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EDIBLE INSECTS AS A POTENTIAL PRODUCT FOR ACHIEVING GLOBAL FOOD SECURITY. PART 2

S u m m a r y

Background. Insect consumption (entomophagy) is increasingly becoming the focus of attention, not only for economic reasons, but also due to environmental and health benefits. Achieving environmentally sustainable food security is one of the greatest global challenges today. A wide range of edible insect species, which are rich in protein, fat, minerals, vitamins and dietary fiber, can play a significant role in addressing the issue of global food insecurity. In addition, insect farming can be a sustainable way to produce food. However, consumer acceptance remains a major obstacle to regarding insects as a food source in many countries, including Europe. The purpose of this study was to determine whether health and environmental concerns would be associated with the willingness to consume foods containing edible insects (fresh, frozen, dried, powdered ones, e.g. meal) with the intention of ensuring food security and environmental sustainability. An empirical study was conducted among students at five Polish universities. The survey questionnaire included statements related to attitudes toward natural foods and concerns about health, the environment, food security and environmental sustainability.

Results and conclusions. Respondents' acceptance of foods containing edible insects as a solution to (or support in solving) the problem of global food insecurity was most highly correlated with concern for health and the environment. Gender also differentiated perceptions of food security issues. For women, issues related to the nutritional value of products with edible insects and environmental aspects were sig-

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nificantly more important than for men. Young people having positive attitudes toward the naturalness of food were significantly more likely than other respondents to agree that implementing the practice of consuming foods that contain edible insects in them could provide access to foods with high concentrations of n-3 fatty acids, ensure sustainability in food production and reduce greenhouse gas emissions.

Keywords: concern for the environment, concern for health, naturalness of food, sustainability, entomophagy, edible insects, willingness to consume, young consumers (generation Z), Poland

Introduction

Edible insects are a regular component of a human diet in many regions of the world. Today, more than 1,900 species of edible insects are consumed worldwide, with more than 100 in Mexico alone, for example, and it is estimated that more than two billion people worldwide regularly consume insects [59]. Commonly consumed insects, according to their percentage of consumption, include *Coleoptera* (beetles) (31 %), *Lepidoptera* (caterpillars) (18 %), *Hymenoptera* (ants, bees and wasps) (14 %), *Orthoptera* (grasshoppers, locusts and crickets) (13 %), *Hemiptera* (cicadas, leafhoppers, planthoppers, scale insects and true bugs) (10 %), *Isoptera* (termites) (3 %), *Odonata* (dragonflies) (3 %) and *Diptera* (flies) (2%) [26]. Today, quite an assortment of insects are consumed in sub-Saharan Africa, Latin America, Australia and South-Eastern Asia. In Africa, for example, insects are an important source of food, providing food security when staple foods such as rice are in short supply or when the availability of food as a source of protein decreases during the rainy season [1, 2, 56, 63].

The development of agriculture in North-Eastern Africa, Western Asia and Europe has led to the domestication of a wide range of animals, which have become the main providers of animal-based food and wool and leather in these regions [8]. This may have contributed to a lack of interest in insects as a food source [8]. Therefore, eating insects has never become accepted in European and North American food culture. Insects in these regions are still sold only as novelty snacks in the niche food sector, mainly in online shops. Eating insects has recently attracted worldwide public attention. Their potential to become major global food of the future has been pointed out [30, 36, 55, 59] due to the presence of high-quality protein, vitamins and minerals [52], as well as economic and environmental benefits [9, 61]. It is assumed that edible insects can successfully become part of a strategy to achieve food security worldwide [9, 61], and especially in the context of more sustainable and environmentally friendly production of nutrient-rich food than that of other animals [9, 22, 60]. Insects are considered a good alternative source of proteins, fats and vitamins, and minerals. They contain essential amino acids such as methionine, cysteine, lysine and threonine [29]. The content of essential amino acids in edible insects ranges from 10 % to 30 %, while the content of all amino acids ranges from 35 % to 50 %. Furthermore, protein digesti-

bility, usually after removal of the exoskeleton, was found to be in the range of 77 ÷ 98 %. Mineral element analyses showed that edible insects are a rich source of phosphorus, calcium, manganese, copper, zinc, sodium, potassium and iron. Edible insects are believed to be a good source of carotene and vitamins such as B1, B2, B6, D, E, K and C [46, 54, 65]. Edible insects contain up to 20 % of sugars and fatty acids [65]. In recent years, attention has also been drawn to the potential of edible insects as not only a source of nutrients, but also of bioactive compounds, including phenolic compounds, tocopherols and phytosterols [20, 28, 44]. Edible insects can also be a rich source of sterols, consisting mainly of phytosterols [5, 45]. A study by Cheseto et al. [5] showed that the desert locust (*Schistocerca gregaria*) consumes phytosterols with plant food and amplifies and metabolizes them into new derivatives with potential health benefits for humans. The chemical composition of edible insects confirms that both insects themselves and products made from them can contribute to improving a human nutritional status and, more broadly, help to deal with malnutrition. Edible insects can therefore be discussed confidently in the context of food security, understood as ensuring that people have access to adequate food quality and quantity [15]. Although there has been an increase in global food security in recent years, the problem of food shortages and malnutrition, resulting from adverse climatic conditions and the increasing cost of animal protein production, is still prevalent in many countries [10, 12].

According to predictions by the Food and Agriculture Organization of the United Nations (FAO), the world's population is estimated to increase to more than 9 billion by 2050, requiring an increase in food production of approximately 100 % [4, 13, 14, 18]. At the same time, there is a reduction in the amount of available land resources needed to produce these foods, which is likely to be exacerbated by climate changes, which are likely to reduce the amount of land available for agriculture and therefore likely to exacerbate the problem of food insecurity [33, 48]. In 2013, the Food and Agriculture Organization of the United Nations began promoting insects as "an unexplored food source that can help address global food insecurity" [13]. However, the limitations and risks of consuming edible insects should be highlighted [24]. Food safety knowledge regarding the use of insects in food production is still limited [53], which is likely to be a barrier to the introduction and promotion of insect use in a human diet in many countries [57]. Similarly to the consumption of other animal or plant products, the consumption of edible insects may be associated with the possibility of a number of factors harmful to human health, such as chemical and biological contaminants or the presence of allergenic substances [42]. The risk of their occurrence is mainly influenced by insect species, the stage of harvesting, feed and production methods [11, 57].

Despite many benefits of entomophagy, consumer acceptance remains a major barrier to promoting edible insect-based foods in western countries. While insects are widely consumed in many regions of the world, their consumption arouses a feeling of disgust/neophobia in many countries [23, 62]. The disgust associated with eating and accepting or rejecting insect consumption is rooted in culturally determined eating habits [37, 38] and plays a major role in people's rejection of a particular food product [16]. An important question, therefore, is whether entomophagy can become part of eating habits. It is worth trying to find an answer to this question and to identify the factors that determine the acceptability of edible insects as a regular part of our diet.

The aim of the study was to determine whether health and environmental concerns and attitudes towards natural foods would be associated with the willingness to eat foods containing edible insects (fresh, frozen, dried, powdered ones, e.g. meal) with the intention of ensuring food security and environmental sustainability.

The study attempted to verify the following research hypotheses:

H1. Food security resulting from the willingness to consume foods containing edible insects is linked to health and environmental concerns and attitudes towards natural foods.

H2. Based on the level of concern for food security and environmental sustainability, purchase intentions of food containing insects by young consumers can be predicted by their gender.

Material and methods

The survey-based research presented in this article was conducted as part of an inter-university project in five Polish higher education providers. The empirical survey was conducted among students, using a specially designed questionnaire, through an indirect interview method, via an online platform in the fourth quarter of 2023. Permission to conduct the study was obtained from the University Research Ethics Committee of the Cracow University of Economics No. KEBN/71/0044/D24/2023. In total, 1,087 questionnaires were collected in the research proceedings, after which incomplete and incorrectly completed questionnaires were eliminated (24): seven people did not agree to participate in the study (they did not continue to complete the questionnaire), 15 people refused to answer about gender, and two people entered very large, unrealistic values in the age field. All respondents gave voluntary, informed consent to participate in the study and were assured of its anonymity. Participants in the study were people who stated that they ate all food types and did not limit their consumption of meat or animal products. In the study population, about 61 % of the subjects were women, and about 39 % were men. Positive attitudes towards caring for health and the environment were declared by about 18 % and 22 % of the respondents, respectively. Only 12.99 % of the respondents declared positive attitudes towards natural products, and as many as

66.13 % declared ambivalent attitudes. The structure of the survey sample (N = 1,063 respondents) is shown in Table 1.

Table 1. Characteristics of the respondents (N = 1,063)
Tabela 1. Charakterystyka badanej grupy respondentów (N = 1,063)

Variables / Zmienne	Number of people / Liczba osób	[%]
Gender / Płeć		
Men / Mężczyźni	414	38.95
Women / Kobiety	649	61.05
Attitudes towards health concerns / Postawy wobec troski o zdrowie		
Negative / Negatywna	167	15.71
Ambivalent / Obojętna	703	66.13
Positive / Pozytywna	193	18.16
Attitudes towards naturalness of products / Postawy wobec naturalności produktów		
Negative / Negatywna	222	20.88
Ambivalent / Obojętna	703	66.13
Positive / Pozytywna	138	12.99
Attitudes towards environmental concerns / Postawy wobec troski o środowisko		
Negative / Negatywna	164	15.43
Ambivalent / Obojętna	666	62.65
Positive / Pozytywna	233	21.92

The questionnaire used in this study was constructed in such a way that the variables contained in it would provide data that would allow the research objective to be achieved and the research hypotheses included in the study to be verified. In the preparation of the questionnaire, a set of statements adapted from other authors' studies/papers was used. The instrument contained 17 items, measured based on a five-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = have no opinion, 4 = agree and 5 = strongly agree) [31]. The questionnaire was validated by assessing the construct validity and estimating the reliability of the scales used using Cronbach's alpha coefficient. The α value obtained was 0.92, indicating good reliability.

The details of the items in each dimension are given below:

- Items in dimension one – Concern for health: 1. I pay attention to how the foods I choose affect my health; 2. I know which foods are healthy and which are not; 3. When shopping, I choose products that have labels indicating their health benefits [40].
- Items in dimension two – Attitudes towards natural foods: 1. The naturalness of products is an important quality attribute for me; 2. I try to buy organic products; 3.

I try to avoid products with food additives; 4. The quality certification of the food I buy is important to me; 5. The naturalness of production methods is important to me [27].

- Items in dimension three – Concern for the environment: 1. When I buy food, I try to pay attention to how its production affects the environment; 2. I try to avoid food products whose production is harmful to the environment; 3. I am interested in how food production affects the environment [40, 50, 64].
- Items in dimension four – Concern for food security (4 items) and environmental sustainability (2 items) (CFS & ES scale) resulting from the willingness to consume foods containing edible insects in its composition: "Implementing the practice of consuming foods containing edible insects in their composition (fresh, frozen, dried, powdered ones, e.g. meal) can solve problems such as: 1. Hunger and malnutrition; 2. Ensuring access to foods with high nutritional value; 3. High demand for protein sources; 4. Ensuring access to foods with high concentrations of n-3 fatty acids; 5. Sustainability in food production; 6. Reducing greenhouse gas emissions. The second, third and fifth items were adapted from Lim et al. study [32], the fourth and sixth from Guiné et al. study [19], and the first one was additional.
- The empirical material collected was presented in the form of a percentage distribution of the answers given and selected descriptive statistics such as the median, mean and standard deviation. Mean scores for individual questions were compared using the Tukey test. The chi-square test with Yates' correction was conducted to determine the relationship between health and environmental concerns, gender and the willingness to pay a higher price and the willingness to eat food containing edible insects for food security. Spearman's rank correlation analysis was used to determine the relationship between the independent variables (concern for health, attitudes towards natural foods and the environment, gender) and the dependent variable (concern for food security and environmental sustainability). A significance level of $p < 0.05$ was assumed for all statistical analyses. Calculations were performed using Excel 2000 and Statistica 13.3 (Tibco Software, Palo Alto, USA).

Results and discussion

An interesting phenomenon also observed in earlier research by the present authors [39] is the prevailing ambivalent attitude of respondents towards health or environmental concerns. In a world where individuals are constantly exposed to information, the experience of ambivalence has become an inherent part of human existence [58]. It is understood as the coexistence of positive and negative associations within a single attitude [25]. Ambivalent attitudes appear to be common and can persist over long periods of time. Their relationship to behavior has also been widely studied. At

the individual level, ambivalence increases delayed reactions when choices have to be made, prolongs information processing, can affect attitude stability and can even lead to discomfort. It is also worth asking whether ambivalence leads to more resistance or increases susceptibility to persuasion and influence. It seems that ambivalent attitudes are flexible and, depending on the context, can either help individuals to adapt better or prevent them from reaching satisfactory conclusions [51, 58].

An analysis of the relationship between health concerns and food security resulting from respondents' willingness to eat foods containing edible insects in their composition showed significant differences in the responses given to the statements on the scale. Significant differences were observed for the statement that food containing edible insects in its composition can contribute to solving world hunger and malnutrition ($p = 0.04$). It is noteworthy that regardless of attitudes towards health concerns, almost half of the respondents declared that edible insects can be a valuable source of food with high nutritional value (Table 2). The respondents were found to differ significantly in their perceptions of food containing edible insects as: food contributing to the demand for protein ($p = 0.04$), being a good source of n-3 fatty acids, ($p < 0.01$), food whose production is sustainable ($p < 0.01$) and contributing to the reduction of greenhouse gas emissions ($p < 0.01$). The respondents with positive attitudes towards health, compared to the respondents with negative and ambivalent attitudes, were more likely to answer 'yes' to all questions on the food security concern scale (Table 2). In addition, a significant correlation was found between the food security concern scale statements: ensuring access to foods with high concentrations of n-3 fatty acids (0.09), sustainability in food production (0.07) and reducing greenhouse gas emissions (0.11), and attitudes towards health concern. It can therefore be concluded that people who are more concerned about their health also pay more attention to the quality of the food they eat and how its production affects the environment. Similar relationships were found by Kornher et al. [27], Mikulec et al. [39] and Modlińska et al. [40]. The authors found that consumers' willingness to adopt insects in their diet is strongly related to attitudinal variables such as preference for an environmentally friendly production method and health aspects [27, 39, 40]. According to Costa-Neto [6], insects are medicinal resources for humans in many cultures around the world because they contain a variety of biologically active compounds, e.g. peptides [21, 66], polysaccharides [34, 41], chitin [29] and phenolic compounds [3, 44], which have a variety of health-promoting or protective properties, namely antioxidant, antihypertensive, anti-inflammatory, antimicrobial or immunomodulatory. The therapeutic potential of insects also includes analgesic, antimicrobial, diuretic, anaesthetic and antirheumatic properties [6]. Thus, insects are not only a source of nutrients for the human body, but can also provide compounds that can be transformed into ingredients for functional foods or nutraceuticals [19].

Table 2. Levels of acceptance (rated on a five-point scale, ranging from 1 – "*strongly disagree*" to 5 – "*strongly agree*") of various forms of concern for food security and environmental sustainability as a function of the segmentation of young consumers according to their level of health concern

Tabela 2. Poziomy akceptacji (oceniane na 5-punktowej skali, od 1 - "*zdecydowanie nie zgadzam się*" do 5 - "*zdecydowanie zgadzam się*") dla różnych form troski o bezpieczeństwo żywnościowe i zrównoważony rozwój środowiskowy jako funkcja segmentacji młodych konsumentów w zależności od poziomu troski o zdrowie

Statements - CFS & ES Scale****/ Stwierdzenia – skala CFS & ES	Scale of health concerns / Skala troski o zdrowie																
	No/ Nie			I have no opinion / Nie mam zdania			Yes / Tak			Chi2	Median / Mediana			Mean±SD / Średnia ±SD **			Spearman's R / R Spearamana ***
	[%]																
	N*	A	P	N	A	P	N	A	P		N	A	P	N	A	P	
HM	39.19	30.58	37.68	19.37	26.32	19.57	41.44	43.10	42.75	Chi2=9.52; df=4; *p*=0.04	2.00	2.00	2.00	2.02^{a}±0.90	2.13^{a}±0.85	2.05^{a}±0.90	0.02
PC-FHNV	31.53	23.47	29.71	22.97	26.74	18.84	45.50	49.79	51.45	Chi2=9.25; df=4; *p*=0.06	2.00	2.00	3.00	2.14^{a}±0.87	2.26^{a}±0.82	2.22^{a}±0.88	0.04
HD-PS	29.73	21.47	20.29	18.02	25.04	21.01	52.25	53.49	58.70	Chi2=9.95; df=4; *p*=0.04	3.00	3.00	3.00	2.23^{a}±0.88	2.32^{a}±0.81	2.38^{a}±0.80	0.05
PC-FHCn-3FA	34.68	23.76	25.36	32.44	37.98	27.54	32.88	38.26	47.10	Chi2=16.08; df=4; *p*<0.01	2.00	2.00	2.00	1.98^{a}±0.82	2.15^{ab}±0.77	2.22^{ba}±0.83	0.09
SFP	36.94	26.17	29.71	30.18	38.69	25.36	32.88	35.14	44.93	Chi2=18.28; df=4; *p*<0.01	2.00	2.00	2.00	1.96^{a}±0.84	2.09^{a}±0.78	2.15^{a}±0.85	0.07
RGGE	36.04	24.18	25.37	30.18	35.42	22.46	33.78	40.40	52.17	Chi2=22.18; df=4; *p*<0.01	2.00	2.00	3.00	1.98^{a}±0.84	2.16^{b}±0.79	2.27^{b}±0.84	0.11

Explanatory notes: *N – negative attitude, A – ambivalent attitude, P – positive attitude – attitude scale towards food containing edible insects; ** Values marked with different letters in rows are significantly different $p < 0.05$; *** bold values are statistically significant; **** Statements – CFS & ES Scale (Concern for Food Security and Environmental Sustainability Scale): HM – hunger and malnutrition, PC-FHNV – providing access to foods with high nutritional value, HD-PS – high demand for protein sources, PC-FHCn-3FA – providing access to foods with high concentrations of n-3 fatty acids, SFP – sustainability in food production, RGGE – reducing greenhouse gas emissions.

Objaśnienia: *N – postawa negatywna, A – postawa ambiwalentna, P – postawa pozytywna – skala postaw wobec żywności zawierającej jadalne owady; ** Wartości oznaczone różnymi literami w wierszach różnią się istotnie $p < 0.05$; *** pogrubione wartości są statystycznie istotne; **** Stwierdzenia skali CFS & ES (Skala Troski o Bezpieczeństwo Żywnościowe i Zrównoważony Rozwój Środowiskowy): HM – głód i niedożywienie, PC-FHNV – zapewnienie dostępu do żywność o wysokiej wartości odżywczej, HD-PS - wysoki popyt na źródła białka, PC-FHCn-3FA – zapewnienie dostępu do żywność o wysokim stężeniu kwasów tłuszczowych n-3, SFP – zrównoważony rozwój w produkcji żywności, RGGE – zmniejszenie emisji gazów cieplarnianych

The declared attitudes of the surveyed group of young consumers towards the naturalness of food significantly differentiated the respondents' attitudes towards selected issues related to food security and environmental sustainability. No significant differences ($p > 0.05$) were observed in the frequency of individual responses to variables arising from the willingness to consume food containing edible insects to address issues such as hunger and malnutrition and to ensure access to nutritious food (Table 3).

In contrast, significant differences were observed for the frequency of responses to statements related to the practice of consuming foods containing edible insects (fresh, frozen, dried, powdered, e.g. meal) to address issues such as ensuring high demand for protein sources ($p = 0.04$), ensuring access to foods containing n-3 fatty acids ($p < 0.01$), ensuring sustainability in food production ($p < 0.01$) and reducing greenhouse gas emissions ($p < 0.01$). The respondents characterized by negative attitudes towards the naturalness of food were significantly more likely to answer 'no' to the above statements compared to the other respondents, and in particular disagreed with the statements: implementing the practice of consuming food containing edible insects (fresh, frozen, dried, powdered ones, e.g. meal) can provide access to foods with high concentrations of n-3 fatty acids (34.69 %), ensure sustainability in food production (36.94 %) and reduce greenhouse gas emissions (36.04 %). In contrast, the respondents with positive attitudes towards food naturalness were significantly more likely to answer 'yes' to the three statements presented above (47.10 %, 44.93 % and 52.17 %, respectively) (Table 3). The mean values calculated from the sum of the scores obtained for the individual statements on the scale of concern for food security and environmental sustainability (scale CFS & ES) also differed significantly for the respondents with declared negative attitudes towards food naturalness compared to those with declared ambivalent and positive attitudes in their responses to the statements, that the consumption of foods containing edible insects can ensure a high demand for protein sources, access to foods with high concentrations of n-3 fatty acids, and sustainability in food production and reduction of greenhouse gas emissions. In addition, a significant positive correlation (0.07 to 0.12) was observed between the attitudes of young consumers (generation Z) towards natural foods if they were the answer to solving problems such as: hunger and malnutrition, ensuring high demand for protein sources and providing access to foods rich in n-3 fatty acids, and that the consumption of natural foods would contribute to sustainability in food production and the reduction of greenhouse gas emissions (Table 3).

Table 3. Acceptance levels (assessed on a five-point scale, from 1 – "*definitely no*" to 5 – "*definitely yes*") for different forms of concern for food security and environmental sustainability as a function of the segmentation of young consumers according to attitudes towards the naturalness of food

Tabela 3. Poziomy akceptacji (oceniane na 5-punktowej skali, od 1 - "*zdecydowanie nie zgadzam się*" do 5 - "*zdecydowanie zgadzam się*") dla różnych form troski o bezpieczeństwo żywnościowe i zrównoważony rozwój środowiskowy jako funkcja segmentacji młodych konsumentów w zależności od postaw wobec naturalności żywności

Statements – CFS & ES Scale****/ Stwierdzenia – skala CFS & ES	Scale of attitudes towards naturalness of food / Skala postaw wobec naturalności żywności																
	No / Nie			I have no opinion / Nie mam zdania			Yes / Tak			Chi^2	Median / Mediana			Mean±SD**/ Średnia±SD			Spearman's R / R Spearmana ***
	[%]																
	N*	A	P	N	A	P	N	A	P		N	A	P	N	A	P	
HM	39.19	30.58	37.68	19.37	26.32	19.57	41.44	43.10	42.75	Chi^2=9.52; df=4; p=0.06	4.00	4.00	4.00	2.94^a±1.29	3.09^a±1.20	3.02^a±1.41	0.03
PC-FHNV	31.53	23.47	29.71	22.97	26.74	18.84	45.50	49.79	51.45	Chi^2=9.25; df=4; p=0.06	4.00	4.00	4.00	3.07^a±1.27	3.26^a±1.17	3.23^a±1.36	0.05
HD-PS	29.73	21.48	20.29	18.02	25.04	21.01	52.25	53.48	58.70	Chi^2=9.95; df=4; p=0.04	4.00	4.00	4.00	3.16^a±1.28	3.34^a±1.14	3.47^a±1.32	0.07
PC-FHCn-3FA	34.69	23.76	25.36	32.43	37.98	27.54	32.88	38.26	47.10	Chi^2=16.08; df=4; p<0.01	3.00	3.00	4.00	2.88^a±1.17	3.09^b±1.06	3.23^b±1.31	0.10
SFP	36.94	26.17	29.71	30.18	38.69	25.36	32.88	35.14	44.93	Chi^2=18.28; df=4; p<0.01	3.00	3.00	4.00	2.81^a±1.21	3.03^b±1.09	3.18^b±1.38	0.09
RGGE	36.04	24.18	25.37	30.18	35.42	22.46	33.78	40.40	52.17	Chi^2=22.18; df=4; p<0.01	3.00	3.00	4.00	2.86^a±1.28	3.15^b±1.14	3.36^b±1.41	0.12

Explanatory notes: *N – negative attitude, A – ambivalent attitude, P – positive attitude – attitude scale towards food containing edible insects; ** Values marked with different letters in rows are significantly different $p < 0.05$; *** bold values are statistically significant; **** Statements – CFS & ES Scale (Concern for

Food Security and Environmental Sustainability Scale): HM – hunger and malnutrition, PC-FHNV – providing access to foods with high nutritional value, HD-PS – high demand for protein sources, PC-FHCn-3FA – providing access to foods with high concentrations of n-3 fatty acids, SFP – sustainability in food production, RGGE – reducing greenhouse gas emissions.

Objaśnienia: *N – postawa negatywna, A – postawa ambiwalentna, P – postawa pozytywna – skala postaw wobec żywności zawierającej jadalne owady; ** Wartości oznaczone różnymi literami w wierszach różnią się istotnie $p < 0.05$; *** pogrubione wartości są statystycznie istotne; **** Stwierdzenia skali CFS & ES (Skala Troski o Bezpieczeństwo Żywnościowe i Zrównoważony Rozwój Środowiskowy): HM – głód i niedożywienie, PC-FHNV – zapewnienie dostępu do żywność o wysokiej wartości odżywczej, HD-PS - wysoki popyt na źródła białka, PC-FHCn-3FA – zapewnienie dostępu do żywność o wysokim stężeniu kwasów tłuszczowych n-3, SFP – zrównoważony rozwój w produkcji żywności, RGGE – zmniejszenie emisji gazów cieplarnianych

Table 4. Levels of acceptance (rated on a five-point scale, ranging from 1 – "*strongly disagree*" to 5 – "*strongly agree*") of various forms of concern for food security and environmental sustainability as a function of the segmentation of young consumers according to their level of concern for the environment.

Tabela 4. Poziomy akceptacji (oceniane na 5-punktowej skali, od 1 - "*zdecydowanie nie zgadzam się*" do 5 - "*zdecydowanie zgadzam się*") dla różnych form troski o bezpieczeństwo żywnościowe i zrównoważony rozwój środowiskowy jako funkcja segmentacji młodych konsumentów w zależności od poziomu troski o środowisko

Statements – CFS & ES Scale****/ Stwierdzenia – skala CFS & ES	Scale of concern for the environment / Skala troski o środowisko																
	No / Nie			I have no opinion / Nie mam zdania			Yes / Tak			Chi2	Median / Mediana			Mean±SD** / Średnia±SD			Spearman's R / R Spearmana ***
	[%]																
	N*	A	P	N	A	P	N	A	P		N	A	P	N	A	P	
HM	48.78	31.83	26.61	16.46	28.08	17.60	34.76	40.09	55.79	Chi2=39.44; df=4; p<0.01	2.00	2.00	3.00	1.86^{a}±0.91	2.08^{b}±0.84	2.29^{c}±0.86	0.20
PC-FHNV	41.46	25.07	17.60	21.34	27.33	20.60	37.20	47.60	61.80	Chi2=36.92; df=4; p<0.01	2.00	2.00	3.00	1.96^{a}±0.89	2.23^{b}±0.82	2.44^{c}±0.78	0.21
HD-PS	36.59	22.97	13.74	17.68	25.53	19.74	45.37	51.50	66.52	Chi2=35.69; df=4; p<0.01	2.00	3.00	3.00	2.09^{a}±0.91	2.29^{a}±0.82	2.53^{b}±0.73	0.21

PC-FHCn-3FA	38.41	25.68	19.31	29.27	40.09	26.61	32.32	34.23	54.08	Chi2=42.26; df=4; p<0.01	2.00	2.00	3.00	1.94^{a}±0.84	2.09^{a}±0.77	2.35^{b}±0.78	0.22
SFP	43.90	28.38	19.74	30.49	38.74	28.33	25.61	32.88	51.93	Chi2=47.17; df=4; p<0.01	2.00	2.00	3.00	1.82^{a}±0.82	2.05^{b}±0.78	2.32^{c}±0.78	0.24
RGGE	42.68	26.57	16.31	31.71	35.89	24.03	25.61	37.54	59.66	Chi2=62.38; df=4; p<0.01	2.00	2.00	3.00	1.83^{a}±0.81	2.11^{b}±0.79	2.43^{c}±0.76	0.28

Explanatory notes: *N – negative attitude, A – ambivalent attitude, P – positive attitude – attitude scale towards food containing edible insects; ** Values marked with different letters in rows are significantly different $p < 0.05$; *** bold values are statistically significant; **** Statements – CFS & ES Scale (Concern for Food Security and Environmental Sustainability Scale): HM – hunger and malnutrition, PC-FHNV – providing access to foods with high nutritional value, HD-PS – high demand for protein sources, PC-FHCn-3FA – providing access to foods with high concentrations of n-3 fatty acids, SFP – sustainability in food production, RGGE – reducing greenhouse gas emissions.

Objaśnienia: *N – postawa negatywna, A – postawa ambiwalentna, P – postawa pozytywna – skala postaw wobec żywności zawierającej jadalne owady; ** Wartości oznaczone różnymi literami w wierszach różnią się istotnie $p < 0.05$; *** pogrubione wartości są statystycznie istotne; **** Stwierdzenia skali CFS & ES (Skala Troski o Bezpieczeństwo Żywnościowe i Zrównoważony Rozwój Środowiskowy): HM – głód i niedożywienie, PC-FHNV – zapewnienie dostępu do żywność o wysokiej wartości odżywczej, HD-PS – wysoki popyt na źródła białka, PC-FHCn-3FA – zapewnienie dostępu do żywność o wysokim stężeniu kwasów tłuszczowych n-3, SFP – zrównoważony rozwój w produkcji żywności, RGGE – zmniejszenie emisji gazów cieplarnianych

As demonstrated by results from previous studies, the highest likelihood of consuming insect-based foods was observed among people with low levels of food neophobia and low disgust sensitivity, but with high levels of variety-seeking tendencies [40, 49]. Motivations related to food choice, such as convenience, health and ecological well-being, had a minimal influence on the acceptance of insects as food and feed among Norwegian and Portuguese residents [49]. In contrast, international travel is an important factor influencing Polish consumers' perceptions of food product innovation among 20 ÷ 44-year-olds. Tourist experience is an important factor in food awareness, a source of knowledge about the positive characteristics of new foods, and a demand factor that determines the willingness to accept these innovations [47].

Concern for the environment was found to be a factor significantly ($p < 0.01$) influencing all food security measurement items in terms of the willingness to eat food containing edible insects (Table 4). Individuals with a positive attitude towards environmental concern were significantly more likely to answer '*yes*' to individual statements on the food security concern scale, and the mean value from the number of points obtained was also significantly higher compared to individuals with ambivalent and negative attitudes towards environmental concern (Table 4). Weak positive significant correlations (ranging from 0.20 to 0.28) were also observed between environmental concern and issues regarding the willingness to eat food containing edible insects in the context of ensuring food security (Table 4). Thus, as concern for the environment increases in respondents, concern for food security resulting from the willingness to consume food containing edible insects in its composition increases. The results obtained for young consumers in Poland are in line with research conducted among consumers in Germany [27]. Kornher et al. [27] indicate that the willingness to consume insects is highly correlated with the demand for low-carbon products. Perhaps, consumers are already aware that growing and consuming insects can provide a solution to environmental and health problems [19, 27].

Table 5. Gender implications for food security and environmental sustainability resulting from young consumers' willingness to eat foods with edible insects in their composition

Tabela 5. Wpływ płci na bezpieczeństwo żywnościowe i zrównoważony rozwój środowiskowy wynikające z gotowości młodych konsumentów do spożywania żywności zawierającej w swoim składzie owady jadalne

Statements - CFS & ES Scale****/ Stwierdzenia – skala CFS & ES	Gender/ Płeć											
	No / Nie		I have no opinion / Nie mam zdania		Yes / Tak		Chi^2	Median / Mediana		Mean±SD**/ Średnia±SD		Spearman's R / R Spearmana ***
	[%]											
	M*	W	M	W	M	W		M	W	M	W	
HM	35.75	31.74	22.22	25.12	42.03	43.14	Chi^2=2.17; df=2; p=0.34	2.00	2.00	2.06^a±0.88	2.11^a±0.86	0.03
PC-FHNV	30.19	23.27	25.12	24.81	44.69	51.92	Chi^2=7.33; df=2; p=0.03	2.00	3.00	2.14^a±0.85	2.29^b±0.82	0.08
HD-PS	26.09	21.11	21.98	23.73	51.93	55.16	Chi^2=3.51; df=2; p=0.17	3.00	3.00	2.26^a±0.85	2.34^a±0.80	0.04
PC-FHCn-3FA	32.13	22.50	36.71	34.67	31.16	42.83	Chi^2=18.28; df=2; p<0.01	2.00	2.00	1.99^a±0.80	2.20^b±0.78	0.13
SFP	32.85	26.35	34.78	35.44	32.37	38.21	Chi^2=7.11; df=2; p=0.04	2.00	2.00	2.00^a±0.81	2.12^b±0.80	0.07
RGGE	32.85	22.96	31.16	33.59	35.99	43.45	Chi^2=13.01; df=2; p<0.01	2.00	2.00	2.03^a±0.83	2.20^b±0.79	0.10

Explanatory notes: *M – men, W – women; ** Values marked with different letters in rows are significantly different $p < 0.05$; *** bold values are statistically significant; **** Statements – CFS & ES Scale (Concern for Food Security and Environmental Sustainability Scale): HM – hunger and malnutrition, PC-FHNV – providing access to foods with high nutritional value, HD-PS – high demand for protein sources, PC-FHCn-3FA – providing access to foods with high concentrations of n-3 fatty acids, SFP – sustainability in food production, RGGE – reducing greenhouse gas emissions.

Objaśnienia: *M – mężczyźni, W – kobiety; ** Wartości oznaczone różnymi literami w wierszach różnią się istotnie $p < 0.05$; *** pogrubione wartości są statystycznie istotne; **** Stwierdzenia skali CFS & ES (Skala Troski o Bezpieczeństwo Żywnościowe i Zrównoważony Rozwój Środowiskowy): HM – głód i niedożywienie, PC-FHNV – zapewnienie dostępu do żywność o wysokiej wartości odżywczej, HD-PS – wysoki popyt na źródła białka, PC-FHCn-3FA – zapewnienie dostępu do żywność o wysokim stężeniu kwasów tłuszczowych n-3, SFP – zrównoważony rozwój w produkcji żywności, RGGE – zmniejszenie emisji gazów cieplarnianych

However, according to Modlinska et al. [40], educating people about the sustainable properties of insect-based foods and targeting marketing strategies to this characteristic is not enough to convince consumers to buy and eat insects. Insects seem to be a suitable alternative to meat only in theory. Familiarity with the idea of eating insects increases acceptance of the basic concept of replacing meat with edible insects, but does not influence the willingness to try real insect-based foods [40]. Understanding which factors may influence consumer perceptions of edible insects plays a key role in the future prospects of entomophagy and, consequently, the production and consumption of new food proteins. According to Mancini et al. [35], in order to achieve this goal, communication with potential young consumers (based on a study conducted among students in Italy) is crucial. Organizing informative tasting sessions is a good method to influence people to try insect-based foods for the first time.

An analysis of the effect of respondents' gender on their attitudes towards food security concerns resulting from their willingness to eat food containing edible insects showed that women were significantly more likely than men to express the willingness to eat food containing edible insects if it had: high nutritional value ($p = 0.03$), was a source of n-3 fatty acids ($p < 0.01$), was sustainable in food production ($p = 0.04$) and significantly reduced greenhouse gas emissions ($p < 0.01$). For these statements, a significant positive correlation was also observed, confirming that female respondents were more attentive to the above-mentioned issues in terms of their perception of the role that food containing edible insects could play to contribute to global food security (Table 5). Our results are in line with those of previous studies; although men are more familiar with entomophagy and more willing to accept the idea of insects as a meat substitute, they are not more likely to consume them than women [40]. Florença et al. [17] highlighted that people's motivations for consuming edible insects are driven by the geographic location of the countries in which they live. Therefore, market segmentation and consumer characteristics must be taken into account when designing strategies to encourage the consumption of edible insects as part of a global strategy for the sustainability of food systems.

Conclusions

Despite their nutritional and environmental potential, insect-based foods are rarely accepted by young consumers in Poland. There is a gap between consumers' understanding of the need to reduce meat consumption and their personal attitudes and intentions to consume and purchase foods containing edible insects (fresh, frozen, dried, powdered ones, e.g. meal). The consumers who declared their acceptance of the idea of edible insects as a substitute for meat may be reluctant to buy insects for their own consumption. This study aimed to determine whether health and environmental concerns are linked to the willingness of young consumers in Poland (generation Z) to

consume food containing edible insects (fresh, frozen, dried, powdered ones, e.g. meal) with the intention of ensuring food security and environmental sustainability. The results of the research allow us to better understand the attitudes and expectations of young consumers in Poland towards new, innovative foods containing edible insects in their composition. Generation Z's acceptance of food containing edible insects as a solution to (or support in solving) the problem of global food insecurity was most strongly correlated with concerns about health and the environment. Gender also differentiated perceptions of food safety issues among Generation Z. For women, issues related to the nutritional value of products with edible insects and environmental aspects were significantly more important than for men. Thus, on the basis of the study of young women's attitudes towards food security concerns and environmental sustainability, their intentions to purchase food containing edible insects can be predicted. In addition, young Poles having positive attitudes towards the naturalness of food were significantly more likely, compared to the other respondents, to agree that the implementation of the practice of consuming food containing edible insects (fresh, frozen, dried, powdered ones, e.g. meal) could ensure access to food with a high concentration of n-3 fatty acids, ensure sustainability in food production and reduce greenhouse gas emissions. The results clearly indicate that among young consumers in Poland, it is worthwhile to undertake initiatives/interventions to support activities aimed at ensuring food security, especially in the context of caring for the environment. Hence, our study implies that there is a positive and significant willingness among representatives of Generation Z in Poland to consume products with a low carbon footprint. The implication for producers of insect-based food products would be to focus on highlighting the negative consequences of meat consumption for climate and health, and to create opportunities for tasting foods containing edible insects. The experience of consuming insects acquired in this way would translate into the willingness of young consumers to purchase and consume new, previously unknown foods. The results obtained can contribute to efforts to promote the legitimacy of producing new foods containing edible insects in their composition. Several other factors should be taken into account in future research, including: the scale of experience with edible insects, the frequency of travel for culinary tastings, the level of tendency to seek diversity, an assessment of knowledge about entomophagy, the willingness to participate in culinary workshops using edible insects, and an analysis of factors taken into account when purchasing food that may influence the acceptance of edible insects as food by young consumers (Generation Z) in Poland.

Limitations of the study

However, there are some limitations related to the presented study. The research was conducted in a narrow subjective approach and only among university students

representing but a segment of young buyers. It should also be emphasized that the surveys can generate valuable information, but the actual consumption results may differ significantly from the survey results.

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OWADY JADALNE JAKO POTENCJALNY PRODUKT SŁUŻĄCY OSIĄGNIĘCIU BEZPIECZEŃSTWA ŻYWNOŚCIOWEGO. CZĘŚĆ 2

S t r e s z c z e n i e

Wprowadzenie. Konsumpcja owadów (entomofagia) skupia na sobie uwagę ze względów ekonomicznych, korzyści środowiskowych ale także zdrowotnych. Osiągnięcie zrównoważonego środowiskowo bezpieczeństwa żywnościowego obecnie stanowi jedno z największych globalnych wyzwań. Szeroka gama gatunków owadów jadalnych, które cechują się dużą zawartością białka, tłuszczu, składników mineralnych, witamin i błonnika pokarmowego, może odegrać znaczącą rolę w rozwiązaniu problemu braku bezpieczeństwa żywnościowego na świecie. Dodatkowo hodowla owadów może stanowić zrównoważony sposób produkcji żywności. Jednak akceptacja konsumentów pozostaje główną przeszkodą w przyjęciu owadów jako źródła pożywienia w wielu krajach, m.in. Europy. Celem badania było ustalenie, czy troska o zdrowie i środowisko będzie powiązana z gotowością do spożywania żywności zawierającej w swoim składzie jadalne owady (świeże, mrożone, suszone, sproszkowane np. mączkę) zamiarem zapewnienia

bezpieczeństwa żywnościowego i zrównoważonego rozwoju środowiskowego. Badanie empiryczne przeprowadzono wśród studentów pięciu polskich uczelni wyższych. W kwestionaruszu ankiety zamieszczono stwierdzenia odnoszące się do postaw wobec żywności naturalnej oraz troski o zdrowie, środowisko, bezpieczeństwo żywnościowe i zrównoważony rozwój środowiskowy.

Wyniki i wnioski. Akceptacja przez respondentów żywności zawierającej w swoim składzie jadalne owady, jako rozwiązania bądź wsparcia problemu związanego z brakiem bezpieczeństwa żywnościowego na świecie, w największym stopniu skorelowana była z troską o zdrowie i środowisko. Płeć także różnicowała postrzeganie zagadnień związanych z bezpieczeństwem żywnościowym. Dla kobiet istotnie ważniejsze, niż dla mężczyzn, były kwestie związane z wartością odżywczą produktów z udziałem owadów jadalnych oraz aspekty środowiskowe. Młodzi ludzie charakteryzujący się postawami pozytywnymi wobec naturalności żywności istotnie częściej, w porównaniu do pozostałych badanych, zgadzali się, że wdrożenie praktyki spożywania żywności zawierającej w swoim składzie jadalne owady może zapewnić dostęp do żywność o wysokim stężeniu kwasów tłuszczowych n-3, zapewnić zrównoważony rozwój w produkcji żywności i zmniejszyć emisję gazów cieplarnianych.

Słowa kluczowe: troska o środowisko, troska o zdrowie, naturalność żywności, zrównoważony rozwój, entomofagia, owady jadalne, chęć konsumpcji, młodzi konsumenci (pokolenie Z), Polska