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**EDIBLE INSECTS IN GUARANTEEING OF FOOD SECURITY**

Key words: edible insects, food security, sustainability, agri-food sector, environment

**ABSTRACT.** The purpose of this article is to assess the current state of knowledge on edible insects and their use in ensuring food security for society. In addition, the current legal status of edible insects is discussed, the economic and environmental benefits of their use are indicated. In addition, consumer opinions on the consumption of edible insects are presented. To achieve the goal, an analysis of the literature on the subject related to such issues as the legal regulation of “new foods”, environmental, economic and nutritional aspects of the consumption of edible insects, products with edible insects available on the market was used. Surveys on the benefits and risks of consuming unusual products and the willingness to undertake the consumption of edible insects were used. Edible insects can become a good alternative for satisfying food security in EU countries. Based on a literature study, it can be concluded that edible insects, are increasingly regulated and allowed for consumption. Currently, products based on edible insects from four species can be consumed in Europe. Edible insects fit into the theme of sustainability, as they can ensure food security in light of a growing population and limited natural resources.

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## INTRODUCTION

In 2015, the United Nations (UN) adopted the resolution “Transforming Our World: 2030 Agenda for Sustainable Development”. The 2030 Agenda contains 17 Sustainable Development Goals (SDGs), divided into 5 areas, i.e. people, planet, prosperity, peace, and partnership. For each goal, specific tasks to be achieved by 2030 are dissected – a total of 169 tasks that indicate actions to ensure a world that is climate-sustainable, environmentally sustainable and guarantees food security for future generations [Sogari et al. 2023]. One of the goals of the SDGs is to “ensure food security, and promote sustainable consumption and agriculture”. Under this goal, 8 tasks have been identified for implementation, 5 of which relate to food security and agricultural sustainability, while the remaining 3 relate to trade and market issues [Sogari et al. 2023].

Today’s food economy faces a number of challenges, which include intense social and demographic changes (i.e., the COVID-19 pandemic, armed conflicts, climate change, population growth), while at the same time reducing the availability of agricultural land [Henchion et al. 2017, Żuk-Gołaszewska et al. 2022, Sogari et al. 2023]. Researchers emphasise that food production, including animal production, has a negative impact on the environment (among other things, it is responsible for increasing CO<sub>2</sub> in the atmosphere). As a result, it is estimated that by 2050, nearly 150 mln people will be faced with the inability to provide a complete dietary protein supply [Żuk-Gołaszewska et al. 2022]. Increasing demand for food is a key issue in creating food security strategies using sustainable agricultural production [Henchion et al. 2017, Żuk-Gołaszewska et al. 2022]. The concept of food security, as defined in the Sustainable Development Goals, coincides with the literature definition, i.e. “food security occurs when all people, without any temporal disruption, have physical and economic access to a daily supply of safe food that covers their dietary needs and preferences, including physically active people” [Webster et al. 2020]. According to UN data, the number of hungry people has increased in recent years to nearly 10% of the world’s population, while some 3 bln people lack access to safe food. On the other hand, more than 800 mln people worldwide struggle with obesity and almost 2 bln people are overweight. Food waste is also a problem. It is estimated that around 1.3 bln tonnes of food is wasted globally each year. Most food is wasted in households (around 60%). The paradox is that the food that is wasted by households could be used to feed people in developing countries. However, this food ends up in the bin. The reasons for this include the COVID-19 pandemic, as well as the worsening gas and wheat crisis, leading to increasing social inequality [FAO 2018, Sogari et al. 2023]. Taking into account FAO estimates, food production should be increased almost twofold by 2030 so that food demand is met [FAO 2018, Wiza 2019, Żuk-Gołaszewska et al. 2022, Sogari et al. 2023, Szulc 2023]. The realization of this goal is questionable, as it involves increased exploitation of the environment, leading to the destruction of biodiversity, ecosystems,

farmland, and the depletion of water resources [Van Huis 2020, Sogari et al. 2023]. The food sector is estimated to generate one-third of climate change due to intensive livestock production, which has a negative impact on the environment, and is necessary for meat production [González et al. 2020, Crippa et al. 2021, Sogari et al. 2023]. In order to reduce meat production and meat consumption, foods are being sought that can satisfy the daily demand for complete protein, and at the same time their production is less harmful to the environment than the production of animal protein. Since 2015, there has been a discussion among European Union (EU) member states to allow edible insects, which have a high protein content and low carbon production [Guiné et al. 2021, Aidoo et al. 2023, Li et al. 2023, Szul 2023].

The subject of edible insects is attracting interest from scientists, politicians to entire societies. The increased interest in edible insects is due to the nutritional properties they possess i.e. insects are a valuable source of digestible protein, which is an essential building block for the human body. In addition, they are rich in minerals (iron, calcium) and vitamins (e.g. B vitamins). Besides, they can contribute to food security in the future, as studies indicate they can be used to produce food, but also animal feed. Such activities reduce environmental costs and food waste costs, as some insect species may have applications in biodegradation and biotransformation of organic by-products [Van Huis 2020, Mancini et al. 2022].

Many researchers [Henchion et al. 2017, Wiza 2019, Van Huis 2020, Guiné et al. 2021, Mancini et al. 2022, Aidoo et al. 2023, Li et al. 2023, Sogari et al. 2023, Szulc 2023] see opportunities in food security in entomophagy, which has been reported in the literature for several years. There is an increasing number of publications that include existing research on edible insects and their potential impact on the environment, as well as their help in ensuring food security for future generations [Onwezen et al. 2021].

The purpose of the article is to assess the current state of knowledge on edible insects and their use in ensuring food security for society. In addition, the current legal status of edible insects will be discussed, the economic and environmental benefits of their use indicated. In addition, consumer opinions on the consumption of edible insects are presented.

## RESEARCH MATERIAL AND METHODS

To achieve the main objective, the literature of the subject was used, which was obtained from such databases as Scopus, Google Scholar, Web of Science. The literature review was conducted between January 2023 and December 2023. Published articles in the above-mentioned databases were given an evaluation without time limitations of the year of publication. Most articles in English were considered. The following key words

were used for the search: “edible insects”, “food security”, “food industry”, “environmental benefits vs. edible insects”, “nutritional value of edible insects”, “regulation of edible insects”. Based on the collected scientific publications, an assessment was made of the legal regulation of edible insects, the nutritional, environmental and economic benefits associated with the production of edible insects, and an attempt was made to assess whether edible insects can contribute to food security in the future. In the course of the analysis, the research question was posed: how can edible insects contribute to global food security? In addition, in order to assess consumers’ views on the consumption of edible insects, a survey was used, which was conducted in June 2023 among 200 high school students in Poznan. The survey investigated the willingness of young people to undertake consumption of edible insects.

## RESULTS OF RESEARCH EDIBLE INSECTS IN LEGAL TERMS

The regulations being introduced by the EU Commission for the approval of selected insect species for consumption are a key rationale for the development of insect farming [Żuk-Gołaszewska et al. 2022]. Edible insects constitute so-called novel foods (or “new foods”). In Regulation (EU) 2015/2283, the term “novel food” is understood as a category that refers to “food consisting of or produced from animals or parts thereof”. In addition, “novel food” means food that has not been used for human consumption to a significant degree in the Union before May 15, 1997, regardless of the dates of accession of the Member States to the Union. By including both whole animals and their parts in the categories of products covered by the new food authorization system, among others, this category includes insects and products of insect origin (Figure 1).

It should be emphasized that the legislation introduced should be mandatory for the entire production chain of food produced with edible insects, i.e. from primary production (wild harvesting of insects) to farmed insects [Grabowski et al. 2020]. Edible insects should be verified for food safety in accordance with current legislation on traditional foods, as well as taking into account regulations on the breeding of edible insects and their use in the production of various food products [Regulation (EU) 2015/2283, Żuk-Gołaszewska et al. 2022]. Although insects approved for private consumption are not registered, insects marketed must meet feed and food hygiene standards, good husbandry practices, good hygiene practices and good production practices [Lähteenmäki-Uutela et al. 2018, Bakula and Gałęcki 2021, Żuk-Gołaszewska et al. 2022]. Producers of edible insects and products based on them must follow certain rules, viz:

1. Products with edible insects must be accurately labeled and certified before being marketed [Redmond and Griffith 2004, Patil et al. 2005, Bakula and Gałęcki 2021, Żuk-Gołaszewska et al. 2022].

<b>June 2021</b>	<ul style="list-style-type: none"> <li>• The European Commission authorises the consumption of mealworm larvae (<i>Tenebrio molitor</i> L), Commission Implementing Regulation (EU) 2021/882</li> <li>• The product can be consumed in frozen, dried or powdered form</li> </ul>
<b>November 2021</b>	<ul style="list-style-type: none"> <li>• The European Commission authorises the consumption of locusts (<i>Locusta migratoria</i> L.), Commission Implementing Regulation (EU) 2021/1975</li> <li>• The product can be consumed in frozen, dried or powdered form</li> </ul>
<b>February 2022</b>	<ul style="list-style-type: none"> <li>• The European Commission has ruled that house cricket (<i>Acheta domestica</i> L.) is a food and can be marketed as such within the European Union, Commission Implementing Regulation (EU) 2022/188</li> </ul>
<b>January 2023</b>	<ul style="list-style-type: none"> <li>• EC Regulation 2023/5 of 3 January 2023 allows the placing on the market of partially defatted cricket powder (<i>Acheta domestica</i> L.), cricket flour</li> <li>• The EU document indicates that, for example, a maximum of 2 g of cricket powder per 100 g of product is allowed in multigrain breads, and 3 g per 100 g of product in cereal grain bars</li> </ul>
<b>January 2023</b>	<ul style="list-style-type: none"> <li>• EC Regulation 2023/58 of 5 January 2023 authorises the placing on the market of larvae of the thrush (<i>Alphitobius diaperinus</i> L.)</li> </ul>

Figure 1. Legislation process of edible insects permitted for consumption within the EU  
Source: own elaboration based on the legal acts listed in the diagram

2. Edible insects are qualified as livestock, so they can only be fed with products of plant or animal origin that have been approved for livestock feeding [Żuk-Gołaszewska et al. 2022].
3. Breeders of edible insects are required to keep documents that contain information on the date of delivery of feed, the manufacturer of the feed and the initial parameters of the feed. Products that do not meet safety standards cannot be used in feeding insects [Żuk-Gołaszewska et al. 2022].
4. Each batch of product should be traceable [Bosona and Gebresenbet 2013]. Each batch of insects marketed must comply with microbiological safety standards [Bakuła and Gałęcki 2021]. It should also be monitored for the presence of undesirable chemicals, including heavy metals, pesticides and mycotoxins of insect-derived products [Bosona and Gebresenbet 2013, Bakuła and Gałęcki 2021, Kwiatek et al. 2021].

Despite food producers' adherence to the above principles, there may be some risks associated with the consumption of food with edible insects. The most commonly mentioned risks include allergies, parasites, zoonoses or contamination (e.g. by heavy metals). It is worth mentioning that these risks are in no way unique to food. In the media, there are often reports of consumers being poisoned by, for example, the consumption of fish that has been found to exceed limit values for dioxins or methylmercury. And yet, if food safety rules were followed, such situations could be avoided. It is therefore important that safety procedures are followed and regular checks are made to ensure that insect food is safe for us. So the chance of COVID-19 caused by eating a diseased cricket is extremely low, if not biologically excluded.

#### EDIBLE INSECTS FROM THE PERSPECTIVE OF CLIMATE CHANGE, ENVIRONMENT AND ECONOMY

The food industry, and meat production in particular, contributes to environmental degradation [Lang and Barling 2013, van Huis 2015]. Meat demand worldwide is estimated to increase by 76% from 2005 to 2050 [Alexandratos and Bruinsma 2012]. According to a report by Christine Chemnitz and Stanek Bechev entitled "Meat Atlas. About the animals we eat", published in 2022 by the Heinrich Böll Foundation in Warsaw in cooperation with the Institute for Sustainable Development, the demand for meat in developing countries will quadruple by 2028 compared to developed countries. Livestock farming contributes to deforestation, soil erosion, loss of biodiversity and pollution of water resources [Van Huis 2015]. It is estimated that livestock production is responsible for about 14% of all greenhouse gas emissions [Gerber et al. 2013] and 59-71% of global ammonia emissions [Aidoo et al. 2023]. In response to the emerging problems of livestock farming, the EU has proposed the use of edible insects for animal feed and market release for human consumption. According to studies conducted by [Van Huis 2020, Bakula, Gałęcki 2021, Guiné et al. 2021], among others, it has been shown that the production of edible insects can bring a number of environmental, nutritional, as well as economic benefits. It was found that [Bartkowicz 2018, Wiza 2019, Bakula and Gałęcki 2021]:

1. The production of greenhouse gases in the farming of most insects can be lower than in the farming of livestock, e.g. pigs produce 100 times more greenhouse gases per kg mass than the mealworm (*Tenebrio molitor* L).
2. Insects can be fed with bio-waste, i.e., by-products of food production, by-products of various food industries, processing can convert this into high quality protein.

3. Insect farming has minimal impact on the environment e.g., crickets produce on average less than 0.1% of the CO<sub>2</sub> of what cattle farming exports; in addition, it takes 13 times less acreage under cultivation to produce 1 kg of protein from insects.
4. Insects can be raised vertically, making their breeding more efficient.
5. Insects have high feed conversion efficiency – can convert 2 kg of feed for 1 kg of insects, while cattle need 8 kg of feed to produce 1 kg of weight gain.
6. Insects use much less water than livestock – currently, 19% of drinking water resources are used for industry and 69% for agriculture. Global consumption has increased 6-fold over the past 100 years due to population growth, economic development and changing consumption patterns, and continues to grow at a rate of about 1% per year. Inefficiency in water use in agriculture is also a cause of environmental degradation, reduced river flows, wildlife habitat degradation and pollution. Insects require only a fraction of the water and feed of traditional farm animals. They can be raised in virtually any climate and environment.

In addition to the positive nutritional and environmental aspects, edible insects are gaining popularity among food producers because of the profitability of production and sales. It is estimated that by 2030 the market for edible insects could be worth USD 8 bln [Guiné et al. 2021]. Currently, producers in Asia and Latin America account for the largest share of the market at 50%, but it is anticipated that North America and Europe may experience an increase in market share in the coming years [Guiné et al. 2021]. Insect prices give an idea of the market for edible insects in the world and where they are distributed (rural, urban, Internet) [Wiza 2019]. For example, in the Democratic Republic of Laos, the price for 1 kg of locusts is about 8-10 euros, while in the Netherlands, one should pay about 9.99 euros for 35 g of migratory locusts [Van Huis 2020]. You can also buy edible insects in Poland, but in online sales. One Polish online shop offers dried crickets in a variety of flavours, as well as whitefly larvae at a price of PLN 14.90 per 20 g product [Food Bugs 2024]. Higher selling prices for edible insects in Europe are determined by lower demand for such products than, for example, in African or Asian countries. Besides, the production of insects is regulated by legal acts issued by the European Commission [Wiza 2019]. It should be noted that insect farming could be a decisive factor in the fight against rural poverty in developing countries in the coming years [Aidoo et al. 2023]. Insect farming can be a source of income for the lowest strata of society, as they are easy to produce and process and do not require a high financial investment to start a business in this area [Guiné et al. 2021, Aidoo et al. 2023].



## EDIBLE INSECTS FROM A CONSUMER PERSPECTIVE

Edible insects are consumed primarily in Southeast Asia and tropical countries, where their consumption is based on tradition and culture [DeFoliart 1999]. One of the primary cultural determinants is consumer preferences for food consumption [Harris and Ross 1987]. In the case of European society, where insect consumption is not a culinary tradition, the real challenge is to study the acceptance and psychological factors determining the introduction of insects into the daily diet [Ghosh et al. 2018, Dagevos 2021].

In recent years, numerous consumer studies have been conducted among countries in Europe [Tan et al. 2016, Verneau et al. 2016, 2020, Mancini et al. 2022], North America [Looy and Wood 2006, Ruby et al. 2015] and Australia [Lensvelt and Steenbekkers 2014, Sogari et al. 2019], i.e. regions that differ from each other due to cultural traditions, as well as the lifestyles led by the studied societies and their eating habits [Sogari et al. 2023]. Considering psychological factors among the studied societies, neophobia and food repulsion were found to play a key role in shaping Western societies' acceptance of edible insects [Tan et al. 2016, Fischer and Steenbekkers 2018, La Barbera et al. 2018, Mancini et al. 2019, Sogari et al. 2019]. Food neophobia is defined as the tendency to avoid unfamiliar and new foods [Pliner and Hobden 1992]. Food revulsion, on the other hand, is an emotional defensive response by humans, where the goal is to prevent the ingestion of potentially harmful substances [Oaten et al. 2009]. Based on research [Björklund and Hursti 2004], the two variables have been shown to be positively correlated. In addition to this, they may be determined by other factors causing limited insect consumption among Western communities, which include consumers' negative attitudes toward edible insects through lack of familiarity with the product [Dagevos 2021], social norms and the degree to which consumers trust the claims of institutions, producers, researchers and product users, social influences and feelings of insecurity [Ghosh et al. 2018, Dagevos 2021].

Most European countries are skeptical about the consumption of edible insects, but depending on the age group, opinions regarding insects are divided, as exemplified by studies conducted in recent years [Żuk-Gołaszewska et al. 2022, Szulc 2023]. For example, Wim Verbeke [2015] highlighted in his study that young men who occasionally eat meat are more likely to consume insects, with concerns about the environmental significance of their dietary choices. In contrast, Samuel Piha et al. [2018] found that consumers from Northern European countries are more positive about consuming insect-based products than societies living in Central Europe. In Poland, insects are consumed occasionally and regarded among the public as occasional and treated as an exotic curiosity [Żuk-Gołaszewska et al. 2022]. Using Joanna Bartkowicz's [2018] research approach and applying the survey questionnaire included in the publication, an in-house survey conducted in June 2023 on a sample of 200 secondary school students in Poznań showed that young men (90%) were more likely than young women (70%) to be willing to consume traditional insect

dishes (Table 1). The willingness to make dishes with insects in the presence of a chef was expressed by 75% of the respondents, 90% of whom in this group were women. As many as 95% of the women participating in the survey indicated that they were more likely to use insects in powdered form. According to 90% of young men, more knowledge about insects would encourage their consumption (Table 1).

In conclusion, Poznań youth have shown curiosity and openness towards an alternative form of food, such as edible insects. In order to get potential consumers to consume insects, it is the task of producers to inform and promote this form of nutrition in the form of an interesting assortment of products with insects [Wiza 2019].

An important factor that may induce consumers to try new foods is the proportional selection of ingredients based on edible insects compared to conventional product ingredients. According to Alessia Lombardi et al. [2019] the addition of cricket flour (*Acheta domestica* L.) to pasta proved more acceptable than a chocolate bar containing whole insects [Lombardi et al. 2019]. Given the beneficial impact that edible insect farming and potential human consumption have on the three pillars of sustainability [Guiné et al. 2021], many researchers have pointed out that effective communication between researchers and consumers in communicating the benefits of insect consumption is important, from both a marketing and policy perspective.

Table 1. Opinion of Polish youth regarding edible insects in June 2023 (N = 200)

Question	Response structure [%]			
	women (N = 100)		men (N = 100)	
	yes	no	yes	no
Would you eat an edible insect	90	10	95	5
If edible insects were added to traditional products would you eat them?	70	30	90	10
If there was an opportunity to make dishes with edible insects under the guidance of a chef would you participate	90	10	60	40
If another form of serving insects was used, e.g. powdered, as an additive (form invisible to the eye) would you accept	95	5	90	10
If you had more knowledge about edible insects and their consumption would you encourage consumption	80	20	90	10

Source: own compilation based on [Bartkowicz 2018]

It has been found that the popularization of information regarding edible insects encourages consumers to try tasting insect-based products. Importantly, information regarding social benefits is more important than information regarding health or environmental benefits [La Barbera et al. 2018, Lombardi et al. 2019, Fasanelli et al. 2020]. Studies by Hanna Schösler et al. [2012], Matthew B. Ruby et al. [2015], Christina Hartmann and Michael Siegrist [2016] confirm that European populations are more likely to consume processed insects of them raw. With that said, foods containing processed insects cannot be described as meat substitutes, i.e. crisps and bars enriched with insect proteins. On the other hand, they can determine the consumption of raw insects. Overcoming the barrier by European societies regarding the consumption of insects is an important problem that can be solved by proper marketing of insects, which would focus on creating positive associations regarding edible insects, where their beneficial effects on health, but also on the environment and climate would be emphasized. In order to convince European consumers to consume insects on a regular basis, insect-infused products should be created with an acceptable taste, product form and at a favorable price, which will result in easy integration into individual dietary practices [Wiza 2019].

## CONCLUSIONS AND SUMMATION

In conclusion, edible insects are important in guaranteeing food security for future generations because:

1. A small amount of resources are needed to raise insects: raising insects requires much less water, feed and space compared to traditional animal husbandry, such as cattle or pigs. This makes them more efficient and more environmentally friendly.
2. Insects provide an alternative source to traditional foods, especially for people who have difficulty accessing traditional sources of protein, e.g. due to poverty or lack of arable land. In addition, due to the low cost of production, they can be accessible to poorer communities.
3. Insects can be a valuable component of a varied diet. Many species of edible insects are known to be consumed for their nutritional as well as taste qualities. Thus, they can add variety to the daily diet of Europeans.
4. Insect farming generates far fewer greenhouse gas emissions and therefore has a lower environmental impact than traditional animal husbandry.
5. Edible insects should be verified for food safety in accordance with current legislation on traditional foods and taking into account the regulations on the breeding of edible insects and their use in the production of various food products.

In summary, edible insects can provide a valuable food source while contributing to sustainable development and ensuring food security in light of a growing population and limited natural resources. It should be emphasized that education about the benefits of consuming edible insects among the general public plays a key role in convincing the European public to consume edible insects. In addition, it is important to conduct further research on edible insects and their potential benefits to society and the environment.

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## OWADY JADALNE W ASPEKCIE BEZPIECZEŃSTWA ŻYWNOŚCIOWEGO

Słowa kluczowe: jadalne owady, bezpieczeństwo żywnościowe, zrównoważony rozwój, sektor rolno-spożywczy, środowisko

ABSTRAKT. Celem artykułu jest ocena dotychczasowego stanu wiedzy w zakresie jadalnych owadów i ich wykorzystania w zapewnieniu bezpieczeństwa żywnościowego dla społeczeństwa. Ponadto omówiono dotychczasowy stan prawny jadalnych owadów, wskazano korzyści ekonomiczne i środowiskowe, jakie wynikają z ich wykorzystania. Dodatkowo przedstawiono opinie konsumentów w zakresie konsumpcji jadalnych owadów. Do realizacji celu posłużono się analizą literatury przedmiotu związaną z takimi zagadnieniami, jak: regulacje prawne w zakresie „nowej żywności”, aspektów środowiskowych, ekonomicznych oraz żywieniowych, dotyczących konsumpcji owadów jadalnych i dostępnych na rynku produktów z dodatkiem owadów jadalnych. Wykorzystano badania ankietowe dotyczące korzyści i ryzyka wynikającego ze spożywania nietypowych produktów oraz gotowości do podjęcia konsumpcji owadów jadalnych. Owady jadalne mogą stać się dobrą alternatywą dla zaspokojenia bezpieczeństwa żywnościowego w krajach UE. Na podstawie studium literatury można stwierdzić, że jadalne owady coraz częściej są dopuszczane do konsumpcji jest to prawnie regulowane. Obecnie w Europie można spożywać produkty na bazie owadów jadalnych z czterech gatunków. Owady jadalne wpisują się w tematykę zrównoważonego rozwoju, gdyż mogą zapewnić bezpieczeństwo żywnościowe w świetle rosnącej liczby ludności i ograniczonych zasobów naturalnych.

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