, pasta, pancakes, sauces)		0.850		
Bakery products (bread, rolls, pizza, etc.)		0.757		
Confectionery (cakes, cookies, chocolate-coated insects, desserts)			0.989	
Snacks (bars, crisps)			0.512	
Post-workout beverages and high-protein supplements		0.511		
Dairy-based products (e.g., cottage cheese, yogurts)				0.979
Sauces and mayonnaise				0.431
Cricket (frozen, dried, or powdered form)	0.894			
Mealworm larvae (frozen, dried, or powdered form)	0.928			
Migratory locust (frozen, dried, or powdered form)	0.980			

F1 *—Whole/Visible Insects, F2—Processed Staples and Basics, F3—Sweet Snacks and Confectionery, F4—Dairy and Sauces.

For purchase attributes (Table 4), a three-factor structure emerged. Within-factor loadings generally ranged 0.600–0.946 for Sensory Appeal, Market Access and Convenience, Claims (Health/Nutrition/CO_2).

Table 4. Factor loadings for attributes of foods containing edible insects.

Product Attribute	F1 *	F2	F3
Appealing taste	0.917		
Pleasant aroma	0.906		
Attractive appearance	0.808		
High nutritional value			0.401
Product variety and market availability		0.600	
Popularity (trendiness)		0.614	
Affordable price		0.442	
Package size and attractiveness		0.712	
Ease of use		0.608	
Health claims			0.946
Nutrition claims			0.917
Reduction in CO_2 emissions			0.472
Recipe availability on blogs and websites		0.791	

F1 *—Sensory Appeal, F2—Market Access and Convenience, F3—Claims (Health/Nutrition/CO_2).

3.3. Willingness to Pay and Effects of Product Formats and Purchase Attributes

Based on the cumulative logit model with seven standardized composites (n = 947), market and usage attributes and claims emerged as the strongest positive correlates of higher willingness to pay. Both composites were statistically significant and consistent in magnitude. Among product formats, dairy and sauces and sweet snacks showed modest positive associations, whereas whole/visible formats and processed staples and basics did not add predictive value in the additive specification.

At the coefficient level, significant positive associations (per +1 SD in the composite) were observed for Market Access and Convenience, Claims (Health/Nutrition/CO_2), Dairy and Sauces, and Sweet Snacks and Confectionery. The remaining composites Whole/Visible Insects, Processed Staples and Basics, and Sensory Appeal were not significant (Table 5). Cut-points were ordered and well separated (low | moderate = −0.295; moderate | high = 1.424), confirming a coherent latent continuum; predictor effects are interpreted as shifts on this latent scale relative to these fixed thresholds (Table 6).

Table 5. Effects of Product and Attribute Composites on Willingness to Pay.

Composite	Estimate	SE	OR	95% CI	z	*p*
Whole/Visible Insects	0.076	0.079	1.08	(0.92–1.26)	0.962	0.336
Processed Staples and Basics	0.110	0.120	1.12	(0.88–1.41)	0.911	0.362
Sweet Snacks and Confectionery	0.216	0.103	1.24	(1.01–1.52)	2.098	0.036 *
Dairy and Sauces	0.227	0.103	1.26	(1.03–1.54)	2.210	0.027 *
Sensory Appeal	−0.092	0.109	0.91	(0.74–1.13)	−0.847	0.397
Market Access and Convenience	0.512	0.125	1.67	(1.31–2.13)	4.098	<0.001 ***
Claims (Health/Nutrition/CO_2)	0.430	0.103	1.54	(1.26–1.88)	4.191	<0.001 ***

OR reflect the change in odds per +1 SD in each composite. * $p < 0.05$; *** $p < 0.001$.

Table 6. Cut-point estimates for the cumulative logit model of willingness to pay.

Threshold (Category Split)	Estimate	SE	z	OR	95% CI	*p*
Low | Moderate	−0.295	0.076	−3.893	0.744	(0.641–0.864)	<0.001
Moderate | High	1.424	0.088	16.104	4.152	(3.492–4.938)	<0.001

Market and usage-related cues are the strongest correlates: a one standard deviation increase in Market Access and Convenience is associated with about a 67% rise in the odds of belonging to a higher willingness-to-pay category, while stronger emphasis on Claims (Health/Nutrition/CO_2) corresponds to roughly a 54% increase. Among product formats, Dairy and Sauces and Sweet Snacks and Confectionery are linked to more modest gains, about 26% and 24%, respectively, indicating that acceptance of these familiar, processed formats contributes positively, though less strongly than attribute-based signals. By contrast, shifts in Whole/Visible Insects, Processed Staples and Basics, and Sensory Appeal correspond to odds ratios near 1, implying little to no meaningful change in the probability of higher willingness to pay (Table 5).

Attribute-driven factors, that is market and use signals (assortment and availability, popularity, price, packaging, convenience, recipe visibility) and the salience of health, nutrition, and CO_2 claims, are the principal correlates of higher stated willingness to pay. Product-format effects are smaller and category dependent, with positive associations concentrated in dairy and sauces and in sweet snacks. The modeling strategy, which combines polychoric-based weighted composites with a cumulative logit specification, preserves ordinal measurement, reduces item-level noise through thematic aggregation, and yields effects interpretable per +1 SD. Typical limitations of three-point scales, for

example, rotation warnings and limited reliability for two-item composites, were noted but did not materially affect inference stability (Tables 5 and 6).

The results indicate that young consumers' willingness to pay a higher price is shaped primarily by cues that facilitate everyday choices, namely market access and convenience, together with credible information on health, nutrition, and CO_2 reduction, while socio-demographic characteristics play a smaller and selective role. Product format matters in a moderate, category-dependent way, with higher acceptance for processed, familiar forms such as dairy and sauces and sweet snacks, which suggests pragmatic pathways for introducing insect-based products into the diets of urban consumers. This orientation supports shorter supply chains, integration with urban circular-economy systems, and reductions in land use and emissions, while aligning with Generation Z's expectations for functionality, transparent labeling, and trustworthy information.

4. Discussion

In the context of Polish urban food systems, the ecological benefits of producing edible insects and insect-containing foods may translate into sustainable urban development, stronger urban–rural integration, and improved food security during crises. The literature emphasizes the need to understand consumer profiles and to develop attractive attributes of insect-based products in order to increase acceptance of entomophagy [53], which is consistent with the concept of controlled indoor vertical farming systems in urban agriculture. It is therefore important to obtain evidence on consumers' willingness to bear higher purchase costs for novel, sustainable foods, including among members of Generation Z in Poland. University students [46], in contrast to other population groups in Poland [45], report positive attitudes toward purchasing foods that contain insect ingredients.

The findings of this study indicate that willingness to pay a higher price for novel, innovative foods containing EI, when produced in an environmentally sustainable manner, is shaped by both socio-demographic factors and perceptions of product attributes and food types. In particular, gender, place of residence, and self-assessed economic status emerged as significant predictors, consistent with prior research showing that women and urban residents tend to be more open to sustainable or alternative food sources [54,55]. In our model, young women, individuals living in larger cities, and those reporting moderate, good, or very good economic status exhibited a significantly higher willingness to incur greater food costs, which may reflect heightened environmental awareness and better access to a wider range of innovative products [56].

Moreover, the findings indicate that product attributes such as availability, convenience, popularity, recipe availability on blogs, packaging, sensory appeal, health and nutrition claims, and the reduction of carbon dioxide emissions play a crucial role in shaping consumers' willingness to pay. These results are consistent with the conclusion of van Huis et al. [16], who emphasize the importance of practicality and the integration of EI into familiar and culturally accepted culinary forms. Furthermore, individuals with low willingness to pay a higher price for foods containing edible insects exhibited the strongest correlations between perceived product attributes and acceptance, suggesting that acceptance within this group depends on the fulfillment of a broad range of sensory and functional expectations [57].

It is particularly noteworthy that young consumers' belief in the environmental benefits of EI production and consumption, especially in terms of reducing CO_2 emissions, was among the three strongest predictors of willingness to pay a higher price. This underscores the growing salience of environmental concerns in young people's food choices [58]. Interestingly, even some respondents who were unsure about the environmental impact of insect consumption nevertheless reported greater willingness to pay, which suggests that environ-

mental messaging may help build acceptance of insect-based foods. Accordingly, there is potential for the development of urban food systems, as urban consumers appear to be the only group demonstrating even a modest yet noticeable willingness to pay a higher price for foods containing edible insects, driven by their concern for the natural environment.

Beyond confirming patterns observed in earlier studies conducted in Western Europe, this research extends existing evidence to Central and Eastern Europe and focuses on Generation Z consumers, whose sustainable consumption behaviors remain insufficiently explored. By combining socio-demographic and product-level determinants, the study provides a more integrated understanding of willingness to pay for sustainable insect-based foods in an emerging market context. Our research has practical implications. It highlights the need to develop a comprehensive strategy for introducing sustainable foods containing edible insects to the Polish market, tailored to the varying levels of Polish students' willingness to pay a higher price for such products. For the most receptive consumers, communication should emphasize the environmental benefits of EI production and consumption. For moderately interested individuals, the focus should be on practical attributes, such as convenience, availability, sensory attractiveness, nutritional information, and health claims. For more skeptical consumers, familiar formats, such as bread or ready meals, may ease adoption. Reducing negative sensory associations, particularly regarding taste and appearance, is also essential for engaging undecided consumers [59].

Studies conducted outside Poland have consistently shown that young adults, men, and individuals with low levels of food neophobia and high culinary curiosity tend to exhibit the greatest openness toward entomophagy [55]. The strongest predictors of rejection of insects in the diet, as identified in Belgium [55], Hungary [60], Denmark [61], among Chinese consumers [62], and among Polish students [46], include neophobia and disgust. Research conducted at Chinese universities has shown that most students were unfamiliar with and unwilling to consume insect-based foods [62]. In studies conducted among Polish university students, acceptance of foods containing edible insects was found to be most strongly correlated with a hedonistic orientation (particularly among young men), low attachment to regional culinary traditions (among both men and women), and high nutritional value awareness and health consciousness (especially among young women) [63].

The findings from international studies are consistent with the present results, indicating that the format in which insect-based products are offered plays a crucial role in shaping consumer acceptance. Snack-type and highly processed foods, such as energy bars, crisps, burgers, sweets, cheeses, yogurts, ice cream, bread, pasta, and baked goods enriched with insect flour, are generally more acceptable than dishes containing visible insects [34–37,64–67]. The species of insect also influences food acceptance. Insects perceived as less disgusting, such as grasshoppers or mealworms, and those presented in more processed, non-visible forms tend to be evaluated more positively than products with visible insect parts [68–70].

Kornher et al. [65] identified three consumer segments in Germany in relation to the acceptance of insect-based burgers. The largest segment expressed a willingness to try such burgers without requiring a price discount, indicating that they were prepared to pay a price comparable to that of conventional meat products. Nevertheless, a considerable share of respondents still reported feelings of disgust and demonstrated no purchase intention. Poortvliet et al. [71] highlighted the ambivalence of consumers who perceived insect-based "meat" as healthy yet simultaneously off-putting. Similarly, a study by Balzan et al. [72] conducted among young adults in Italy revealed that, despite increasing awareness of edible insects, actual willingness to consume them in sweet products remained low. However, some studies provide evidence supporting consumers' readiness to include edible insects in their diets. Woolf et al. [73] found that factors such as gender and awareness of the

benefits of insect-based foods influenced Americans' willingness to consume such products. Overall, U.S. consumers demonstrated curiosity, particularly toward snack-type items marketed as healthy and high in protein [73].

In our study, the type of EI-based food showed a moderate influence on young consumers' willingness to pay a higher price. In the cumulative logit model with seven standardized composites, positive, though modest, associations were observed for the dairy and sauces category and for sweet snacks, whereas whole or visible formats and processed staples and basics did not improve model fit in the additive specification. These results point to pragmatic entry pathways for introducing insect-based foods into urban diets. Although mean acceptance appeared lowest for migratory locust products, this difference was not statistically significant, so it should be interpreted cautiously. Taken together, the findings suggest that Generation Z students tend to favor simple, familiar, and functional products.

Our results further indicate that awareness of potential benefits of edible insects is increasing among young Polish consumers, likely reflecting a growing recognition that insect farming can be more sustainable than conventional livestock production. Demographically, the most receptive segment comprises young, well-educated, urban residents, among whom approximately 55% reported a willingness to purchase insect-based foods. To bridge the gap between consumer behavior and the development of sustainable urban systems, it is therefore essential to implement educational initiatives targeting this group, as confirmed by the results of the conducted analyses. The findings also made it possible to identify a segment of students, representing young consumers in Poland, who are willing to purchase edible insect–based products at higher prices than conventional foods, provided that their production contributes to reducing environmental degradation. In the coming years, additional research will likely document whether acceptance of EI-based foods increases among Polish consumers. For such growth to occur, the market should introduce EI products that match well-known and widely accepted formats, especially those embedded in the everyday diets of young people in Poland. This orientation supports shorter supply chains, integration with urban circular-economy systems, and reductions in land use and emissions, while meeting Generation Z expectations for functionality, transparent labeling, and trustworthy information.

5. Conclusions

In this study, we examined how the willingness of young consumers, specifically Generation Z students, to pay a higher price for foods containing edible insects relates to socio-demographic characteristics, gender, place of residence, field of study, and self-assessed economic situation, as well as to product attributes and the type of EI-based food.

Interpreting the results against our hypotheses gives a clear, if nuanced, picture. For H1, socio-demographic differences were present but not overwhelming. Women, students living in larger cities, and those reporting a higher economic status were more likely to fall into the higher willingness-to-pay category, while field of study did not matter. Demographics therefore shape readiness to some extent, yet they do not account for most of the variation we observe.

H2 finds strong support. When students perceived better market access and convenience and when health, nutrition, and CO_2 claims felt salient and credible, their stated willingness to pay increased. These attribute-based cues, which signal that products are easy to find and use and come with meaningful information, emerged as the most consistent correlates in the model, whereas sensory appeal alone did not show an independent association.

H3 is supported only in part. Acceptance of familiar, processed formats, especially dairy and sauces and sweet snacks, was linked to higher willingness to pay, while whole

or visible insect formats and processed staples did not add explanatory value once other factors were considered. Product form therefore matters, but its influence is smaller than that of purchase attributes and appears to be category-specific. The positive, yet modest, effects for dairy and sauces and for sweet snacks align with the broader pattern that processed, non-visible formats are more acceptable than visible ones, reinforcing the case for "hidden entomophagy" as a pragmatic market entry route.

Taken together, the evidence suggests that who the consumer is matters less than how the product is framed and where it fits into everyday routines. Clear market presence, practical usability, and trustworthy claims do more to shift willingness to pay than demographic profiles or the visibility of the insect ingredient.

Polish students' willingness to pay a higher price for foods that contain edible insects in hidden form, for example, finely milled into flours used as ingredients in familiar products, stems from acceptance of foods with high nutritional and health value that are produced within sustainable food systems. Students at Polish universities express concern for the environment in the context of food production with a reduced carbon footprint. Among young Poles this environmental concern can translate in practice into more sustainable urban development, more efficient land use, and stronger integration between urban and rural areas in Poland.

Our study underscores the importance of understanding the needs of Generation Z, illustrated here by students at Polish universities, and of leveraging product attributes that are attractive to this group in order to implement urban food systems that reduce cities' dependence on foods imported from rural areas. Our examination of local urban food self-sufficiency reveals the complexity of this process and highlights the urgent need for regionally grounded interventions that harness motivational factors, including environmental benefits and social acceptance.

5.1. Limitations

Several limitations should be considered when interpreting these results. The sample consisted of students, recruited with a non-probability strategy; therefore, generalizability to the wider population is limited. The cross-sectional design, based on self-reports collected through a CAWI survey, does not permit causal inference and may be affected by response biases. Measurement choices, including collapsing five-point items into three categories and building two-indicator composites for some factors, constrain reliability and precision. Although the ordered logit assumptions were checked, minor deviations cannot be fully ruled out. Model discrimination was modest, which indicates that important psychological or cultural determinants were not observed.

The results of this study should not be interpreted as categorical recommendations but rather as indicative findings and supplementary insights that enhance our understanding of the investigated issue. The model analyzed in this research, illustrating the relationships between qualitative variables describing potential young consumers of edible insect-based foods and specific product attributes and food types, indicates the directions for future research that may provide the foundation for developing integrated urban food systems. Future studies should be conducted on a representative sample of young urban consumers in Poland and should also consider the multicultural context of city residents.

5.2. Recommendation for Future Studies

Future research should aim to validate the findings of this exploratory study using larger, representative samples of young urban consumers in Poland and other Central and Eastern European countries. Comparative studies across diverse cultural contexts could

clarify whether the observed patterns, particularly the effects of gender, place of residence, and environmental awareness, generalize beyond the Polish setting.

Further research should also integrate psychological and behavioral constructs, such as food neophobia, perceived risk, and moral attitudes toward sustainability, to capture additional explanatory variance in willingness to pay. Applying experimental or longitudinal designs could help determine causal mechanisms underlying the relationship between perceived environmental benefits and consumer acceptance of insect-based foods.

Finally, future studies could employ discrete choice experiments or conjoint analysis to estimate specific price premiums consumers are willing to pay for different product types and labeling schemes. Such evidence would strengthen the practical relevance of consumer research for sustainable food system design and for marketing strategies promoting edible insect-based products in urban markets.

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Data Availability Statement: All relevant data for this study are publicly available from the Github repository.

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