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Edible Insects: A Study of the Availability of Insect-Based Food in Poland

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Abstract: In Poland, there has been a significant surge of interest in exploring insects as a novel food source in recent years. This increased interest is evident in various sectors of society, from researchers and food manufacturers to consumers and culinary experts. For example, research institutions have been conducting studies to assess the nutritional value and environmental impact of insect-based foods, while food companies are actively experimenting on how incorporating insect-based ingredients into their product lines affects consumer preferences. Although insect-based food products are highly valued in many parts of the world, their development has only gained attention in Poland over the last decade. Researchers and startups began conducting studies and developing insect-based food alternatives at the beginning of 2015. Therefore, the aim of this study was to examine the market availability of insect-based food products in Poland. Since the success of insect-based food products in the Polish market depends on the willingness of consumers to buy this type of food alternative, the results of a narrow recent literature review have been summarized in this study and point out consumer perceptions and barriers to choosing insect-based food products. The aim of this narrow literature review was to provide information on consumer perceptions and barriers to consuming insect-based food products so that producers and manufacturers in Poland can design marketing strategies. To achieve the aim of this study, the websites of several food stores were examined that sell insect-based food products in Poland and created a database. Then, to identify the perceptions and barriers towards insect-based food products, the results of a few studies conducted in Poland and other countries were summarized. Six online food stores operating in Poland that sell insect-based food products were found. In total, seventy-three products that were available on the market were analyzed. The results showed that Polish consumers have access to a large variety of insect-based food alternatives, such as whole insects, protein bars, and several types of powdered insect-based food products. However, their purchasing behavior is reluctant due to several barriers, such as food neophobia and disgust, lack of familiarity with the product, lack of information about the handling and preparation of insects, and ways to incorporate insects into the daily diets of consumers. Insect-based food producers and manufacturers in Poland should consider these results when tailoring their marketing strategies.

Keywords: edible insects; insect-based food; market availability; alternative protein; Poland

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1. Introduction

Food consumption, especially meat consumption, accounts for a large part of the ecological footprint. Livestock and fish are crucial and fundamental sources of protein in the global human diet, playing a central role in providing the essential amino acids and nutrients necessary for growth, development, and overall wellbeing [1]. These sources of protein have been integral to human nutrition and food security for centuries, forming the basis of diets around the world. The increasing costs of animal production, an increasing number of new diseases among livestock, a growing global population, the depletion of freshwater resources, climate change, and environmental pollution are the most common factors contributing to the intensive search for alternative sources of food

that are safe for human consumption and can be produced at low costs [2–4]. As these concerns continue to gain prominence and recognition, there is a growing emphasis on exploring alternative protein sources that have a lower environmental impact, promote biodiversity conservation, and uphold higher animal welfare standards [5]. A promising alternative to conventional sources of protein is edible insects, which have immense potential as a component of the human diet due to their high nutritional value [2,6]. Insects have been recognized globally as a potential source of nutritional components, including proteins [7–11], carbohydrates [12–14], and lipids [2,15,16], coupled with an abundance of various vitamins and minerals [12,13]. Edible insects have a good nutritional profile and offer individual benefits when incorporated into the diet. For example, oils extracted from insects may contain higher levels of unsaturated fatty acids, including omega-3, compared to meat sources [17,18]. Furthermore, insects contain bioactive peptides [19,20], including antioxidant [21,22], antihypertensive [11], immunomodulatory, anti-inflammatory [23], and antimicrobial [24] properties, among others. The nutritional composition and profile of insects are influenced by several factors, such as species, diet, stage of development, gender, and habitat [20,25]. Processing and preparation methods also play an important role [13,26]. Numerous insect species can convert low-value organic by-products into high-value protein products [18]. Insect protein concentrates and isolates, after processing, exhibit desirable functional properties [27]. Insect proteins also exhibit high emulsifying activity and moderate foam-forming abilities. Therefore, they can be used in food production, such as improving the nutritional value, while also improving the texture, consistency, and appearance of the food product [22]. For example, cricket flour was introduced into the recipe for several cereal products, such as muffins [28] and pasta [29]. The use of insects increased the protein contents and mineral compounds in the obtained products. Consumers have well accepted these cricket products. Their colors resembled that of whole grain products and are generally considered healthier. Sensory evaluation showed that pasta produced with cricket flour gained a level of consumer acceptance comparable to that of conventional products.

One of the key environmental advantages of edible insects is their resource efficiency. Insects, such as crickets and mealworms, require significantly less water, feed, and land compared to traditional livestock, such as cattle and poultry [30]. In addition, insects have a higher feed conversion efficiency, and their greenhouse gas and ammonia emissions are significantly lower [31,32]. Crickets have feed-to-meat conversion rates that are twice as high as chickens, and 4–12 times higher than pigs and cattle. Compared to cattle, crickets need 12 times less feed than cattle to produce the same amount of protein [33]. Insects produce 10 to 100 fewer greenhouse gas emissions per kg of weight than cattle and beef [3]. This efficiency reduces the demand for agricultural land and water resources, making insect farming a more sustainable option in a world facing increasing population growth and limited resources. Insect farming, if carried out sustainably, can support biodiversity conservation. Insects require less space for farming, thus preserving natural habitats and ecosystems [4]. One kg of edible protein from mealworms requires 50% less water and 2–3 times less land than chicken. Compared to mealworms, beef requires ten times more land and approximately five times more water to produce 1 kg of edible protein [4,34,35]. Furthermore, by converting waste into nutritious insect biomass, we can close the nutrient cycle and minimize waste generation, contributing towards a more sustainable food system. Water scarcity is an urgent environmental issue, especially in regions affected by prolonged droughts and water stress [36].

The consumption of insects as a sustainable and nutritious food source has gained international attention. However, despite their potential benefits, the availability of insect-based food products on the Polish market is limited by many factors. Currently, the main factor that limits the use of edible insects in Poland, as well as throughout Europe, is the lack of consumer acceptance [11]. Insects as a food source are relatively new and unfamiliar to many consumers. There may be psychological barriers, such as disgust or neophobia (resistance to trying new foods), that can affect consumer acceptance. This

hesitancy can slow down the demand for insect-based food products, which, in turn, affects market availability. Overcoming cultural prejudices and fostering acceptance can take time. Furthermore, a lack of awareness and accurate information about the health and environmental benefits of insect consumption can hinder consumer interest. An increased awareness of entomophagy is required to accept insects as food, in addition to the willingness to try them [37]. However, a study conducted in 14 countries, including Poland, investigated Polish participants who had high scores of knowledge about the sustainability of edible insects [38]. Afterward, insect-based food products are now more expensive to produce compared to their traditional alternatives. This limits the affordability of these products. In addition, the regulation of new food products, including edible insects, can be complex and vary between countries. Insect breeding, as well as the maintenance of other Polish livestock, are controlled in Poland by the Veterinary Inspection and the Sanitary Inspection in the case of animals intended for human consumption. However, in Poland, there are still no national regulations in this regard. Therefore, the relevant EU regulations apply for this country. This process can be time-consuming and can influence the speed with which new insect-based food enters the market. Furthermore, edible insect consumption is gradually appearing in European countries and is likely to become more widely accepted in the coming months [6]. However, acceptance of the insect-based food alternative first depends on the availability of the product on the market and, second, the willingness of consumers to accept and purchase these products. From the producer's point of view, although the presence of insect-based food products in Poland is recent (2015), compared to other EU member states, there are several producers that supply insect-based food products in the local market. However, there are no studies available that examine the availability of insect-based food alternatives on the local market. Therefore, the aim of this study was to examine the market availability of insect-based food products in Poland. From a consumer point of view, several studies have been conducted to understand the purchasing behavior and preferences of consumers on the food market [30,39–41]. These studies have highlighted the importance of several factors, such as quality, health, and convenience, in consumer decision making. In addition, cultural and social differences have been identified as key determinants of consumer behavior. Since the success of insect-based food products on the Polish market depends on the willingness of consumers to buy this type of food alternative, the results of a narrow recent literature review have been summarized and point out consumer perceptions and barriers to choosing insect-based food products. The aim of this narrow literature review was to provide information on consumers' perceptions and barriers to insect-based food producers and manufacturers in Poland and help them design marketing strategies.

Perceptions and Barriers to Consuming Insect-Based Food Products

There is a long history of human consumption of insects in many parts of the world, especially in Asia, Africa, and South America, where insects have been a primary source of protein for centuries [42,43]. In tropical regions, insects are traditionally prepared by either roasting or frying with onions, pepper, salt, and other spices. They are also used as insect-based ingredients in dishes, such as larvae (*Cirina forda* and *Bunaea alcinoe*) in vegetable stews [44].

The acceptability of edible insects in Europe, Australia, and North America is still low [45,46]. Taste, appearance, safety, and quality were considered to be the most likely factors influencing the willingness of consumers to try eating insects, but consumer attitudes towards entomophagy were influenced by both food neophobia and disgust [47–50]. Moreover, past research has indicated that while the awareness of insects as food is increasing, certain factors, such as lack of familiarity and disgust, remain as barriers [48,51].

Poland, like many other countries, has cultural factors that influence the perception of consuming insects. Historically, insects have not been part of traditional Polish cuisine, and there may be a certain level of resistance or hesitation towards incorporating them into the diet. Orkusz et al. (2020) [40] conducted research to uncover the knowledge, behaviors,

and attitudes of the Polish community about edible insects and understand the key factors influencing edible insect consumption. It was found that among Polish students, there is a low inclination to accept insects as a meat substitute due to psychological barriers, such as neophobia and disgust. However, the willingness to consume processed food containing insects (e.g., bread) is significantly higher than that for whole, unprocessed insects. Environmental benefits were found to be the least influential factors affecting students' willingness to try insects. Additionally, a significant majority of participants participated in a bread tasting with powdered edible insects, indicating that positive sensory experiences can improve the acceptance of insects as food. The idea of consuming insects as food is a relatively new and controversial concept for Polish consumers [52]. In Poland, insects are eaten sporadically and are considered an exotic curiosity, as there is no tradition of eating insects as food. This absence of cultural familiarity contributes to the initial skepticism associated with the incorporation of edible insects into the diet. The media (including news articles, TV, and the internet) discussing insect consumption contributes to public awareness but can also fuel debates around the appropriateness of incorporating insects into the diet. In addition, it is necessary to develop a strategy to raise awareness that edible insects are healthy and safe for human and animal nutrition.

The emergence of startups focusing on insect-based products, while innovative, also highlights the challenges of breaking into a market that is unfamiliar with this type of food. According to Zielińska et al. (2021) [53], the food industry should focus on processed foods with insect-based ingredients to make them known to consumers. Introducing insect-based food products may face an initial resistance due to the unfamiliarity and the perception of insects as unconventional food sources [54]. However, as with any new food trend, acceptance and openness may increase over time as people become more exposed to the concept and its potential benefits. Lectures and workshops for children may be of particular importance, as learning entomophagy from an early age may allow for greater acceptance of this phenomenon in the future [52].

Disgust is one of the most common reactions, and is also the biggest barrier [55]. Another reason to reject edible insects is food neophobia. Insects are considered dirty, primitive foods, and their sensory qualities are generally viewed negatively [56]. Food neophobia refers to the fear or reluctance to try new foods, particularly those that are unfamiliar or outside of one's cultural norms [46,47]. In modern societies with abundant food choices and diverse culinary practices, food neophobia can influence dietary behaviors and limit the adoption of new and potentially nutritious foods, including insects [49]. This can have implications for overall nutrition and health, as different foods offer unique sets of nutrients. Neophobia can be influenced by cultural norms and social pressures. In societies where insects are not traditionally consumed, the fear of trying insect-based foods might be heightened due to cultural aversion [57,58]. In addition, food neophobia might prevent consumers from considering insects as a viable alternative to resource-intensive animal products [49,59]. Even if consumers show a high tendency to care for the environment and a balanced diet, this does not change into a higher level of acceptance and willingness to try insect-based food products [60]. Surveys of Taiwanese and Korean consumers have shown that food neophobia and disgust for some forms of insects have also been identified as the main factors in not buying or eating insects [61,62]. Mancini et al. (2019) [63] and Grasso et al. (2019) [64] also showed a low propensity to eat insects as a meat substitute, among Italian consumers, mainly based on feelings of disgust and neophobia. Lammers et al. (2019) [59] obtained similar results when studying the propensity of German consumers to eat insect burgers. Orsi et al. (2019) [65] also identified disgust as the most common psychological barrier.

When consumers are confronted with new or unfamiliar foods, common reactions include both rejection and curiosity. An interest in trying new things has been defined as an important motivational aspect of food selection [42]. Not all consumers find insects disgusting [66]. In the US, 72.5% of the study participants were willing to consume at least one insect-based food product, and in Canada, it was shown that 67% of the participants

had already tried foods with insects [56]. Danish consumers see insects as a sustainable food source and a viable alternative to meat. Aspects such as more sustainable production, protein, and other nutrients were mentioned and were also considered tasty [66].

Belgian consumers over the age of 45 years were more willing to accept insect-based foods compared to other age groups [67]. In other studies, younger consumers were more willing to accept new foods, such as insects [68], while, for example, young Australians were found to be less willing to accept them [69], and food neophobia had a negative impact on the desire to eat insect burgers among children and adolescents in Germany [70]. Opinions vary in terms of the influence of gender on neophobic behavior, finding either a greater tendency for men to consume insect-based foods compared to women or no effect of gender [67,71]. In a Danish study, it was examined how in-person classroom exposure to educational and tasting interventions affected children's perceptions of edible insects and insect-based cuisine. Children who attended the live classroom session said that there was a good association between their willingness to eat insects and their agreement that society needs sustainable meals [72].

Stone et al. (2021) [43] found that perceptions of both unprocessed (whole and cooked) and processed insects (such as cricket flour) were more favorable after tasting compared to previous expectations. Therefore, the first step to reducing neophobia is to integrate insects into familiar foods frequently eaten by consumers [56]. Furthermore, an interesting new food experience and a sense of excitement related to adventure, frenzy, and sensation seeking have also been identified as important in food acceptance [73]. The predominant Danish media has shown great interest in entomophagy. There are regular reports on insect production or on the use of insects as food [66].

Several studies have been conducted to explore customer attitudes towards insect-based food products. The results showed that although most people had never eaten an insect-based food product before, there was some willingness to try these foods [54,56,59]. The environmental and health benefits of eating insects increase acceptance. Moreover, familiarity plays an important role in reducing food disgust [55]. When insects are added as an ingredient in the elaboration of familiar products (e.g., bread and snacks), food neophobia is reduced, and consumers attach positive ratings to the taste and appearance of insect-based foods [40,48,74]. According to Wilkinson et al. (2018) [48], taste, appearance, safety, and quality were identified as the factors most likely to influence the willingness of Australian consumers to try eating insects, but consumer attitudes towards entomophagy were supported by both food neophobia (i.e., reluctance to eat new or novel foods) and past insect consumption. Neophobic consumers were much less accepting of entomophagy than neophilic consumers, while consumers who had previously eaten insects were more accepting of insects as food. The inclusion of insects in familiar products (e.g., biscuits) or cooked meals also made them more attractive. For example, creating insect-based bread can provide a sense of familiarity and make it easier for people to incorporate insects into their diet. This familiarity helps reduce the psychological aversion associated with trying something entirely new and unknown. Additionally, sharing recipes with insect-based ingredients can help people view insects as a varied dietary option. In the literature, several applications of insect powders have been successfully used by consumers to produce bread, cakes, cookies, muffins, or meat analogues [17]. In addition, insect-based ingredients increase protein levels while reducing carbohydrate levels [53,75,76]. Kowalski et al. (2022) [77] assessed the quality of bread enriched with flour from three insect species (mealworm, lesser mealworm, and house cricket). A 10% inclusion of insect flour significantly increased protein content compared to wheat bread. For consumer acceptance, a limited amount of insect flour is allowed to substitute cereal flour; for example, bakery products allow up to 10% insect-based flour in their formulations [77,78]. An additional percentage of insect-based flour (e.g., bread) would give the product a darker color and a distinct smell, which often negatively affects the acceptability of the product.

Furthermore, insect-based products seem to be more widely accepted than whole insects [73,79]. Certain products, such as insect powders (flours), bakery products, and

protein bars, have improved their acceptance [77]. Introducing insect-based ingredients into familiar products helps consumers become accustomed to the idea of eating insects without significantly changing their dietary habits. These findings suggest that barriers to the acceptance of insects as food can be overcome through product design, education, and effective marketing strategies. Allowing consumers to try insects or insect-based products will likely be the most effective marketing strategy to promote acceptance of this type of food [48]. The availability of insect-based food products within the local market is of significant importance, as it directly influences consumer perceptions, attitudes, and consumption behaviors. The accessibility of these products determines the feasibility of incorporating insects into daily diets. Limited research on insect-based food availability on the Polish market can provide valuable information to producers, retailers, policy makers, and researchers to promote more accessible insect-based food products in Poland.

2. Materials and Methods

2.1. Availability of Insect Food in Poland

In recent years, there has been an increase in the assortment of insect food due to the increasing awareness of the importance of edible insects among consumers, farmers, manufacturers, and policy makers [80]. The market for edible insects is expected to reach USD 1.2 billion by 2023 [57].

Recently, an increase in the availability of insect food has been observed in Poland. While still considered a niche market, the demand for edible insects is growing, driven by several factors, such as sustainability, nutritional benefits, and culinary curiosity. Additionally, it explores the origin of these products and the limited variety of insect-based food items found on the Polish market compared to other European countries.

2.2. Data Collection

Data were collected (from November 2022 to January 2023) through conducting a market analysis in several online stores that offer insect-based food alternatives in Poland. This study did not include stationary stores (e.g., supermarkets, hypermarkets, and discount stores) due to the lack of availability of these products. In this study, website analysis was performed to analyze content using the following specific keywords: 'insects', 'insect products', 'insect food', 'insect-based food', 'insect producer', 'insect farm', and 'novel food'. In this way, six online stores operating in Poland that sell insect-based food products were found. These were food stores that only sold their products online. The store's offer was exclusively addressed to retail customers. According to several studies [80,81], analysis using a systematic approach to the food store website allows for the collection of data on the product from the edible insect industry. To create a dataset, information was collected on the origin of products, insect species, form (whole or powdered), category of the product, and price. The retail prices of all products were collected in Polish currency. To compare these data with other results, the data were converted into EUR and all referred to the format of 100 g of an insect-based product. This analysis covered a total of seventy-three products. A classification of insect food products currently available in Polish markets was carried out by classifying them into the seven following categories: sweets (i.e., chocolates and lollypops), powders (i.e., flours and mixes), pasta, granola, chips and crackers, whole insects, and protein bars.

3. Results and Discussion

Poland, like many European countries, has increasingly focused on environmental sustainability. Highlighting the environmental benefits of insect-based foods, such as their lower carbon footprint and reduced resource use, can resonate with environmentally conscious consumers and contribute to a more positive perception. Changing perceptions and encouraging consumer acceptance can be facilitated through ensuring the food safety of edible insects. In order to promote edible insects more effectively and persuasively as future food, more knowledge is needed about the nutritional value of insects and the

environmental advantages of entomophagy [33]. It is crucial to educate people about the health, environmental, and economic benefits of edible insects to introduce them as food in the future, as this can increase their willingness to do so [51,79,82,83]. The availability and variety of insect-based food products on the Polish market can also influence perceptions. Offering a diverse range of well-crafted, tasty, and convenient options can attract curious consumers and encourage them to try insect-based foods. Orkusz et al. (2020) [40] indicated that it may be easier for Polish consumers to accept a new taste (product) if it is served as a product already known and liked. In addition, insect-based food was found to be more acceptable when prepared by someone else, such as in a restaurant [84]. Offering consumers the opportunity to sample insect-based foods through tasting events or collaborations with restaurants and food festivals can provide first-hand experiences, help overcome initial hesitations, and ultimately contribute to its acceptability by consumers. Positive taste experiences can lead to a greater acceptance and word of mouth recommendations [85]. Padulo et al. (2022) [85] found that even a single tasting experience can decrease aversion and consequently diminish disgust and the idea that insects are non-edible in Italian culture.

The Polish market predominantly offers food products containing whole insects, accounting for 33% of the available products (Figure 1). These whole insects come in dried form and various flavors, such as lime and chili-flavored dried crickets. The next significant categories include protein bars (23%) and powdered forms (mainly flour; 19%). Powdered insects are available in the form of flours, mixes (e.g., brownie or pancake mixes), and multi-flavored protein shakes. Various flavors and spices, such as curry powder, garlic, paprika, or fried onion flavor, can be added to dried insects to increase their acceptance on the European market. Producers also provide insects with chocolate or salted caramel, so that their selection is not just limited to savory tastes [86].

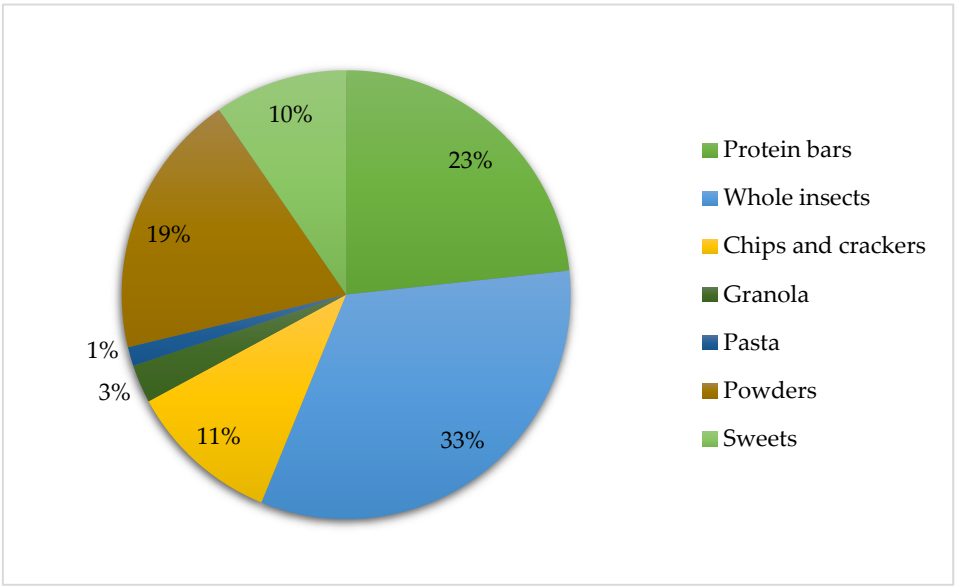

Figure 1. Availability of insect-based food products by category on the Polish market.

The Polish market is mainly divided between products containing whole insects and those in powdered form (Figure 2). Products containing ground insects with visible fragments are scarce, while powdered insect products dominate the market, representing 56% of the Polish market. Meanwhile, products with whole insects constitute 43% of the market.

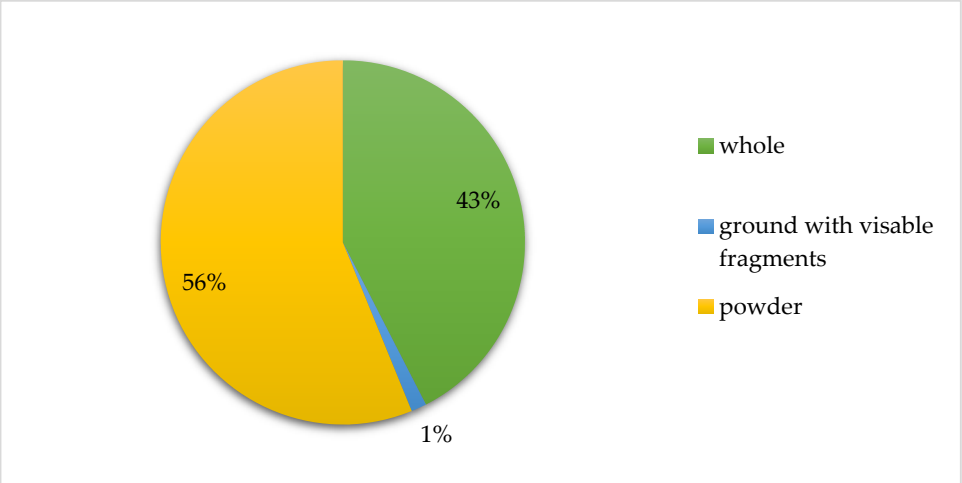

Figure 2. Availability of insect forms in food products on the Polish market.

This supply indicates that insect-based food companies are mainly trying to push insect-based powders, even though there are a large number of food products containing whole insects. On the other hand, the literature on consumer studies states that texture, appearance, and sensory attributes (taste, aroma) of the insect-based products play a vital role in shaping consumers' perceptions and willingness to consume such food. However, when it comes to edible insects as a new food source, these criteria are not necessarily decisive. The main aspect is the acceptability of the food. To assess the sensory evaluation and acceptability of protein and energy bars enriched with cricket flour, Adámek et al. (2018) [87] revealed that insect bars were accepted as a new type of food by consumers. On the other hand, Bartkowicz and Babicz-Zielińska (2020) [37] evaluated the acceptability of bars containing insects, mealworm larvae, and house crickets. These products were prepared in four different variations: without insects, with whole mealworms, with ground mealworms, and with house crickets. According to consumers, bars containing whole mealworms were the least preferred. In addition, the color and the visible parts of the insects in the bars caused crucial issues with accepting the product. Past research has shown that the acceptability of bars containing insects depended on the taste, aroma, and specific variation. The variation without insects received the highest level of acceptance. Furthermore, bars containing ground mealworms and ground crickets exhibited better acceptance rates compared to bars with whole insects, highlighting the importance of processing techniques in improving consumer acceptability [37].

A common trend is that people are less likely to eat whole edible insects than other foods that come from animals [65]. For these reasons, Florença et al. (2021) [88] suggested that if edible insects are to be introduced to the food market, food products that already contain edible insects should be used as a starting point, rather than moving straight to the possibility of eating the whole counterparts.

The following insect species are available in insect-based food products available on the Polish market: the house cricket (*Acheta domesticus*), the migratory locust (*Locusta migratoria*), the mealworm (*Tenebrio molitor*), and the lesser mealworm (*Alphitobius diaperinus*) (Figure 3). The products available on the market may vary in terms of their composition, flavorings, and processing methods. The majority of food products (42.5%) feature house crickets as a key insect-based ingredient, particularly in pasta, chips, and crackers. Lesser mealworms were predominantly found in protein bars and insect powders. In sweet products, the primary insect-based ingredient was mealworm.

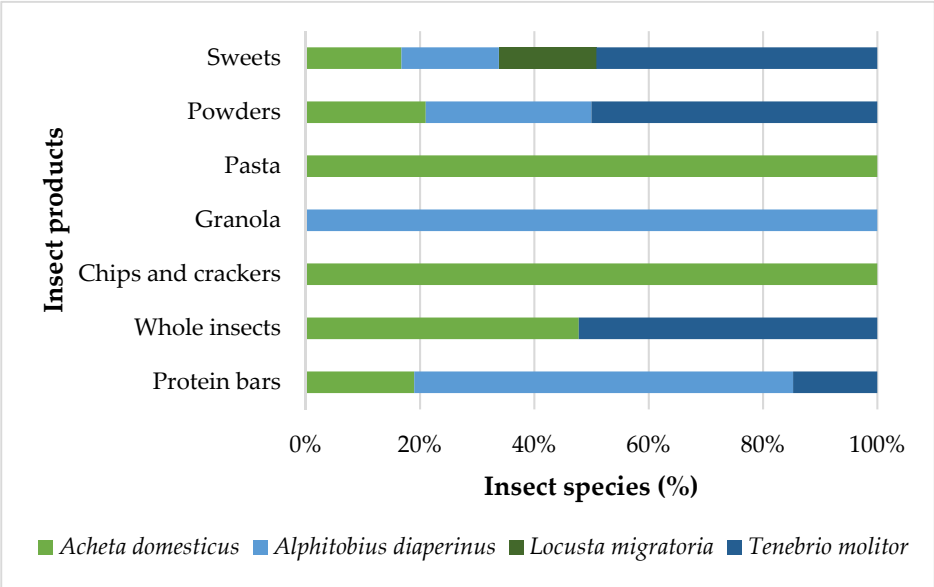

Figure 3. Availability of insect species in given food product categories on the Polish market.

In terms of origin, insect-based food products in Poland mainly come from Germany (24 products) and domestic producers (22 products), as well as France, and the United Kingdom (Figure 4).

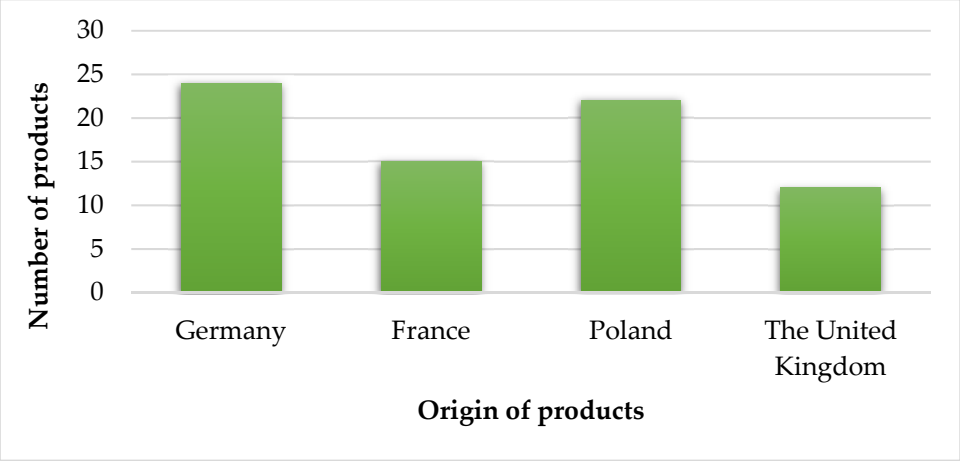

Figure 4. Origin of insect-based food products available on the Polish market.

To support the development of the industry, European legislation has been improved to guarantee the safety of novel foods to protect consumers [89]. The commercialization of edible insects in the European Union is regulated by Regulation (EU) No. 2015/2283, which has since been updated with new regulations. Under this legal framework, a fourth insect has been approved as food [39,90–92]. The authorization of novel foods will allow for the applicants to place this insect species on the EU market under certain conditions of use.

Considering the rapid development of the industry and the exponentially increasing number of companies engaged in the edible insect farming, processing, and distribution chain, it can be expected that the supply of edible insect products and ingredients based on insect protein and fat will significantly increase in the coming decade.

In Poland, the most expensive insect food products are whole insects and sweets (Figure 5), which confirms previous research [81]. The average price of whole insects and sweets was EUR 26.26 and EUR 18.70 per 100 g, respectively. Next, popular categories

of products in Poland, such as protein bars and insect powders, had a lower cost—EUR 5.40 EUR and EUR 5.23 per 100 g, respectively. According to Pippinato et al. (2020) [81], the lower prices (more attractive to the consumer) for certain products, such as protein bars or snacks, with a lower content of insect meal, also suggest that these types of products, where the insect component is not visible, are currently more acceptable to the consumer. In addition, significant price fluctuations have been observed within each category, which might be due to several factors, including the specific product, brand, production method, packaging, and distribution channels. Insect products within each category were differentiated in terms of the weight contained on the packaging, and thus also in terms of their price.

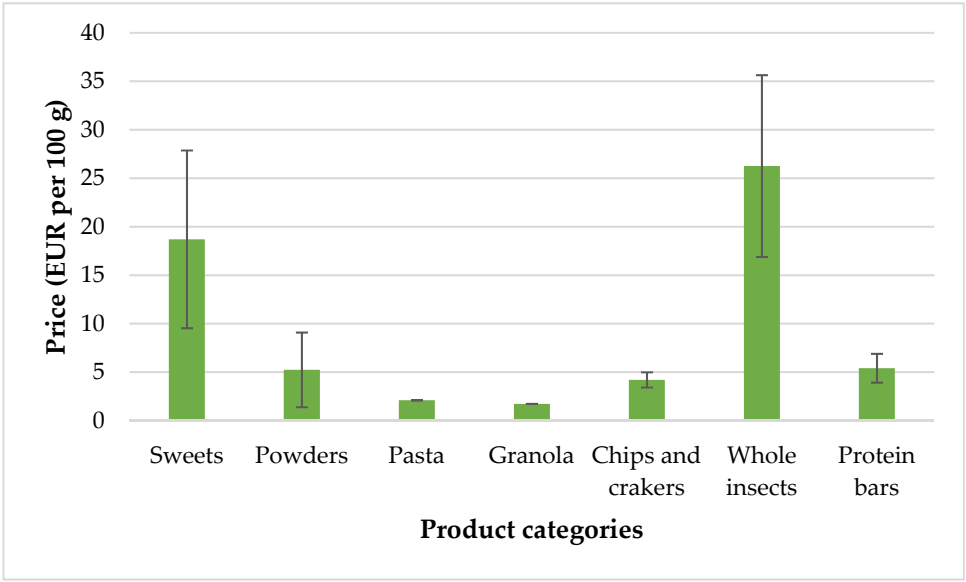

Figure 5. Price of insect-based food products available on the Polish market.

The results of studies by Lensvelt and Steenbekkers (2014) [93] showed that both the price and the quality of insect-based food were important to the Dutch and Australian survey participants. In general, the high prices of insect-based food products were associated with increases in their expected quality. The Irish survey participants thought that their prices should aim to match the corresponding bestseller in the chosen category (i.e., an insect snack should cost the same as its traditional counterpart). They agreed that lower prices would create a perception of poor quality [94]. In turn, to increase acceptance, insect-based foods should be affordable and easy to prepare. An affordable price ensures availability, and an ease of preparation increases convenience and encourages wider use. These factors play a crucial role in shaping consumer perceptions, choices, and behaviors when it comes to adopting new food sources, like edible insects. Affordable insect-based options expand accessibility, making them viable for a larger demographic. This is particularly crucial in ensuring that sustainable protein sources are available to a wider range of consumers. Additionally, they should be able to replace other sources of animal protein, and taste as good as the foods they replace [84]. Research conducted by Giotis and Drichoutis (2020) [95] showed that most Greek consumers are not willing to pay more for an energy bar and an insect-based cookie; in contrast, they would need a discount to purchase such products. This confirms previous research [82]. However, in an experiment conducted by Berger et al. (2018) [96], German participants were exposed to insect-based burgers at two different prices: EUR 2.99 and EUR 14.99. The higher price had a positive impact on participants' expectations and willingness to pay for the insect-based burger, as it was related to the quality of the product [97]. Also, the majority of the respondents attached more importance to the environmental impact of food than to the price. This concern about emissions from food production suggests that a food product made from insects could be

marketed as a replacement for high-emission foods, such as beef [84]. Consumers who recognize the environmental benefits of such products may be willing to pay a higher price for insect-based food products that are produced using sustainable farming practices and have a lower environmental impact.

Generally, insect-based food products tend to be priced higher than their traditional counterparts due to several factors, such as novelty, production costs, and limited-scale production. However, as the market for insect-based food products grows and production scales up, prices may become more competitive and potentially decrease over time. The automation of production processes and the quest for inexpensive substrates to feed the insects are two areas of research being conducted to reduce their costs [84,98]. Due to the specific nature of insect production, it is anticipated that the prices of these ingredients will be competitive compared to conventional sources of protein and fat. This could become a key argument for introducing insect raw materials into mass food production, especially with the sharply rising costs of food production.

The growing interest in eating edible insects in Poland can be attributed to several factors, including their nutritional potential, environmental awareness, cultural acceptance, education and awareness, availability and accessibility of products, and food neophobia [38,40,49,64]. Nevertheless, the acceptance and consumption of insect-based foods in Poland are still relatively low compared to other countries. The lack of familiarity with insect-based foods limits their consumption and market growth [99]. Conventional eating habits and food products, such as price, taste, availability, and suitability for a person's diet, are what primarily affect the repeated use of insects in day-to-day food consumption. However, gaining taste experience, trying appropriate insect foods or preparing them at home, and adapting them to your daily eating habits will facilitate the acceptance and adoption of insects as food [31].

4. Conclusions

The growing world population, year by year, decreasing natural resources, and the search for more ecological food alternatives will contribute to the spread of food with insects in Poland. Insects, as a food alternative, have some ecological benefits, including reduced resource consumption and greenhouse gas emissions. These benefits can help to address some of the environmental challenges associated with traditional livestock production, making insects a more sustainable and environmentally friendly food source. However, there is still a need to conduct many studies on the properties of insects, as well as the threats that specific species may pose.

The market availability of insect-based food products in Poland is gradually expanding, with whole insects, protein bars, and powdered forms dominating the offerings. However, the variety of products is currently limited compared to other European markets. This study underscores the potential for further market development and the need to address regulatory challenges to foster the growth of the insect-based food industry in Poland. Educating consumers requires a multipronged approach that combines informative content, engaging experiences, partnerships, and innovative technologies. By addressing nutritional, sustainability, and cultural aspects through various strategies, the insect-based food industry can effectively break down barriers and create a more informed and accepting consumer base. Current strategies should focus on using a variety of insect species to create different flavors and textures for innovative products, such as insect-based sauces, that can be used to enhance the flavor of existing meals, making the transition to insect consumption more gradual, organizing educational/cooking workshops and activities to educate consumers about the nutritional value, culinary potential, and environmental benefits of insect-based foods, by collaborating with researchers, chefs, entrepreneurs, culinary bloggers, and influencers to explore the innovative uses of insects in food products, and by collaborating with food bloggers and influencers who have a strong online presence to create content that demystifies insects and encourages experimentation. These strategies are important in expanding the product range, encouraging consumer engagement, and fostering a cultural

shift towards accepting a wider variety of insect-based food products on the Polish market, aligning it more closely with the offerings seen in other European markets.

Studying the market dynamics and competitiveness of the insect-based food industry in Poland would provide insight into the growth potential of this industry. This could involve analyzing market trends, competition, pricing strategies, and distribution channels. Understanding the market landscape would help identify opportunities and challenges for the growth of this industry.

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