

Public Opinion on Dried Mealybug (*Tenebrio molitor*) Larvae Usage in Food Products: Consumer Acceptance in Lithuania

Žymantė Jankauskienė¹, Erika Kubilienė^{1*} and Miglė Ezerskytė²

¹Associate Professor, PhD, Faculty of Health Care, Vilnius Kolegija/HEI, Lithuania

²Dietitian, Faculty of Health Care, Vilnius Kolegija/HEI, Lithuania

***Corresponding Author:** Erika Kubilienė, PhD, Associate Professor, Faculty of Health Care, Vilnius kolegija/HEI, Vilnius, Lithuania.

Received: August 22, 2023; **Published:** September 06, 2023

Abstract

Proper nutritional habits are associated with good health. Proteins for food enrichment are currently produced from vegetable or animal sources with limited sustainability [11], and the stocks are not enough for the market demands. For this purpose, insect proteins are investigated as a practical, cost-effective alternative to traditional animal source of proteins. Insects represent a novel source of edible high nutritional value proteins which are gaining increasing interest as an alternative to traditional animal foods.

The research aimed to assess public opinion on dried mealybug (*Tenebrio molitor*) larvae usage in food products and consumer acceptance in Lithuania. To achieve the aim of the research, consumer perception and acceptability of insect-based foods in the context of scientific literature were examined and acceptability of edible insects' usage in food for Lithuanian consumers was assessed.

A questionnaire was used to complete the quantitative study. Statistical analysis was performed using the statistical program SPSS (IBM SPSS Statistics v.29), statistically significant differences among variables, considering age, nutrition, educational and social status, were determined under significance levels $\alpha = 0,01$ and $\alpha = 0,05$.

After the analysis of scientific literature had been carried out, it was found that the interest in eating insects as food is increasing. Insects are consumed all over the world, but in Western countries consumption of edible insects is low and restricted mainly to food items based on insect proteins. Three main obstacles facing the edible insect sector were distinguished in research literature: consumer acceptance, technology and regulation. The scientific literature reveals that the most likely users of insects as a novel and more sustainable protein source in Western countries are younger males, who are more open to trying novel foods and interested in the environmental impact of their food choice. There is a great complexity of different factors influencing consumer acceptability of insects as food in different countries. After research was carried out and statistical analysis of the research data was performed, it was found that the majority of research participants in Lithuania, who are promoting a plant-based diet, are not interested and do not intend to include insects and/or their protein flour in their diet. Meanwhile, Lithuanian omnivores are a bit more open to this newly emerging food alternative. Statistically significant differences between omnivores and vegetarians considering acceptability of insect-based foods (intent to purchase, interest in trying insect protein foods) were determined during the study ($\alpha = 0,001$ and $\alpha = 0,003$ respectively).

Keywords: Health; Nutrition; Edible Insects; Omnivores and Vegetarians; Alternative Protein Sources; Entomophagy; Willingness to Consume; Lithuania

Introduction

According to the World Health Organization (WHO), nutrition is an important part of health and personal development. Proper nutritional habits are associated with good health, a strong immune system, and lower risk of non-communicable diseases including diabetes, heart disease, stroke and cancer, and longevity [21]. The emergence of diet-related diseases is supported by studies that encourage a focus on unprocessed foods, fruits and vegetables, plant-based fats and proteins, legumes, whole grains and nuts, and limiting the consumption of added sugar [9]. The food we eat and how we produce it will determine the health of people and world, and major changes must be made to avoid both reduced life expectancy and continued environmental degradation. Food systems can foster human health and support environmental sustainability; however, they are currently under threat [19].

A growing number of individuals seek to change their lifestyle and nutritional habits for better well-being and a better future for our ecosystem. An increasing number of people are choosing a plant-based diet, the main reasons for which are concerns about their health, ethical, environmental and social issues [8,20].

An increase life expectancy of individuals in the future is also observed, which leads to an increase in the share of the elderly population. This population group is at increased risk of malnutrition for a variety of physiological and psychological reasons. This affects health and quality of life. A healthy diet has many health benefits for older adults and helps prevent age-related diseases [5].

The Food and Agriculture Organization (FAO) estimates that by 2050 the world's population will grow to 9 billion, so the need for food will hardly be met. Proteins for food enrichment are currently produced from vegetable or animal sources, with limited sustainability, and the stocks are not enough for the market demands. For this purpose, insect proteins are strongly investigated as a practical, cost-effective alternative to traditional animal source of proteins [11]. Insects represent a novel source of edible high nutritional value proteins which are gaining increasing interest as an alternative to traditional animal foods.

Providing a growing global population with healthy diets from sustainable food systems is an immediate challenge. Although global food production of calories has kept pace with population growth, more than 820 million people have insufficient food and many more consume low quality diets that cause micronutrient deficiencies and contribute to a substantial rise of diet-related obesity and diet-related non-communicable diseases (coronary heart disease, stroke, and diabetes) [19]. With the rapid increase in the world's population, the need for protein consumption is also increasing. Therefore, alternative food products are being sought, one of them being edible insects. Alternative food products from insects can be a useful source of protein for nutritional enrichment. Insects are a valuable source of protein, fatty acids (omega-6 and omega-3), vitamins (B12, folic acid, biotin) and minerals (magnesium, selenium, iron, zinc, calcium), while being low in calories and low in fat [13].

Research shows that the chitin and chitosan in the larvae inhibit pathogenic microorganisms in the intestine, so due to the bioactive compounds and peptides, the larvae have antioxidant, anti-inflammatory and anti-diabetic effects on health [1].

In addition, insects can be grown efficiently and with less impact on the environment. They require less water, less land and emit less greenhouse gases than traditional animal farms, making insects a sustainable food. There are about 2,000 species of edible insects worldwide, such as worms, ants, wasps, bees, beetles, crickets, and grasshoppers. In Asian, African and Latin American countries, insects have dominated the human diet for some time, but in the West and Europe, the consumption of insects is still limited because consumers are still rejecting this type of food [14].

One of the most promising insect species for industrial use and commercial large-scale production is mealybug (*Tenebrio molitor*) larvae. *Tenebrio molitor* larvae are highly nutritious and high in protein and lipids [15].

On June 1, 2021, the European Commission adopted Regulation (EU) 2021/882, which approved the authorization to place on the market larvae of the mealybug (*Tenebrio molitor*) as a new food product [3]. Fresh and dried mealybug larvae or dried mealybug larvae powder are used for food. Scientific studies have established that the nutritional value of mealybug larvae is equivalent to the nutritional value of conventional animal meat [15]. Dried mealybug larvae contain: 58% of protein; 27% of fat; 5.6% of fibrous materials (mainly chitin); palmitic, oleic and linoleic acids make up 76.3% of all fatty acids; energy value of 100g - 496 kcal.

With the increasing interest of consumers to include insects in their diet, it's important to emphasize that the use of insects for human food is regulated by European Union (EU) documents. The documents emphasize that only the following insects can be used for human consumption: the black flatfly (*Hermetia illucens*), the large mealybug (*Tenebrio molitor*), the mill black beetle (*Alphitobius diaperinus*) larvae and crickets - the house cricket (*Acheta domestica*) and the banded cricket (*Grylloblatta campodeiformis*) [3]. All insects are sold on the market in frozen, dried and powdered form.

At the same time, it's important to mention that the consumption of dried *Tenebrio molitor* larvae can cause allergic reactions in individuals who are allergic to crustaceans and dust mites, therefore dried *Tenebrio molitor* larvae supplied to consumers and food products, containing dried *Tenebrio molitor* larvae, should be properly labeled in accordance with the Regulation (EU) 2015/2283 in Article 9 and Regulation (EU) No. 1169/2011 established requirements [3].

Global food systems seem to provide many key factors that may help in solving these challenges. In comparison to traditional protein sources, such as meat, insects are considered to be sustainable because they exert less pressure on natural resources and contribute lower emissions of greenhouse gases. Insects contain large amounts of high quality and highly digestible proteins and unsaturated fats, as well as vitamins, minerals and other bioactive compounds [4].

Most consumers are well-informed about the use of insects and larvae in the diet; however, many also regard consumption of these as undesirable. A major barrier to edible insect consumption is the paucity of information available, both about the importance of alternative protein sources in the human diet and recommended cooking methods and preparation of dishes using insects [18].

The study with participants in German-speaking countries (Germany, Austria and Switzerland) revealed that only a quarter of the respondents were prepared to eat insects. Food neophobia, subjective disgust towards insects, risk assessment, degree of processing, sex and age proved to be significant predictors [10].

The study on entomophagy in the German population underlines the results of previous studies in other European countries. In total, 15.9% of German participants were willing to consume unprocessed insects. In Belgium, 16.3% were prepared to integrate insects into their diet as food. In Poland, about 37% of study participants found products with processed insects (insect flour) acceptable [7].

Sensory appeal may be a major factor in determining whether insects are viewed as pleasant food components, social and cultural norms, and peer influence are also important [6]. In the short term, eating insects is still considered exotic in Hungary. There was a direct link between familiarity and neophobia among the Hungarian respondents. In line with previous findings [17], food neophobia is a barrier for the consumption of insects in Hungary similar to most of the Western countries. Hungarian respondents had higher food neophobia, but lower food technology neophobia scores compared to the Belgian sample. So, food industry should focus on food processed with insect-based food ingredients within a familiar product category or flavor profile. Hungarian respondents had limited knowledge and were not convinced of the additional health benefits of consumption of insects [6].

The study of Australian consumers' response to insects as food aimed at understanding opinions about eating edible insects and insect-based products among a group of younger Australian adults. It was revealed that even if edible insects are considered a more

sustainable way to increase animal-based proteins, there is still a relatively low general readiness to adopt entomophagy as a meat substitute practice. The study suggested that there is strong prejudice and a lack of knowledge about edible insects among Australian residents which is reflected in the low willingness to consume them. Thereby, education and adequate communication style by the media might help to reduce prejudice and increase consumers' knowledge about insects as food, including an understanding of how to prepare and consume them [16].

After years of uncertainties, the EU legislation is moving towards a harmonized legislation considering edible insects as potential Novel Food, giving to applicants the possibility of following a notification procedure able to speed up the approval process [3]. The story of edible insects and legislation taught us that novel protein sources should no longer be neglected by outdated legislation and that the possibility of developing sustainable food alternatives should be granted to Food Business Operators without dismissing public health protection [2].

It's interesting to notice that, despite the fact that most studies rely on non-representative samples, the empirical results are broadly consistent across the literature. This observation seems to suggest that the main factors influencing the choice of consuming (or not) insect-based food are fairly stable across populations, (Western) countries and Italian regions [12]. A few differences emerge in the literature related to the measure of the "effect" of some specific variables, but the main message seems to be mostly common to different contexts. Thanks to the inclusion of cheese with fly larvae in old traditional Italian food, Italy is a rather special case among Western countries. However, the empirical results discussed are broadly in line with those of other Western countries where consumers are reluctant to consume insect foods. In fact, cheese with insects, although persistent, is becoming less and less common in Italy; moreover, it is possible that the use of insects as an ingredient is not perceived as entomophagy by the Italian population [12].

Materials and Methods

Research problem: Is it statistically significant difference between omnivorous people and vegetarians considering acceptability of insect-based foods?

The goal of research: To assess public opinion on dried mealybug (*Tenebrio molitor*) larvae usage in food products and acceptability for consumers in Lithuania.

Objectives of research:

1. Examine consumer perception and acceptability of insect-based foods in the context of scientific literature.
2. Assess the acceptability of dried mealybug (*Tenebrio molitor*) larvae usage in food products by Lithuanian consumers.

Respondents, their selection criteria

The study sample was formed by random non-probability sampling. Lithuanian respondents took part in the study, including omnivores (63,8%, n = 90) and vegetarians (36,2%, n = 51), half of all respondents (66%, n = 93) were young people (18 - 25 years old). Altogether, 141 participants took this survey.

Methods of the research

Electronic databases of scientific publications - EBSCOhost, Oxford Academic, PubMed, ScienceDirect, SpringerLink, Taylor and Francis - were chosen to collect data from the scientific literature.

The instrument chosen for the research was a questionnaire. The questionnaire was prepared considering the goal and objectives of the research. The questionnaire was placed on the www.manoapklausa.lt website. The questionnaire was publicly distributed through the social network Facebook.

The questionnaire was divided into 4 diagnostic blocks: Demographic data (gender, age, education, social status), Nutrition (dietary choices, reasons and time spent promoting alternative plant-based diet), Selection of food products (Variety of food products, selection criteria, reasons), Novel food (insect protein flour) in the diet (knowledge, opinion, motivation and interest in insect protein meal). A Likert scale was used for the evaluation, the research participants had to choose the most suitable answer to the given statements: "Completely agree", "Agree", "Neither agree nor disagree", "Disagree", "Completely disagree".

A questionnaire was used to complete the quantitative study. Statistical analysis was performed using the statistical program SPSS (IBM SPSS Statistics v.29), statistically significant differences among variables, considering age, nutrition, educational and social status, were determined under chosen significance levels $\alpha = 0,01$ and $\alpha = 0,05$. Research results were discussed to assess public opinion on dried mealybug (*Tenebrio molitor*) larvae usage in food products and consumer acceptance in Lithuania.

Results and Discussion

Demographic data of study respondents (Gender, age, education, social status)

The research included 141 respondents, 128 women (90,8%) and 13 men (9,2%). More than half of the respondents (63,8%, $n = 90$) were omnivores, the rest - vegetarians (36,2%, $n = 51$). Most participants were female omnivores (90%, $n = 81$), therefore, no statistically significant differences according to gender were sought (Table 1). The age of the respondents - between 18 and 65 years, more than half of them (66%, $n = 93$) are 18 - 25 years old. Most of the respondents had secondary education (52,5%, $n = 74$) and were students (54,6%, $n = 77$). Sociodemographic characteristics (in percent) of study respondents ($n = 141$) according to their nutritional choices are provided in the table 1.

Sociodemographic Indicators		Omnivores (n = 90)	Vegetarians (n = 51)
Gender	Women	90 (n = 81)	92,2 (n = 47)
	Men	10 (n = 9)	7,8 (n = 4)
Education	Primary	2,2 (n = 2)	2 (n = 1)
	Secondary	62,2 (n = 56)	35,3 (n = 18)
	Professional Bachelor	11,1 (n = 10)	13,7 (n = 7)
	Bachelor	16,7 (n = 15)	33,3 (n = 17)
	Master	6,7 (n = 6)	11,8 (n = 6)
	Higher than Master	1,1 (n = 1)	3,9 (n = 2)
Social Status	Student	66,7 (n = 60)	33,3 (n = 17)
	Employed Student	10 (n = 9)	2 (n = 1)
	Employed Person	23,3 (n = 21)	60,8 (n = 31)
	Unemployed	-	3,9 (n = 2)
Age	18 - 25	76,7 (n = 69)	47,1 (n = 24)
	26 - 33	5,6 (n = 5)	27,5 (n = 14)
	34 - 41	11,1 (n = 10)	11,8 (n = 6)
	42 - 49	5,6 (n = 5)	9,8 (n = 5)
	50 - 57	-	2 (n = 1)
	58 - 65	1,1 (n = 1)	2 (n = 1)

Table 1: Sociodemographic indicators of study respondents ($n = 141$), in percent.

Nutritional status of study respondents (Dietary choices, reasons and time spent promoting alternative plant-based diet (only for vegetarians (36,2%, n = 51)) - 3 statements in the questionnaire

The majority of all vegetarians were vegans (41,2%, n = 21) and semi-vegetarians (27,5%, n = 14). Lactoovegetarians (3,9%, n = 2), lactoovovegetarians (15,7%, n = 8), ovovegetarians (3,9%, n = 2) and pescovegetarians (7,8%, n = 4) made up only a small part of all vegetarians. Slightly more than half of all vegetarians (51%, n = 26) promoted plant-based nutrition for 6-10 years; almost a third of them (27,5%, n = 14) - for 1-5 years; 8 vegetarians (15,7%) actively used plant-based nutrition for more than 10 years, and 3 vegetarians (5,9%) - for less than a year.

The main reasons for choosing a plant-based diet by vegetarians were ethical beliefs (animal welfare) (64,7%, n = 33), concern for health (17,6%, n = 9), and the search for innovation (11,8%, n = 6). Such options like religious beliefs, environmental protection, or the influence of other people motivated to choose a plant-based diet just one vegetarian per each option. So, it could be assumed, when changing the diet from the traditional (omnivorous) to a plant-based one, people mostly think about the welfare of animals and their own health.

Selection of food by study respondents (Variety of food products, selection criteria, motivation) - 9 statements in the questionnaire

Seeking for food diversity

Statement 1: "While choosing food products, I look for alternatives to the products I've already used".

Slightly less than half of all study participants (48,2%, n = 68), including omnivores (42,2%, n = 38) and vegetarians (58,8%, n = 30), agree, more than a third of the all respondents (36,9%, n = 52), including omnivores (40%, n = 36) and vegetarians (31,4%, n = 16) - have doubts, and only a small part of all respondents (14,9%, n = 21), including omnivores (17,8%, n = 16) and vegetarians (9,8%, n = 5), disagree with the statement that while choosing food products, alternative products are sought for products already consumed.

A statistically significant difference ($\alpha = 0,004$) among vegetarians with different educational status who look for alternatives to the products already used, was found: higher educational status vegetarians were more interested in this option.

Statement 2: "While choosing food products I like to try novelties".

The majority of all research participants (72,3%, n = 102), including omnivores (70%, n = 63) and vegetarians (76,5%, n = 39), agree, more than a fifth of all respondents (21,3%, n = 30), including omnivores (21,1%, n = 19) and vegetarians (21,6%, n = 11), - have doubts, and only a small part of all respondents (6,4%, n = 9), including omnivores (8,9%, n = 8) and vegetarians (2%, n = 1), disagree with the statement that they like to try novelties while choosing food products.

Statement 3: "While choosing food products, I like to try as diverse a range of food as possible".

The majority of research participants (70,9%, n = 100), including omnivores (71,1%, n = 64) and vegetarians (70,6%, n = 36) agree, more than a fifth of all respondents (22%, n = 31), including omnivores (22,2%, n = 20) and vegetarians (21,6%, n = 11) - have doubts, and only a small part of all respondents (7,1%, n = 10), including omnivores (6,7%, n = 6) and vegetarians (7,8%, n = 4) - disagree with the statement that they like to try as diverse a range of food as possible while choosing food products.

A statistically significant difference among different age omnivores ($\alpha = 0,017$), who like to try as diverse a range of food as possible while choosing food products, was found: younger omnivores were more interested in this option.

A statistically significant difference among omnivores of different educational and social status ($\alpha = 0,020$ and $\alpha = 0,017$ respectively), who like to try as diverse a range of food as possible while choosing food products, was found: lower educational status omnivores (mainly students) were more interested in this option.

It could be concluded, that, seeking for food diversity, respondents look for alternatives to the products they've already used (48%), like to try novel foods (72%) and like to try as diverse a range of food as possible (71%).

Criteria for choosing food products

Statement 4: "While choosing food products, I pay attention to whether they are organic or made from organic ingredients".

A little less than half of all study participants (46,8%, n = 66), among them - omnivores (40%, n = 36) and vegetarians (58,8%, n = 30) agree, close to a third of all respondents (29,1%, n = 41) - have doubts, among them - omnivores (31,1%, n = 28) and vegetarians (25,5%, n = 13), and almost a quarter of all respondents (24,1%, n = 34), including omnivores (28,9%, n = 26) and vegetarians (15,7%, n = 8) - disagree with the statement that while choosing food products, attention is paid to whether they are organic/or made from organic ingredients.

A statistically significant difference ($\alpha = 0,01$) among different age omnivores, paying attention to whether a product is organic or made from organic ingredients was found: younger respondents were more interested in this option.

Statement 5: "While choosing food products, I pay attention to the way they are processed (e.g. smoked, salted, boiled, fried, etc.)".

More than half of all study participants (68,8%, n = 97), including omnivores (78,9%, n = 71) and vegetarians (51%, n = 26) agree, less than a fifth of all respondents (15,6%, n = 22) - have doubts, including omnivores (11,1%, n = 10) and vegetarians, (23,5%, n = 12) and the same number of all respondents (15,6%, n = 22), including omnivores (10%, n = 9) and vegetarians (25,5%, n = 13) - disagree with the statement that while choosing food products, attention is paid to the way food is processed (e.g. smoked, salted, boiled, fried, etc.).

Statement 6: "While choosing food products, I pay attention to the composition of the products".

The vast majority of research participants (77,3%, n = 109), including omnivores (74,4%, n = 67) and vegetarians (82,4%, n = 42) agree, less than a fifth of all respondents (14,2%, n = 20) - have doubts, including omnivores (15,6%, n = 14) and vegetarians (11,8%, n = 6), and only a small part (8,5%, n = 12), among them - omnivores (10%, n = 9) and vegetarians (5,9%, n = 3), disagree with the statement that, while choosing food products, attention is paid to the composition of the products.

A statistically significant difference among different age omnivores ($\alpha = 0,007$), who pay attention to the composition of the products while choosing food products, was found: younger omnivores were more interested in this option.

A statistically significant differences among different educational and social status omnivores ($\alpha = 0,014$ and $\alpha = 0,012$ respectively) and different educational status vegetarians ($\alpha = 0,008$), who pay attention to the composition of the products while choosing food products, was found: lower educational status omnivores and vegetarians, mainly students, were more interested in this option.

It could be concluded, that considering criteria for choosing food, respondents pay attention to whether food is organic (47%), to the way food is processed (69%), and to the composition of the products (77%). Vegetarians are more likely to pay attention to the environmental friendliness and composition of food products than omnivores.

Motivation for choosing food products

Statement 7: “While choosing food products, I pay attention, whether this product is environmentally friendly”.

Less than half of all study participants (45,4%, n = 64), among them - omnivores (33,3%, n = 30) and vegetarians (66,7%, n = 34) agree, close to a third of respondents (30,5%, n = 43) – have doubts, among them - omnivores (33,3%, n = 30) and vegetarians (25,5%, n = 13), and close to a quarter of all respondents (24,1%, n = 34), among them - omnivores (33,3%, n = 30) and vegetarians (7,8%, n = 4) disagree with statement that while choosing food products, attention is paid to whether this product is environmentally friendly.

Statement 8: “While choosing products, I pay attention to whether this product is friendly to animals and their well-being”.

More than half of all study participants (56,7%, n = 80), including omnivores (42,2%, n = 38) and vegetarians (82,4%, n = 42) - agree, more than a fifth of respondents (22%, n = 31) – have doubts, among them - omnivores (25,6%, n = 23) and vegetarians (15,7%, n = 8), and close to a fifth of respondents (21,3%, n = 30), including omnivores (32,2%, n = 29) and vegetarian (2%, n = 1), disagree with the statement that, choosing food products, attention is paid to whether this product is friendly to animals and well-being of fauna.

A statistically significant differences among different age omnivores, paying attention to whether a product is environmentally friendly or friendly to animals ($\alpha = 0,01$ and $\alpha = 0,016$ respectively), was found: younger respondents were more interested in these options while choosing food.

A statistically significant differences among different educational and social status omnivores, paying attention to whether a product is environmentally friendly or friendly to animals ($\alpha = 0,014$ and $\alpha = 0,019$ respectively), was found: lower educational status omnivores, mainly students, were more interested in these options.

Statement 9: “While choosing products, I pay attention to whether this product is health-friendly”.

Most of the study participants (76,6%, n = 108), including omnivores (78,9%, n = 71) and vegetarians (72,6%, n = 37) agree, less than a fifth of respondents (16,3%, n = 23) – have doubts, including omnivores (15,6%, n = 14) and vegetarians (17,7%, n = 9), and only a small part of all respondents (7,1%, n = 10), among them - omnivores (5,6%, n = 5) and vegetarians (9,8%, n = 5) - disagree with the statement that, while choosing food products, attention is paid to whether this product is healthy.

A statistically significant differences among different age omnivores ($\alpha = 0,01$) and vegetarians ($\alpha = 0,03$), who pay attention to whether a product is health-friendly, was found: younger omnivores and vegetarians were more interested in this option.

A statistically significant difference among different educational status omnivores ($\alpha = 0,018$), who pay attention to whether a product is a health-friendly, was found: lower educational status omnivores were more interested in this option.

It could be concluded, that, considering motivation for choosing food, respondents pay attention, whether food is environmentally friendly (45%), friendly to animals and animals’ well-being (57%), whether the food is health-friendly (77%). Vegetarians are more likely to pay attention to friendliness to the environment and animals.

Novel food (insect protein flour) in the diet (knowledge, opinion, motivation and interest in insect protein meal): 7 statements and 2 questions in the questionnaire.

External influence on food choices

Statement 1: “I rely on recommendations from friends/family while trying new foods”.

The majority of study participants (71,6%, n = 101), including omnivores (76,7%, n = 69) and vegetarians (62,8%, n = 32) agree, less than a fifth of all respondents (17%, n = 24) – have doubts, among them - omnivores (17,8%, n = 16) and vegetarians (15,7%, n = 8), and only a small part (11,4%, n = 16), including omnivores (5,6%, n = 5) and vegetarians (21,6%, n = 11) - disagree with the statement that friends/family recommendations are referred to while trying new food products.

A statistically significant difference among different educational and social status vegetarians ($\alpha = 0,014$ and $\alpha = 0,028$ respectively), who, testing new food products, rely on recommendations from friends/family, was found: higher educational status vegetarians, mainly employed persons, were more interested in this option.

Statement 2: “While trying new foods, I rely on the advice of physicians/nutritionists”.

Less than half of the study participants (44,7%, n = 63), including omnivores (47,8%, n = 43) and vegetarians (39,2%, n = 20), agree, a third of all respondents (31,2%, n = 44) – have doubts, among them - omnivores (31,1%, n = 28) and vegetarians (31,4%, n = 16), and almost a quarter (24,1%, n = 34), including omnivores (21,1%, n = 19) and vegetarians (29,4%, n = 15) disagree with the statement that while testing new food products they rely on the opinion of specialists (physicians/nutritionists).

A statistically significant differences among different age and different educational status omnivores ($\alpha = 0,007$), who, testing new food products, rely on the opinion of physicians/nutritionists, was found: younger and lower educational status omnivores were more interested in this option.

A statistically significant difference among vegetarians of different social status ($\alpha = 0,003$), who, testing new food products, rely on the specialists’ opinion, was found: employed vegetarians were more interested in this option than students.

Statement 3: “I rely on the internet/television (advertisements) when trying new foods”.

Less than half of the research participants (41.8%, n = 59), including omnivores (44.4%, n = 40) and vegetarians (37.3%, n = 19) agree, almost a third of all respondents (31.2%, n = 44) have doubts, including omnivores (28.9%, n = 26) and vegetarians (35.3%, n = 18), and more than a quarter of all respondents (27%, n = 38), including omnivores (26.7%, n = 24) and vegetarians (27.5%, n = 14), disagree with the statement that, when trying new food products, they rely on advertisements on the Internet/TV.

A statistically significant difference among vegetarians of different social status ($\alpha = 0,038$), who, testing new foods, rely on advertisements (the Internet/TV), was found: employed vegetarians were more interested in this option than students.

It could be concluded, that, considering external influence on food choices, respondents when trying new foods, rely on recommendations from friends/family (72%), on the advice of specialists (physicians/nutritionists) (45%), on the internet/television (advertisements) (42%). Omnivores are more likely to rely on external recommendations while trying new food than vegetarians.

Insects in the human diet. Food products that contain insect protein flour

Question 1: “Have you heard about the use of insects (crickets/larvae) and their protein meal in human nutrition”?

The vast majority of study participants (81,6%, n = 115), including omnivores (74,4%, n = 67) and vegetarians (94,1%, n = 48) have heard, a small part of all respondents (2,8%, n = 4) have doubts, among them - omnivores (3,3%, n = 3) and vegetarian (2%, n = 1), and

less than a fifth of all respondents (15,6%, n = 22), including omnivores (22,2%, n = 20) and vegetarians (3,9%, n = 2) have not heard about the use of insects (crickets/larvae) and their protein flour in human nutrition.

A statistically significant differences among different age omnivores and vegetarians ($\alpha = 0,017$ and $\alpha = 0,001$ respectively), who have heard about the use of insects in human nutrition, was found: younger omnivores and older vegetarians were more acquainted with insect-based food.

A statistically significant difference among different educational status omnivores ($\alpha = 0,011$) and different social status vegetarians ($\alpha = 0,031$), who have heard about the use of insects in human nutrition, was found: lower educational status omnivores and employed vegetarians were more acquainted with insect-based food.

Question 2: Have you used insects/insect protein powder in your diet?

Only a small part of all study participants (6,4%, n = 9), including omnivores (6,7%, n = 6) and vegetarians (5,9%, n = 3) have consumed insects/insect protein powder in their diet, close to a tenth of all respondents (9,2%, n = 13) - have doubts or do not know, among them - omnivores (10%, n = 9) and vegetarians (7,8%, n = 4), and the majority of all respondents (84,4%, n = 119), including omnivores (83,3%, n = 75) and vegetarians (86,3%, n = 44) have never used insect/insect protein powder in their diet.

A statistically significant difference among different age vegetarians ($\alpha = 0,029$), who have used insects in their diet, was found: older vegetarians are more likely to consume insect-based food than younger ones.

Statement 4: "Rate your interest in trying insect protein foods from 1 to 5 (where 1 is not willing; 5 is very willing)".

Only close to a fifth of all respondents (17,7%, n = 25) have expressed an interest in trying food products made from insect proteins, including omnivores (22,2%, n = 20) and vegetarians (9,8%, n = 5). A similar number of respondents (17%, n = 24) had doubts, including omnivores (20%, n = 18) and vegetarians (11,8%, n = 6). However, the interest of more than half of all respondents in food products from insect proteins was low - more than half of respondents (65,3%, n = 92), including omnivores (57,8%, n = 52) and vegetarians (78,4%, n = 40), noted, that they are unwilling or very unwilling to try insect-based foods.

It could be concluded, that, considering insects in the human diet, respondents have heard about the use of insects (crickets/larvae) and their protein meal in human nutrition (82%), but only small part of respondents have used insects/insect protein powder in their diet (6%). Vegetarians have slightly better knowledge about insect-based food, but both groups (omnivores and vegetarians) are not keen to use this kind of food. Interest in trying insect protein food was expressed only by less than a fifth of respondents (18%), mostly omnivores.

Food products that contain insect protein flour

Statement 5: "Many sports foods and supplements contain insect protein due to their very high protein content (e.g. protein bars, protein shakes, vitamin/supplement pills, etc.)".

More than a quarter of all study participants (26,2%, n = 37), including omnivores (32,2%, n = 29) and vegetarians (15,7%, n = 8) agree, close to half of all respondents (48,9%, n = 69) - have doubts, among them - omnivores (48,9%, n = 44) and vegetarians (49%, n = 25), and less than a quarter of all respondents (24,8%, n = 35), including omnivores (18,9%, n = 17) and vegetarians (35,3%, n = 18) disagree with the statement that many food products and food supplements intended for athletes, due to their very high protein content, contain insect proteins (e.g. protein bars, protein shakes, vitamin/supplement pills, etc).

A statistically significant difference among different educational status vegetarians ($\alpha = 0,027$), who agreed with the statement “Many sports foods and supplements contain insect protein due to their very high protein content”, was found: higher educational status vegetarians were most likely to agree with this statement.

Statement 6: “The cultivation and consumption of insects has a very low negative impact on the environment and ecosystem, offers great prospects for sustainable agriculture and the planet, and insects are a rich source of proteins, amino acids and other important nutrients”.

Slightly less than half of all study participants (43,3%, n = 61), including omnivores (47,8%, n = 43) and vegetarians (35,3%, n = 18) agree, more than a third of respondents (38,3%, n = 54) – have doubts, among them - omnivores (40%, n = 36) and vegetarians (35,3%, n = 18), and only less than a fifth (18,4%, n = 26), including omnivores (12,2%, n = 11) and vegetarians (29,4%, n = 15) disagree with the statement that the cultivation and consumption of insects has a very low negative impact on the environment and ecosystem, offers great prospects for sustainable agriculture and the planet, and insects are a rich source of proteins, amino acids and other important nutrients.

Statement 7: “I intend to buy insect foods/ insect protein meal as soon as they become available”.

Only small part of all study participants (12,8%, n = 18), among them - omnivores (16,7%, n = 15) and vegetarians (5,9%, n = 3), intend to buy food products made from insects/insects protein meal as soon as they appear on the market; a third of all respondents (32,6%, n = 46) - have doubts, including omnivores (41,1%, n = 37) and vegetarians (17,7%, n = 9), and even more than half of all respondents (54,6%, n = 77;), including omnivores (42,2%, n = 38) and vegetarians (76,5%, n = 39) are not going to buy food products from insects/insects protein flour as soon as they appear on the market.

It could be concluded, that, considering food that contains Insect protein flour, more than a quarter of all study participants (26%) agree (mostly omnivores) and close to half of all respondents (49%) - have doubts that many sports foods and supplements contain insect protein; less than half of study participants (43%), mostly omnivores, agree, that the cultivation and consumption of insects has a very low negative impact on the environment, and only small part of all study participants (13%), mostly omnivores, express intention to buy insect foods/ insect protein meal as soon as they become available. Based on these findings, it can be assumed that the level of respondents' knowledge about insect-based food and its nutritional value is not sufficient.

Conclusion

1. After the analysis of scientific literature was carried out, it was found that the interest in eating insects as food is increasing; insects are consumed in many countries, but in Western countries consumption of edible insects is low and restricted mainly to specialized food items based on insect protein. Three main obstacles facing the edible insect sector were distinguished in research literature: consumer acceptance, technology and regulation. The scientific literature reveals that the most likely users of insects as a novel and more sustainable protein source in Western countries are younger males with a weak attachment to meat, who are more open to trying novel foods and interested in the environmental impact of their food choice. It could be concluded that there is a great complexity of different factors influencing consumer acceptability of insects as food in different countries.
2. After research of public opinion on dried mealybug (*Tenebrio molitor*) larvae usage in food products and acceptability for consumers in Lithuania was carried out and statistical analysis of the research data was performed, it was found that research participants in Lithuania who promote plant-based nutrition are usually not interested and do not intend to include insects and their protein flour in the diet. Meanwhile, Lithuanian omnivore respondents, mostly women, are a bit more open to this newly emerging food alternative. Statistically significant differences between omnivores and vegetarians considering acceptability of insect-based foods (intent to purchase, interest in trying insect protein foods) were determined during the study ($\alpha = 0,001$ and $\alpha = 0,003$ respectively). It was

found that insect-based food might attract consumers who are looking for new food choices and who are ready to reduce meat intake. In line with findings in scientific literature, food neophobia in European consumers is an obstacle for the consumption of insects. So, the food industry should focus on processed foods with insect-based food ingredients within a familiar product or flavor. It could be assumed that Lithuanian respondents lack knowledge and aren't convinced of the additional health benefits of insect consumption. In general, the findings of this research paper correlate well with research data on consumer acceptance of insect-based food that has already published in the scientific literature.

Bibliography

1. Aksoy AB and El SN. "Nutritional evaluation of biscuits enriched with cricket flour (*Acheta domestica*)". *International Journal of Gastronomy and Food Science* 29 (2022): 100583.
2. Belluco S., et al. "New protein sources and food legislation: the case of edible insects and EU law". *Food Security Act* 9 (2017): 803-814.
3. European Commission Implementing Regulation (EU) 2021/882 authorizing the placing on the market of dried *Tenebrio molitor* larvae as a novel food product pursuant to Regulation (EU) 2015/2283 of the European Parliament and of the Council and amending Commission Implementing Regulation (EU) 2017/2470. Official Journal of the European Union (2021).
4. Carvalho NM., et al. "The potential of insects as food sources - a review". *Critical Reviews in Food Science and Nutrition* 60.21 (2020): 3642-3652.
5. Clegg ME and Williams EA. "Optimizing nutrition in older people". *Maturitas* 112 (2018): 34-38.
6. Gere A., et al. "Readiness to adopt insects in Hungary: A case study". *Food Quality and Preference* 59 (2017): 81-86.
7. Lammers P., et al. "Acceptance of insects as food in Germany: Is it about sensation seeking, sustainability consciousness, or food disgust?". *Food Quality and Preference* 77 (2019): 78-88.
8. Lawler M. "What Is a Plant-Based Diet? A Complete Beginner's Guide". *Everyday Health* (2022).
9. Locke A., et al. "Diets for Health: Goals and Guidelines". *American Family Physician* 97.11 (2018): 721-728.
10. Meixner O., et al. "Material und Methode". Die Akzeptanz von Insekten in der Ernährung. Studien zum Marketing natürlicher Ressourcen. Springer Gabler, Wiesbaden (2018).
11. Nissen L., et al. "Gluten free sourdough bread enriched with cricket flour for protein fortification: Antioxidant improvement and Volatilome characterization". *Food Chemistry* 333 (2020): 127410.
12. Palmieri N., et al. "Exploring consumers' willingness to eat insects in Italy". *British Food Journal* 121.11 (2019): 2937-2950.
13. Pauter P., et al. "Effects of the replacement of wheat flour with cricket powder on the characteristics of muffins". *Acta Scientiarum Polonorum Technologia Alimentaria* 17.3 (2018): 227-233.
14. Quinteros MF., et al. "Functional, Antioxidant, and Anti-Inflammatory Properties of Cricket Protein Concentrate (*Gryllus assimilis*)". *Biology* 11.5 (2022): 776.
15. Rumbos CI., et al. "Evaluation of various commodities for the development of the yellow mealworm, *Tenebrio molitor*". *Scientific Reports* 10.1 (2020).

16. Sogari G., *et al.* "Australian Consumers' Response to Insects as Food". *Agriculture* 9.5 (2019): 108.
17. Verbeke W. "Profiling consumers who are ready to adopt insects as a meat substitute in a Western society". *Food Quality and Preference* 39 (2015): 147-155.
18. Wendin KME., *et al.* "Factors influencing consumer perception and acceptability of insect-based foods". *Current Opinion in Food Science* 40 (2021): 67-71.
19. Willett W., *et al.* "Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems". *The Lancet* 393 (2019): 447-492.
20. World Health Organization. "Plant-based diets and their impact on health, sustainability and the environment". Regional Office for Europe (2021).
21. World Health Organization (2022).

Volume 18 Issue 8 August 2023

©All rights reserved by Erika Kubilienė, *et al.*