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Insects as “new” foods

1. Summary

The rapid growth of world population and the scarcity of natural resources are serious problems from an agricultural point of view, therefore, sustainable food production is an increasingly important issue. According to researchers, insects could mean the solution to the impending “protein crisis”, among other things. In recent years, society’s interest in the consumption of foods made of insects increased significantly in Europe, but it should be mentioned that entomophagy (the consumption of insects) is not a new phenomenon, because hints of it can already be found in the Bible. Several studies, discussing mainly the advantages and possible risks of insect consumption have already been prepared, however, our knowledge is still very limited. Although legislation is far from being uniform, we have to be prepared that, sooner or later, foods made of insects are likely to become part of our everyday diet.

2. Introduction

Searching for solutions to sustainable food production has become a very urgent task in recent years. One of the possible directions is exploiting the potential use of raw materials and resources not of traditional origin, such as the application of edible insects as foods or feedstuffs [38]. The consumption of insects (entomophagy) has been part of everyday life in several cultures for a long time, even though it may seem like an unusual idea to the European and American population. In the following, we try to find the answer to the questions of how recent insect consumption is, what the laws that regulate it are, and we also consider potential advantages and risks of utilizing insects as foods. The question arises what the consumer attitudes connected to this are, because, in the future, it will probably be necessary to rethink our habits to ensure global food security [38].

3. Insects were already consumed in prehistoric times

Archeological findings attest to the fact that entomophagy is as old as mankind itself [8], [21], and that all stages of history were accompanied by the practice of eating insects. The first written source about the fact that insects were consumed in Europe was produced in ancient times, in Greece: according to the records, cicadas were considered a delicacy [5]. Evidence of the consumption of different larvae, grasshoppers and crickets is available not only from

Europe, but from all over the world China, German and French territories, Africa, Australia, etc.) [40]. Interestingly, even though German soldiers were fond of eating deep-fried silkworm in the 1600s, by the end of the 1800s entomophagy was not considered “suitable for civilized people” [19].

Insect consumption was also among the habits of Christian, Islamic and Jewish cultures, which was also recorded in their literature [40]. In the Bible, in the texts of the Old and the New Testament, it was written that the consumption of certain species was not prohibited [21]. In Chapter 11 of Leviticus, we can read this: „²¹Yet these may ye eat of every flying creeping thing that goeth upon all four, which have legs above their feet, to leap withal upon the earth; ²²Even these of them ye may eat; the locust after his kind, and the bald locust after his kind, and the beetle after his kind, and the grasshopper after his kind.” [4]. And in Mark you can find the following sentence: „⁶And John was clothed with camel’s hair, and with a girdle of a skin about his loins; and he did eat locusts and wild honey.” [3].

There are also several references to show that the Islamic religion has a tradition of eating insects, such as locusts, bees, ants, lice and termites [11]. There are hints in Jewish literature at the acceptance of entomophagy as well – or to be more exact, at the consumption of kosher locusts, but this tradition survived only in certain parts of North Africa [1].

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Despite all this, entomophagy is mainly rejected by contemporary Western societies, it is even considered a taboo [39], although it is expected to be inevitable in the future and to become a part of everyday life [7].

4. Advantages of using insects as food

The rapid growth of world population is a serious burden on agriculture and food production. With population growth, there is a significant increase in the demand for animal proteins, but the increase in meat production is accompanied by a significantly greater environmental load. Almost the entire amount of ammonia, responsible for soil acidification and eutrophication, is released by the agricultural sector, 2/3 of it coming from livestock farming [36], but, compared to other animal species, a very small load is caused by edible insects, such as mealworms or migratory locusts, relative to the amount of protein produced [28]. Another sustainability aspect is the virtual water content, i.e., the water consumed in the entire production process, per unit of end product [20]. In the case of animal products, this value is very significant, because the amount of water required for feedstock production is added to the water demand of livestock farming, slaughtering and processing [31]. By contrast, insects are more drought-tolerant and, in addition, they are less demanding from a feeding point of view, being able to utilize a wide range of agricultural and food industry byproducts, so their virtual water content is well below that of traditional animal products [32]. Furthermore, the feed conversion ratio (FCR) of insects is excellent. Feed conversion ratios calculated for live weight are shown in **Figure 1**. 80% of the live weight of house cricket is edible, while the figure for pigs and poultry is only 55%, and in the case of cattle it is a meager 40% [38].

The reason for better feed conversion might be that insects are poikilothermic organisms, their growth phases do not require metabolic energy, so they do not have to spend energy on maintaining a constant body temperature [38].

This is why it is possible that, according to some researchers, insects could mean the solution to the impending "protein crisis", because, as opposed to other meat animals, insects do not require vast agricultural areas, they can be "produced" cheaper, faster, and in significantly larger quantities, so the feeding of larger masses can be solved this way, rather than by using other, classic meat proteins. They can be used as foods not only as whole insects, but certain components can be extracted, or specific insect parts can be powdered and used as food ingredients, to enrich the protein content of the given food.

Worldwide, roughly 1,900 insect species are consumed as foods, at different developmental stages [38]. Insects are currently considered to be valuable, sustainable protein sources, because they contain

large amounts of proteins/amino acids and other nutrients (fatty acids, carbohydrates, minerals: Ca, Mg, Cu, Mn, Zn, Se; vitamins: A, D₂, D₃, E, C, B₁, B₂, B₃, B₅, B₆, B₇, B₁₂, folic acid). Their nutrient content – without taking into account different species and developmental stages (egg, larva, pupa, adult insect) – depends on the feedstock of the insects [6], [16], [29], [30], [2], [33], [23], [25], [26], [34]. Consequently, their nutritional values vary widely. Their main ingredients are protein, fat and, to a smaller extent, fibers, and these are also present in varying amounts, depending on the species, the developmental stage and the feedstock.

5. Potential food safety hazards

Beside the advantages of consuming and distributing insects as foods, several concerns have also been raised. Studies aimed at the potential harmful health effects of insects have been prepared by both the European Food Safety Authority (EFSA), and by EU member states that tolerate insect consumption. In these studies, attention was called to the following potential food safety hazards:

- Insects intended to be used as foods, that have been bred and treated in a non-controlled manner, can be sources of severe infections, since they can carry microbiological contamination (e.g., pathogenic microorganisms);
- Toxic substances (e.g., heavy metals, mycotoxins, pesticides, veterinary products, toxins produced by insects) may be present;
- They may pose physical hazards (e.g., the non-digestible chitinous wing covers), the possibility cannot be ruled out that, in the case of sensitive individuals, sensitization and allergic reactions may occur following the consumption of whole insects or insect proteins, and it can also happen, in the case of persons who are allergic to seafood and/or (house dust) mites, allergic reaction may occur after the consumption of insects;
- As a result of exposure to insects (or insect body parts), hypersensitivity or allergic reactions can develop at the personnel of insect breeding facilities.
- According to the scientific assessment of EFSA, properly produced insects pose about the same risk as properly produced and treated fresh meat.

In order to clarify the above concerns, the safety assessment of three insects, that had been commercially available before, was ordered by the Dutch food safety and health minister, taking into consideration the chemical, microbiological and parasitological risk of consumption with or without heat treatment. Based on the results of the study which appeared on October 15, 2014, a recommendation was made

for the three insects – the yellow mealworm beetle (*Tenebrio molitor*), the lesser mealworm (*Alphitobius diaperinus*) and the migratory locust (*Locusta migratoria*) – to fall under the general food law in the Netherlands, and not to be classified as novel foods according to Regulation (EC) No 258/97.

According to the Dutch assessment, no toxicological tests of whole insects or insect proteins have been conducted so far in human subjects or test animals. They think that, if the expected intake of dried or freeze-dried whole insects exceeds 45 grams per day, then the risk due to chitin intake has to be reevaluated. The shelf life on product packaging (52 weeks) was also questioned, because there were no studies available to show whether products were really safe over this period. In addition, attention was called to the proper labeling of the products (e.g., in the case of locusts, it has to be indicated that the legs and wings have to be removed before use, and that heat treatment of insect products is necessary before consumption) [27].

Since there are many uncertainties regarding the safety of insect consumption, EFSA was asked by the European Commission to evaluate the microbiological, chemical and environmental risks of insects, compared to other sources of protein. In this context, a risk profile was published by the EFSA on October 8, 2015, regarding the production and consumption of insects as foods and feedstocks. The conclusion of EFSA was that, from an assessment point of view, the important factors are the microbiological and chemical risks, and knowledge of the production method, the substrate used, the harvesting stages, the specific insect species and the subsequent processing methods. It stated that, on these topics, there were only very limited data available. Therefore, it was strongly recommended to perform further research – including the study of the use of different substrates, such as food waste and manure – for a better chemical and microbiological assessment of the use of insects as food [12].

6. The presence and legal regulation of edible insects in the European Union

Currently, the legal regulation of the distribution and consumption of insects as food is not uniform throughout the European Union. In the European Commission, the following question was first asked about eight years ago: “Are edible insects considered novel food?”

Foods that are not traditionally consumed in the European Union, or are produced by a process previously not used, can only be marketed in the EU after an authorization procedure. The concept of novel foods and the authorization procedure for such products is described by Regulation (EC) No 258/97 of the European Parliament and of the Council of 27 January 1997 concerning novel foods and novel food

ingredients [13]. In the case of arthropods, Section e) of Paragraph 2 of Article 1 of the regulation would be relevant („foods and food ingredients consisting of or isolated from plants and food ingredients isolated from animals, except for foods and food ingredients obtained by traditional propagating or breeding practices and having a history of safe food use”).

This means that ingredients extracted from insects (e.g., protein isolates), and also insects, part of which (legs, wings, the head, the intestines) have already been removed, fall under this category. Based on this, authorization is necessary before these products can be marketed in the EU, if there had been no significant human consumption within the territory of the Union before May 15, 1997. However, the wording of this category makes it uncertain whether whole animals (e.g., products consisting of whole insects or larvae) are subject to Regulation 258/97/EC.

According to some member states (for example, the UK, Belgium and the Netherlands), certain whole insects are not constitute novel foods, because they had been consumed in significant amounts before May 15, 1997. However, the significant amounts could not be credibly proven by the above-mentioned member states, so they are still considered novel foods. The European Commission took the position that the consumption and distribution of these insects that have already been marketed in these member states will be tolerated until the release of the new novel food regulation (EU 2015/2283). Currently, in the absence of a uniform EU regulation, the issue is regulated by the individual member states.

In 2011, the occurrence of insects as food in the community market was assessed by the Commission, with the help of member state representatives. Beside Belgium, the Netherlands and the UK, it was Austria alone who declared that there was a growing social interest, although the use and consumption of insects was not significant. In all other member states, according to their statements, there were no commercially available edible insects.

The production and distribution of ten insect species as food is currently tolerated in Belgium [15], while the number is three in the Netherlands, under specific statutory requirements. There are also snacks made of whole insects on the UK market, such as chocolate-dipped grasshoppers. On July 25, 2015, a call for data collection was issued by the food safety office of the United Kingdom (Food Standards Agency, FDA), regarding the distribution of whole insects as food before May 15, 1997. At the same time, it drew the attention of entrepreneurs to the fact that, if no significant amounts of consumption can be proved, these products will have to be authorized as well after the new novel food regulation comes into force [17].

In Hungary, insects are not considered traditional food, there are no historical data showing that they had been consumed in significant amounts previously. Currently, there is no domestic decree regulating the distribution of insects as food, or their public consumption, so these products are considered novel foods under Regulation 258/97/EC.

On December 11, 2015, the *new novel food regulation*, standardizing the regulation of the authorization of insects as food on an EU level, was officially published [14]. Based on Section a) v. of Paragraph (2) of Article 3 of the new regulation, whole insects are clearly considered novel food, unless it is proven that they had been consumed in significant amounts in the European Union before May 15, 1997. The regulation shall enter into force on January 1, 2018, so from that date, whole insects have to be authorized on an EU level (except those that are accepted by the Commission, having had significant, certified consumption before May 15, 1997). This is also true for insects that are currently tolerated by certain member states. However, it is important to note that conditions of the distribution itself are not specified by the novel food regulation, they have to be regulated on a national level. Since the authorities of different member states, as well as the EFSA came to the conclusion that uncontrolled insects coming from unsafe sources can pose a health risk, therefore, to protect the health of consumers, it is worth considering to have domestic distribution linked to a separate authorization.

7. Consumer openness

Beside the already known risks, and the arising uncertainties and the legal background, the spreading of entomophagy is mainly hindered by the consumers' attitudes. Although some of the consumers are interested in the advantages of insect-based or insect-containing products – for example, because of their favorable composition or sustainability – most people are still reluctant, afraid of them [24]. The main problem is that people often react to insects with disgust, because they are not thought of as food, but rather as pests or spreaders of pathogens [37].

Obviously, in areas where insects are part of the general diet (e.g., Africa, certain parts of Asia), people are characterized by a different attitude, and different species are accepted [37]. In a study assessing the preparedness of Western societies for insect consumption, it was determined that neophobia itself, i.e., the rejection of new and unknown food, has a serious effect on attitudes [41]. However, neophobic behavior can be reduced by the tweaking or removal of characteristics triggering disgust [24], for example, by using only the proteins extracted from insects [10], or by adding insect meal to other food [42]. This is confirmed by the results of a 2015 study, in which German subjects showed a greater willingness to try processed, insect-containing food [18].

In that case if they would like to use insects as feedstock, consumer rejection is probably not going to be a problem, since insects are a natural food for certain animal species. However, in the case of introduction as food, organoleptic and health motivations are going to be the decisive factors, this definitely has to be kept in mind [38].

The most important claims of the paper are summarized in **Table 1**.

In conclusion, it can be stated that no matter how serious our reservations are regarding the consumption of insects as food, it is very likely that sooner or later, in one way or another, we will all encounter foods made of insects or with the use of them.

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