Possibility of introducing insect-based foods to the Croatian market

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Possibility of introducing insect-based foods to the Croatian market

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1. Introduction

A large number of new products, including food products, are placed on the market every day. However, the market success of these products mostly depends on whether and to what extent consumers are ready to accept the new product (Tomić and Cerjak, 2014).

On the EU market, as well as in Croatia, new food products from the Novel Food category can be found every day. The term novel food is defined by EC Regulation (258/97) and includes food that is new on the market or was not consumed to a significant extent in the EU before 1997, food that is traditionally eaten outside the EU and new technologies in food production, and new ingredients used in food preparation (Mancini et al., 2019).

One of the new trends on the EU food market is entomophagy, i.e. the consumption of insects, which is considered something modern (Caparros Megido et al., 2014). This category also includes food based on insects, whether they are whole insects or processed parts (e.g. "flour"). Traditionally, insects are consumed in various parts of the world (Asia, Africa, South America) and it is estimated that over 2 billion people around the world use insects in their diet every day (Jongema, 2017). Such practice was not known in Western countries (EU, USA) until now.

The main potential of insect-based food lies in the social and personal benefits of consuming insects as food. Insects are considered a food rich in crude proteins, fats, unsaturated fatty acids omega-3 and omega-6, minerals and vitamins (Jansson and Berggren, 2015; Ramos-Elorduy et al., 1997) and their consumption can bring personal benefits to the consumer. Social benefits are manifested in the ecological aspect of insect production. Production areas, food and water consumption, and the generation of greenhouse gases in the production of insects are significantly smaller per unit of protein compared to today's livestock production (Jansson and Berggren, 2015).

Regardless of the possible benefits, consumers in Western countries are skeptical about the consumption of insect-based foods, mainly due to psychological and cultural barriers related to the consumption of insects, which make it difficult to introduce such foods to the market. Although people around the world have been using insects in their diet since time

immemorial, in the last few years the potential of insects as food is slowly being discovered in Western countries as well. Nevertheless, although the acceptance of insect-based food in the EU is slow (Deroy et al., 2015), in the last few years such food is becoming more and more popular and in some countries it can even be found in supermarkets (Mancini et al., 2019).

There are numerous advantages that insects provide as food, but they still do not have a significant place on the shelves of EU stores (Mancini et al., 2019). Insect-based food is not yet available for sale in Croatia, and before its introduction to the market, it is necessary to examine how willing consumers are to consume and buy such food.

This work aims to investigate the potential of the Croatian market for the introduction of products containing insects, and to examine the point of view and attitudes of young consumers towards such food.

2. Insects

Insects belong to the most numerous group of animals in the world. They inhabit all parts of the world where life is possible (tropical rainforest, arid deserts, boreal forests and meadows, arctic environment, etc.). They primarily inhabit land, but they can also be found in aquatic environment. According to some authors, there are more than 1,200,000 species of insects on Earth and more than 75% of all animal species are insects (Oštrec, 1998).

Due to their abundance, insects play important rule in the biodiversity of an area, they play a significant role in the fertilization of plants and the decomposition of waste materials. On the other hand, insects are also the most important pests of plants, and in humans and animals they can be carriers of diseases as well as intruders (van Huis et al., 2013).

Their abundance and distribution allowed people to use insects in their daily diet for thousands of years as a source of valuable nutrients and as a delicacy (Durst et al., 2010). In some inaccessible parts of the world, insects were the main source of the necessary nutrients for human survival, and because of this, people specialized in their collection, preparation, preservation and even their cultivation (van Huis and Tomberlin, 2017).

Today, more than 2 billion people consume insects in their diet every day. It is estimated that more than 2000 different species of insects are used for consumption (van Huis et al., 2013).

According to data from 2017, it is mentioned that 2111 different species of insects are edible in the world (Jongema, 2017).

Insects are eaten in all parts of the world, only the so-called The Western World, i.e. Europe and North America, still do not have a culture of insect consumption. Most insects are consumed in tropical regions (Asia, Africa, and South America), but insect consumption is known even among the inhabitants of the Arctic (van Huis et al., 2013; Mancini et al., 2019).

The main food of Eskimos, inhabitants of the Arctic, is reindeer. Since reindeer can be attacked by the larvae of flies that live in the area (*Hypoderma tarandi* and *Cephenemyia trompe*), the Eskimos eat them when hunting reindeer. Larvae are found under the skin or in the nostrils of reindeer, so when the Eskimos catch reindeer, they use the larvae in their diet (Halloran et al.,2018).

Most insects are consumed in tropical area, and there are several reasons for this. Firstly, insects are present in tropical regions throughout the year; secondly, insects from tropical areas are much larger than other insects, and as the third important reason, he states that people in tropical regions are more connected to nature. If we consider the above factors and if we also take in consideration the nutritional value of insects, it becomes clear why insects are considered an important food item in the tropics (van Huis and Tomberlin, 2017).

This is precisely why insects are increasingly being cultivated in countries where for centuries insects have been collected from nature and used in food. People realized the advantages of farming insects over collecting them from nature.

The main advantage of insect farming compared to collecting them from nature is human safety. The use of pesticides in nature is increasing, which is why insects collected in nature represent a potential danger to human health. In addition to the safety aspect, another advantage of insect farming is their ease of cultivation. Insect farms require low investment costs. For cultivation, closed spaces are used, where there is food, water and space for hiding and reproduction. Since insects have a high reproductive capacity, a large amount of insects can be grown in a very short time. In addition to the fact that insect farms represent an important agricultural branch of a region, they are also a tourist attraction that attracts numerous visitors from the Western countries (van Huis and Tomberlin, 2017).

The insect farming industry is also present in Western countries. The pioneers of insect farming for agricultural purposes came from Europe. Beneficial insects are cultivated; bumblebees and predatory insects used in protected areas (greenhouses). Bumblebees are used for pollination of plants (Figure 1), while predatory insects are used to control harmful insects (Figure 2 and Figure 3). The market for beneficial insects is estimated to grow from the current $877 million in 2023 to $1,630 million by 2028 (Marketsandmarkets, 2022). This is due to the growing trend of organic production, in which the use of pesticides is prohibited and beneficial insects are used as their alternative.

Figure 1 Use of bumblebees in strawberry farming

Source: Kazimir Koraca persona gallery

Figure 2 Introducing of beneficial insects in peppers: Orius laevigatus and Amblyseius swirskii

Source: Kazimir Koraca personal gallery

Figure 3 Introducing of beneficial insects in peppers: Orius laevigatus and Amblyseius swirskii

Source: Kazimir Koraca personal gallery

The potential of insects as food for animals and humans has been increasingly explored in Europe in recent years (Mancini et. al, 2019). In this, researchers from the Netherlands, mainly from the University of Wageningen, are leading the way.

In addition to scientific institutions, there are more and more companies that professionally farm insects for animals as well as for people in Europe.

Meticulousresearchestimates (2023) estimes that Europe edible insect market in the period 2023-2030 will reach a value of 2.98 billion dollars, and in terms of quantity, it is estimated that it will reach 7,85,042.7 t by 2030.

Some of the world's largest companies specializing in farming, research and processing of insects for human and animal consumption are in Europe:

Ÿnsect - (France) – founded in 2011 with headquarters in Paris, deals with the production and processing of insects for human, animal and plant needs. The company turns farmed insects

into premium ingredients needed for animal feed as well as human food. In addition, it deals with the design and construction of plants for the production and processing of insects.

In 2021, the company raised $435 million in funding and hired 130 employees. The company is present throughout North America, Europe, Asia and the Pacific, Latin America and the Middle East and Africa.

Protix B.V. (the Netherlands) – founded in 2009 with headquarters in Dongen, the Netherlands. The company was awarded by the World Economic Forum as a technological pioneer. In 2020, the Erasmus Center for Entrepreneurship nominated Protix as the fastest growing Dutch company with a social mission. Protix was recognized as the most innovative Dutch company and won the Dutch Innovation Award 2020.

The company's products are available in 13 countries. With more than 15 partners, the company is present throughout Europe, North America and Asia and the Pacific.

InnovaFeed (France) – founded in 2016 with headquarters in Paris. A biotechnological company specializing in the production of natural and sustainable ingredients for animal feed and plant nutrition from insect farming.

The company is geographically present in Europe, North America, Asia-Pacific and Latin America.

There are also numerous companies that offer insect products. Most of these companies sell their products through online sales and are small start-ups. Among processed products, the most sold ones are protein bars, insect "flour", insect-based chips, insect-based pasta, and even beer containing insects.

Companies dealing with insects can be classified based on their main activities as e.g. Engström, A. (2019) classified them on the blog bugburger.se as follows:

COMPANIES PRODUCING PRODUCTS FROM EDIBLE INSECTS:

- Insects for human consumption
- Insect products for human consumption
- Online stores that sell insects for human consumption
- Wholesale - edible insects

INSECT FARMING

- Professional insect farmers
- Other farms, agricultural consultancy, technology, equipment
- Domestic farming of insects
- Insect farming for the poor

INSECTS AS PET FOOD OR ANIMAL FOOD

- Insects as pet food
- Insects as animal food

RESEARCH/ADVOCATES

- Research projects
- Organizations of the insect industry
- Advocates of eating insects and chefs
- Podcasts and YouTube channels

There are two insect farms in Croatia. *Insektarij tvornica buba* was founded in 2015 and deals with farming of two types of insects; crickets - *Gryllus assimilis* and flies - *Hermetia illucens*. In 2018, the farm was registered in the Register of Farms at the Croatian Agricultural Agency. In addition to farming insects, an additional activity is participation in scientific research on insect farming as well as the production of insect-based products – one example is developing cricket-based beer (Insektarij.com, 2016 – 2023).

The second farm, *Cricky*, was founded in 2016 and deals with farming of several types of insects, as well as the promotion and education of insects as food (Cricky.eu, 2017).

2.1. Benefits from insects

When talking about the benefits of insects used for food, they can be divided into two main categories.

- Nutritional or personal benefits
- Environmental or social benefits

2.1.1. Nutritional benefits of insects as food

The nutritional benefit of insects as food could also be defined as a personal benefit because the consumer realizes certain benefits by consuming them. It is difficult to generalize the nutritional value of insects in general. It depends on many factors. The main factor is the species, over 2000 edible species of insects are mentioned in the literature and their nutritional value is different. Another factor is the developmental stage of insects, not all stages are edible, that is, not all stages have the same nutritional value. Some insects are consumed as eggs, for example certain species of ants (*Oecophylla sp*), some in the larval stage (*Tenebrio molitor, Alphitobius diaperinus*), while some are consumed in the adult stage (crickets, grasshoppers). Environmental factors of insect growth also play an important role. These include nutrition, temperature, humidity and day length (Finke and Oonincx, 2018). The ratio of n-6 to n-3 fatty acids can vary considerably depending on the diet the insects are fed. For example, adding flax seeds to the diet of insects significantly increases the proportion of n-3 fatty acids in insects. Exposure of mealworm or house cricket larvae to a low concentration of ultraviolet radiation increases vitamin D in them.

The nutritional value of insects also changes depending on their preparation (cooking, frying, freezing, etc.) (Kouřimská and Adámková, 2016).

Despite the great variety of species, as well as metamorphosis, edible insects are basically food of animal origin and the bulk of their composition consists of fats and proteins. In addition to the body structure of muscles and deposits of fat and other tissues, insects are also characterized by an exoskeleton consisting of chitin. Chitin is a complex polysaccharide which, along with cellulose, is the most abundant polymer in nature (Martinec and Filipović-Grčić, 2002). Chitin is recognized as a fiber in terms of human digestion (DeFoliart, 1992).

Deacetylation of chitin produces chitosan. Chitosan has numerous medical roles in the human body; from wound healing, antihypertensive role, anticancer role, coagulant, anticoagulant, antiulcer, antimicrobial, antiviral, hypolipidemic and hypocholesterolemic effects and properties (van Huis, 2020).

Di Mattia et al. (2019) has been done to compare the antioxidant capacity of water or liposoluble extracts of insects with that of fresh orange juice and olive oil. The results showed that certain insects have an antioxidant capacity double or triple that of orange juice or olive oil.

In addition to the fact that insects are rich in proteins, fats and fibers (chitin), they are also rich in minerals and vitamins. They are extremely rich in iron and zinc, which can be a solution for almost 25% of the world's population who suffer from a lack of these elements (van Huis, 2020).

Stull et al. (2018) investigated the impact of cricket "flour" on the digestive flora in humans. A 14-day study showed that daily consumption of the "flour" has a positive effect on the intestinal microflora, mostly on the increase in the number of *Bifidobacterium animalis*. Research indicates that eating crickets can improve gut health and reduce systemic inflammation; however, more research is needed to understand these effects and their underlying mechanisms.

2.1.2. Environmental benefits of insects as food

In addition to nutritional benefits, insects also have environmental or social benefits. They are manifested in terms of their cultivation in relation to other current animal production (production of livestock, poultry, pigs, etc.).

Livestock production directly and indirectly affects the environment. The biggest negative impact is manifested in the production of greenhouse gases. The livestock sector is responsible for 18% of global greenhouse gas emissions, the most of any other sector, even more than traffic (Stainfeld, 2006).

NEGATIVE IMPACT IN NUMBERS:

- lifestock sector is responsible for 18% of global greenhouse gas emissions
- lifestock sector is responsible for 8% of water for human consumption
- 30% of the total area that is not covered by ice is wasted directly or indirectly through grazing or the production of feed for the lifestock sector
- 33% of all crops are used in the lifestock sector
- 50% of the antibiotics produced in the world are used in the lifestock sector
- 37% of pesticides are used in the lifestock sector
- 70% of arable land is used in the lifestock sector
- 70% of deforested areas are turned into livestock pastures
- 37% of anthropogenic methane is produced by the lifestock sector

If the ever-increasing demand for meat and milk is added to the list, the consequences can be even greater.

Steinfeld and Gerber (2010.) state that the global projection of the demand for meat in the period from 2000 to 2030 will increase by 68%, and the demand for milk by 57%.

If we compare insects farming with the livestock sector, then insect farming has many advantages in terms of reduced production of greenhouse gases, but also in terms of smaller requirements for farming per unit of protein.

- The production of greenhouse gases per 1 kg of protein in insects is significantly lower compared to the livestock sector .
- To produce 1 kg of protein, insects need significantly fewer resources: land, water and food.

2.2. Negative influence of insects as food

Insects as food must comply with all laws and regulations, like all other food that is placed on the market. As insects have not had a history of consumption in Europe until now, they are considered a new food. Such food still undergoes strict controls and tests in order to reduce the possible negative impact on human health.

When it comes to safety, possible chemical and biological contaminants must be taken into account, especially when the insects are not fed organic food and if they are taken from nature. Taxonomically, insects are similar to house mites and crustaceans, so the possible allergic danger that insects could pose to certain groups of people, especially those allergic to seafood, must be taken into account (van Huis, 2020).

3. EU and Croatian Legislation

European legislation, through its Regulations and laws, regulates the food that may be placed on the EU market and under what conditions.

Food or parts of food originating from plants, animals, microorganisms, etc., which were not used to a significant extent in human nutrition in the EU before May 15, 1997, are regulated by EU Regulation 258/97 as novel food - Novel Food Regulation.

In order for a food to receive EU authorization to be placed on the market, it needs to undergo strict controls and risk assessments to protect the health of consumers. EFSA (European Food Safety Authority) is an agency of the European Union established in 2002 with the aim of providing a scientific basis for legislation to protect EU consumers from food-related risks. (www.efsa.europa.eu/en)

One of the prerequisites for certain food to be categorized as Novel Food is that it is traditionally consumed in third countries, among other things. Insects as food are consumed almost in all parts of the world and as such can enter the procedure for classification in the Novel Food category.

EU Regulation 258/97 included insects as food in Article 1 as food ingredients isolated from animals.

This definition does not include the whole insects, which created a big confusion in the market.

Progress in the acceptance of insects as food was made through EU Regulation 2015/2283. In contrast to Regulation 258/97, which covers only parts isolated from animals, Regulation 2015/2284, under the term Novel Food, includes food consisting of or isolated from or produced from animals and their parts (Figure 4). This expands the criteria for the term Novel Food.

Summary overview of the respective scopes of Regulation (EC) No 258/97 and Regulation (EU) 2015/2283 with respect of whole insects, parts of whole insects and insect-based preparations

	Regulation (EC) No 258/97	Regulation (EU) No 2015/2283
Whole insects	✗ Not in scope * **	✓ In scope
Parts of whole insects and ingredients processed from whole insects (e.g. whole insects powder)	✗ Not in scope * **	✓ In scope
Ingredients other than (parts of) whole insects (e.g. insect extracts)	✓ In scope	✓ In scope

*Diverging national interpretations - some Member States did consider these categories of products as novel food under Regulation (EC) No 258/97.
** According to the CJEU ruling from the 1 October 2020, 'whole insects' were not covered by the Regulation (EC) No 258/97. From this ruling, 'whole insects' could be interpreted as covering the ingredients processed from whole insects.

Figure 4 Comparation of Regulation 258/97 and Regulation 2015/2283

Source:1 Briefing paper on the provisions relevant to the commercialisation of insect-based products intended for human consumption in the EU

www.ipiff.org – accessed 03.10.2023.

3.1. IPIFF – International Platform of Insects for Food and Feed

IPIFF - is a non-profit organization founded in 2012 that represents the interests of the sector for the production of insects as food for humans and animals to EU policy makers and ultimately to EU citizens.

Today, IPIFF has 77 members from 23 countries (Figure 6), most of which are small and medium-sized companies producing insects for the EU market. In addition to companies engaged in production, members of the organization include scientific institutions as well as companies located outside the EU.

The mission of IPIFF is to promote, support and inform. The organization promotes the use of insects as an alternative food and a new source of protein in dialogue with the EU institutions. EU member states have different views towards insects, so one of the tasks of the IPIFF is to lobby towards all member states (Figure 5). It supports the development of the insect food sector and informs about the benefits of insects as food for humans and animals.

Figure 5 IPIFF members

Source: Briefing paper on the provisions relevant to the commercialisation of insect-based products intended for human consumption in the EU

www.ipiff.com - accessed 03.10.2023.

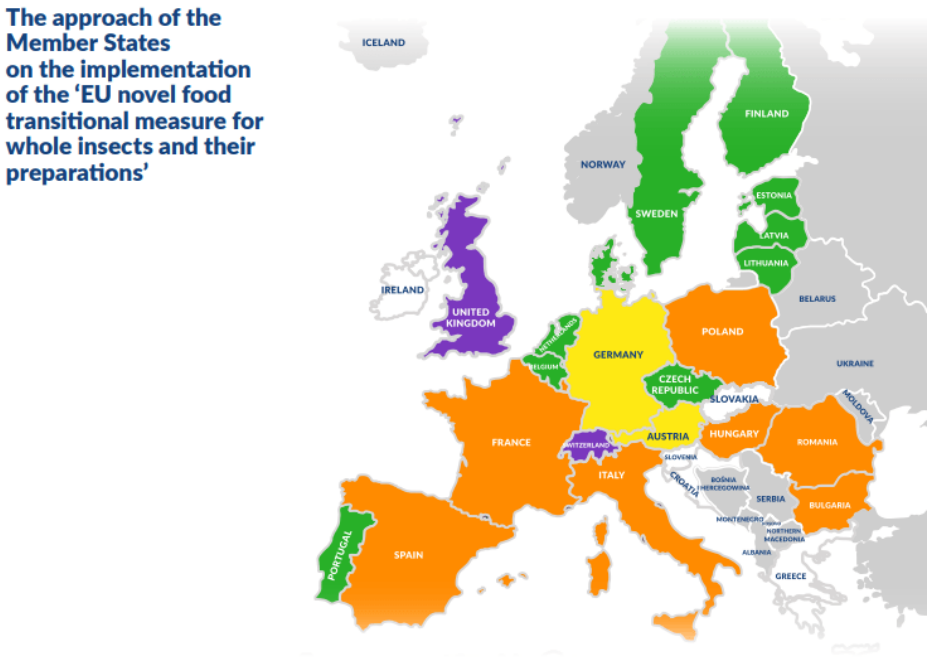


Figure 6 The approach of the Member States on implementation of the EU novel food transitional measure for whole insects and their preparations

Source: Briefing paper on the provisions relevant to the commercialisation of insect-based products intended for human consumption in the EU

www.ipiff.org - accessed 03.10.2023.

3.2.Species of insects which received a positive opinion

In January 2021, EFSA issues **the first** positive opinion on insects as food, which authorizes dried larvae of the mealworm (*Tenerio molitor*) at the EU level as a Novel Food.

The second positive opinion of EFSA on insects as New Food was issued in November 2021, and it related to dried and frozen locusts (*Locusta migratoria*).

At the beginning of 2022, the European Commission issues **the third** opinion, i.e. an amendment for mealworm larvae (*Tenerio molitor*), which expands the permit to frozen and ground mealworms in addition to dried ones.

The fourth positive opinion is issued for dried, ground and frozen domestic cricket (*Acheta domesticus*).

The fifth positive opinion on edible insects published by EFSA was on the partially defatted house cricket (*Acheta domesticus*).

The sixth positive opinion was published on frozen and freeze-dried formulations of *Alphitobius diaperinus* larvae.

3.3. Experiences in the introduction of insect- based food in Croatia

In Croatia, as in the entire EU, insects were not consumed in the past. The trend that insects present as new, healthy, socially and environmentally acceptable food has made it possible for Croatian consumers to encounter insects in food to a lesser extent. In the last few years, this trend has led to increasing media coverage of insects as food. They are mostly mentioned in the context of the food of the future, sustainable food and even super food. All this is based on scientific facts that are increasingly being researched in the EU and in Croatian scientific circles.

The first attempt to introduce insect-based food was in 2020, when the Kaufland retail chain placed several insect-based products on the Croatian market (Figure 7). Such introduction caused great media coverage, but since insects as food did not yet have a legal basis for placing them on the market, they were soon withdrawn from the shelves of the retail chain.

Figure 7 Kaufland's insect-based food flyer, 2020

Source: Kaufland leaflet 2020

Currently (June 2023), no insect-based products can be found on the Croatian market. To a large extent, the reason for this is the repulsion that insects create in consumers, as well as insufficient knowledge of the legal framework for the introduction of insects as food on the Croatian market.

4. Methodology

Primary and secondary sources of data were used in this paper. Professional and scientific literature on the production of insects and the acceptance of insect-based food as well as legal provisions and regulations were used as secondary sources. Primary data was collected by surveying consumers. In order to gain a first insight into the thinking of consumers about insect-based food, an in-depth interview was conducted with 5 interviewees, postgraduate MBA students at the University of Zagreb.

Based on the results of the in-depth interview and findings from the literature, an online questionnaire was defined. The invitation to complete the survey was distributed via social networks and e-mail, and the target group consisted of consumers of the Y and Z generations. This target group was chosen because it is known that younger consumers have greater preferences / less aversion to new products.

The questionnaire included questions related to: knowledge of entomophagy, degree of neophobia, attitudes towards insects as food, willingness to taste food based on insects, and socio-demographic characteristics of the respondents.

The obtained data were processed by univariate and bivariate methods of analysis in the SPSS software package.

The survey was conducted from December 2020 to May 2021.

4.1. Knowledge of entomophagy

The name entomophagy comes from Greek (/ˌɛntəˈmɒfədʒi/, ἔντομον *éntomon*, 'insect', and φαγεῖν *phagein*, 'to eat') and implies feeding on insects (Wikipedia).

Consumer knowledge is considered essential in theoretical models of consumer behavior as well as in marketing practice (Flynn and Goldsmith, 1999).

To measure product knowledge, Flynn and Goldsmith developed a measuring instrument consisting of a series of statements about the product in question, with which respondents express their agreement on a 5-point Likert scale.

Piha et al. (2016) in the paper: *The effects of consumer knowledge on the willingness to buy insect food: An exploratory cross-regional study in Northern and Central Europe* used questions that they adapted to measure consumer knowledge about the product on the willingness to buy products based on insects.

The same three questions were used in this research, the answers of which were measured on a Likert scale of 5 possible answers; 1 – I completely agree with the statement to 5 – I do not agree with the statement at all.

Questions used to measure knowledge about entomophagy:

1. “I know pretty much about insect food.”,
2. “Compared to most other people, I know less about insect food.” (reversed)
3. “When it comes to insect food, I really don’t know a lot.” (reversed)

4.2. Degree of neophobia

Food neophobia is defined as the reluctance to eat and/or avoid novel food (Pliner and Hobden, 1992). For measuring the degree of food neophobia a measuring scale called the Food Neophobia Scale (FNS) has been invented. This scale measures the difference between the food neophobic and food neophilic persons (Schickenberg et al., 2007). The scale is made of ten self-administered statements: five positively worded and five negatively worded statements. The statements are measured on a 5-point scale that ranges from Strongly Disagree to Strongly Agree. The negative items are reversed, so that lower FNS scores reflect greater reluctance to try novel foods.

FNS is tool for scientists to measure consumers expectations and eating behavior for novel food.

In recent studies, the NFS is also applied to the case of the possible introduction of insects into the human diet. Many scientists show that food neophobia significantly and negatively affects people's willingness to eat insect food (La Barbera et al., 2017); (Alemu et al., 2015); (Pedersen, 2014) and many more. La Barbera et al. (2017) find that people who score high on the FNS will reject insects as food because they think of them as unfamiliar, novel and unusual food. This Food Neophobia Scale was used in the research.

Food Neophobia Scale questionnaire:

1. „I am constantly sampling new and different foods.“
2. „I don’t trust new foods.“
3. „If I don’t know what is in a food, I won’t try it.“
4. „I like foods from different countries.“
5. „Ethnic food looks too weird to eat.“
6. „At dinner parties, I will try a new food.“
7. „I am afraid to eat things I have never had before.“
8. „I am very particular about the foods I will eat.“
9. „I will eat almost anything.“
10. „I like to try new ethnic restaurants.“

4.3.Attitudes towards insects as food

In order to measure respondents' attitudes towards insects as food, questions from several sources were used. Two questions were used from the paper by Costa-Font and Gill in 2009 to measure attitudes towards food. Other questions were used from papers that focus on insects as food (Piha et al., 2016); (Sogari et al., 2017).

Attitudes towards insects-based food questionnaire:

1. „In general, my attitude towards the consumption of insect-based food is positive.“
2. „I am interested in food based on insects.“
3. „Insects are considered disease carriers and are not suitable as food.“
4. „Consuming food based on insects is disgusting.“
5. „Consuming food based on insects is healthy.“
6. „Consuming food based on insects is acceptable like any other conventional food; such as meat.“
7. „ Food based on insects contains important nutrients and is therefore good for consumption.“
8. „Insect-based food is a good alternative source of protein.“
9. „People should not consume insects (insect-based food).“

4.4. Willingness to try insect-based food

Willingness to taste insect-based food was measured for three products containing insects. The research used common everyday products, which the respondents knew contained parts of insects; insect-based chips, insect-based hamburgers, and insect-based biscuits.

Respondents expressed their willingness on a 5-point scale, where 1 meant I would not try it at all. and 5 I would completely try it.

4.5. Sociodemographic characteristics

The following sociodemographic characteristics were measured:

1. GENDER:
    - Male
    - Female
    - Prefer not to answer
2. EDUCATION:
    - Elementary school
    - High school
    - Undergraduate degree
    - Graduate degree
    - Postgraduate degree
3. EMPLOYMENT STATUS:
    - High school student
    - University student
    - Employed
    - Unemployed
4. PLACE OF RESIDENCE DURING CHILDHOOD AND ADOLESCENCE:
    - In a city
    - In a rural area or a small town

5. HAVE YOU LIVED ABROAD FOR MORE THAN 2 MONTHS
    - YES
    - NO
6. PERSONAL MONTHLY BUDGET:
    - <265,45 € (2.000,00 kn)
    - 265,58 € - 663,61 € (2.001,00 – 5.000,00 kn)
    - 663,75 € - 995,42 € (5.001,00 – 7.500,00 kn)
    - 995,55 € - 1.327,23 € (7.501,00 – 10.000 kn)
    - > 1.327,36 € (10.001,00 kn)

5. Research results

The results of the conducted survey are described below.

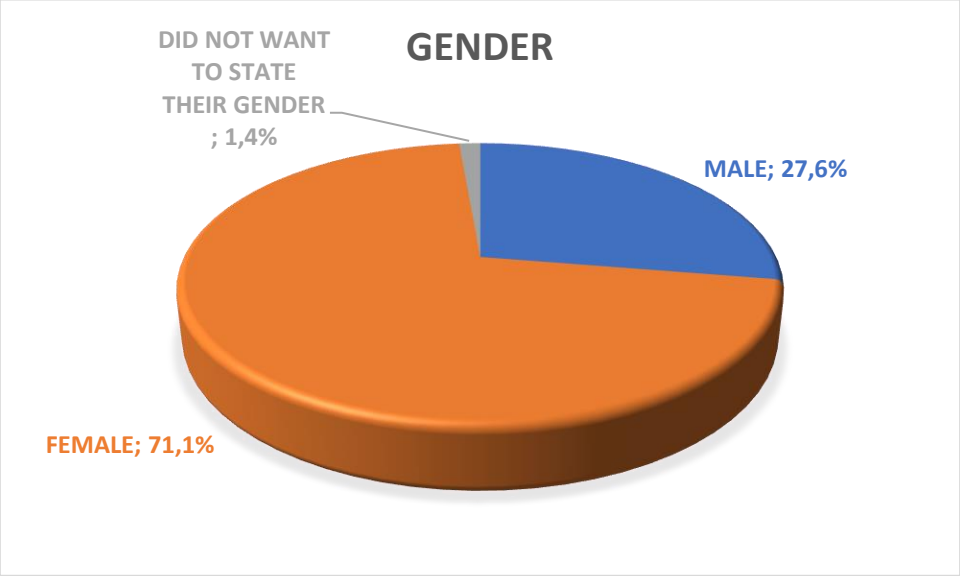
5.1. Sociodemographic characteristics of respondents

Table 1 Sociodemographic characteristics of respondents

Sociodemographic characteristics	n	%		n	%
Age ($\bar{x}$ = 27.81 ± 6.53):			**Employment status:**		
18-20	52	10.2%	High school student	14	2.7%
21-25	185	35.9%	University student	201	39%
26-30	90	17.5%	Unemployed	18	3.5%
31-35	98	19.1%	Employed	282	54.8%
36-40	90	17.5%	**Monthly budget:**		
Gender:			< 2.000.00 kn	149	28.9%
Female	366	71.1%	< 265.45 €		
Male	142	27.6%	2.001.00 – 5.000.00 kn	100	19.4%
Prefer not to answer	7	1.4%	265.58 € - 663.61 €		
Education:			5.001.00 – 7.500.00 kn	140	27.2%
Elementary school	8	1.6%	663.75 € - 995.42 €		
High school	136	26.4%	7.501.00 – 10.000.0 kn	84	16.3%
Undergraduate degree	143	27.8%	995.55 € - 1.327.23 €		
Graduate degree	209	40.6%	>10.001.00 kn	42	8.2%
Postgraduate degree	19	3.7%	>1.327.36 €		
Place of residence during childhood or adolescence:			**Lived abroad for more than 2 months:**		
In a city	261	51.3%	Yes	98	19%
In a rural area or small town	251	48.7%	No	417	81%

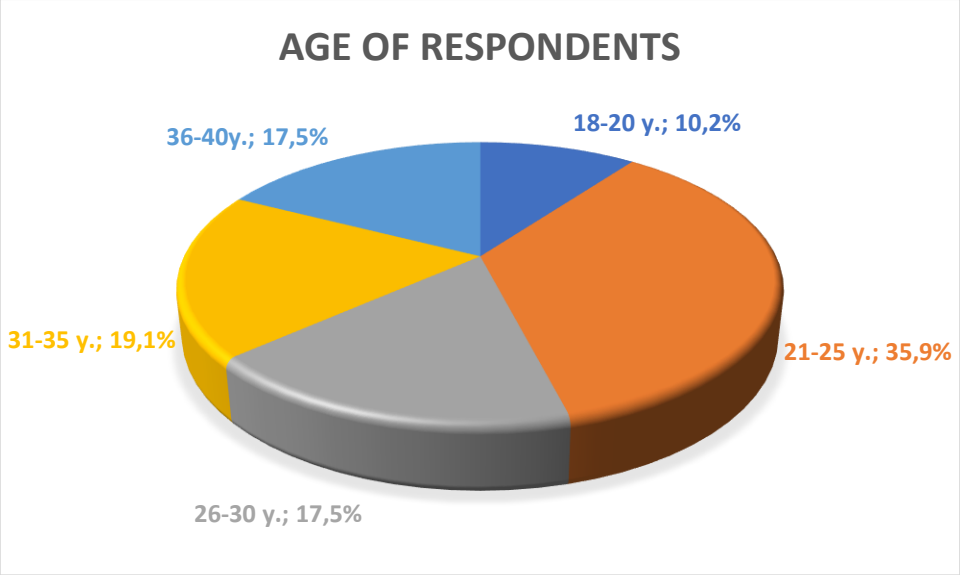
A total of 1163 respondents accessed the survey (they opened the first page), while 515 of them filled out the survey to the end and these respondents were included in the further analysis. Of the 515 respondents who completed the survey, 142 or 27.6% were men, 366

respondents or 71.1% were women, while 7 or 1.4% did not want to state their gender (Graph 1).



Graph 1 Gender of respondents

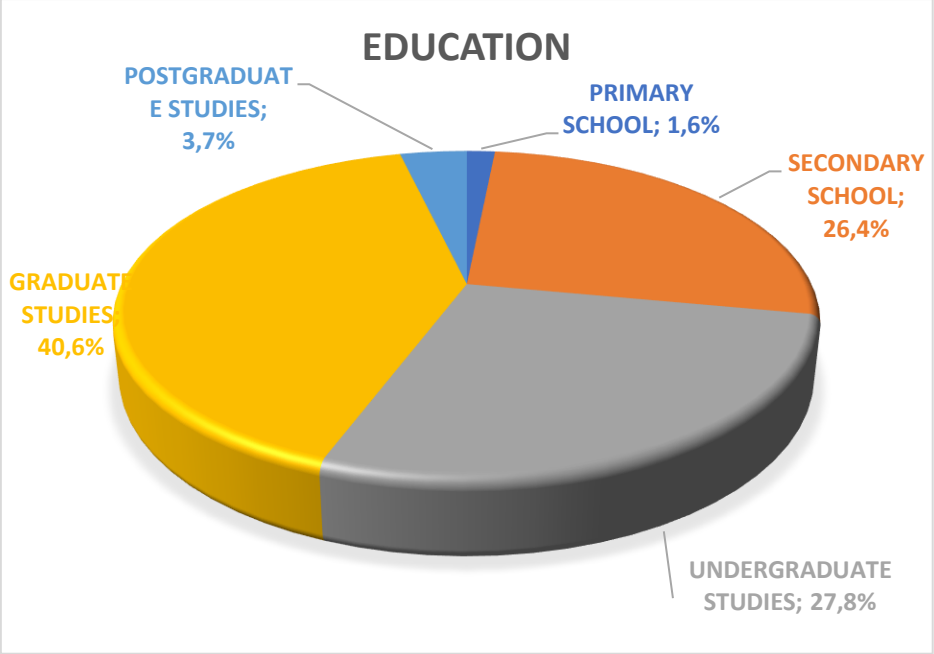
Most of the respondents are aged 21 to 25 (35.9), followed by respondents aged 31 to 35 (19.1%), then 26 to 30, 36 to 40 (17.4 %) and finally respondents aged 18 to 20 (10.2%). The average age of the respondents was 27.81 ± 6.53 years (Graph 2).



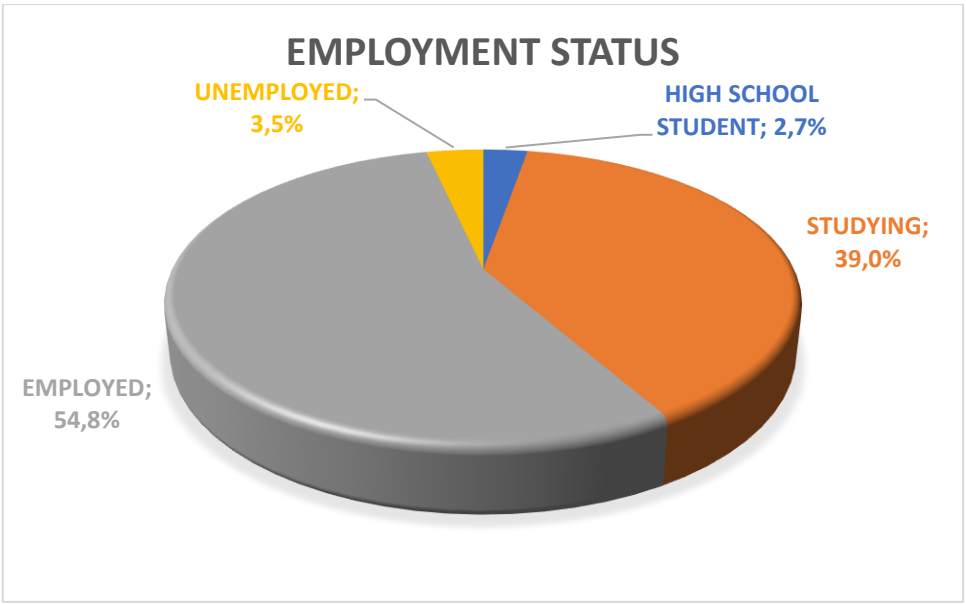
Graph 2 Age of respondents

When it comes to education, the majority of respondents have completed graduate studies, 40.6% of them. This is followed by respondents who have completed undergraduate studies (27.8%) and respondents who have completed secondary school (26.4%), followed by respondents who have completed post-graduate studies (3.7%), and the least are those who have completed only primary school (1.6%) (Graph 3).

At the time of the survey, more than half of them were employed (54.8%), 39% of them were studying, 3.5% were unemployed and 2.7% were high school students (Graph 4).



Graph 3 Education of respondents

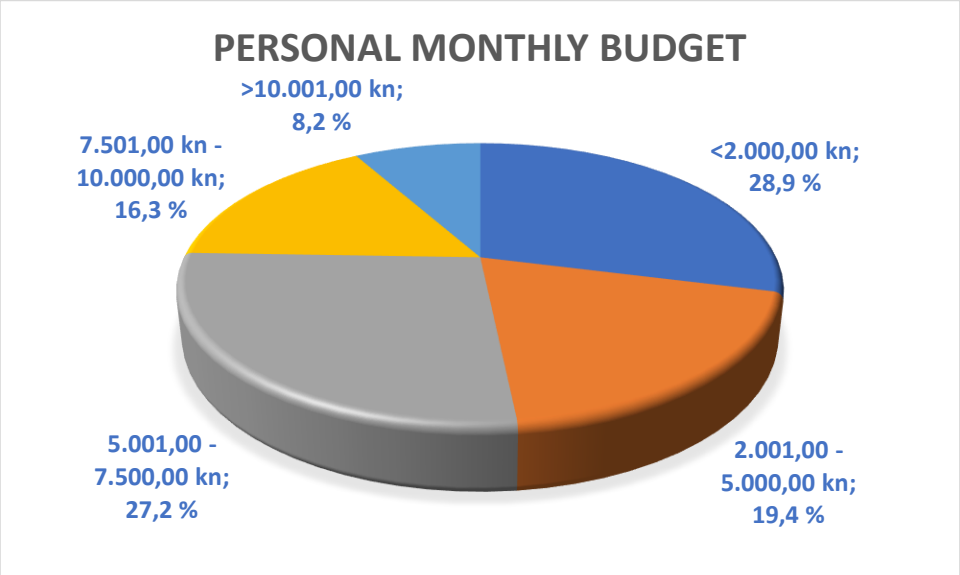


Graph 4 Employment status of respondents

Almost the same number of respondents grew up in a rural area or a small town (48.7%) as those who grew up in the city (51.3%).

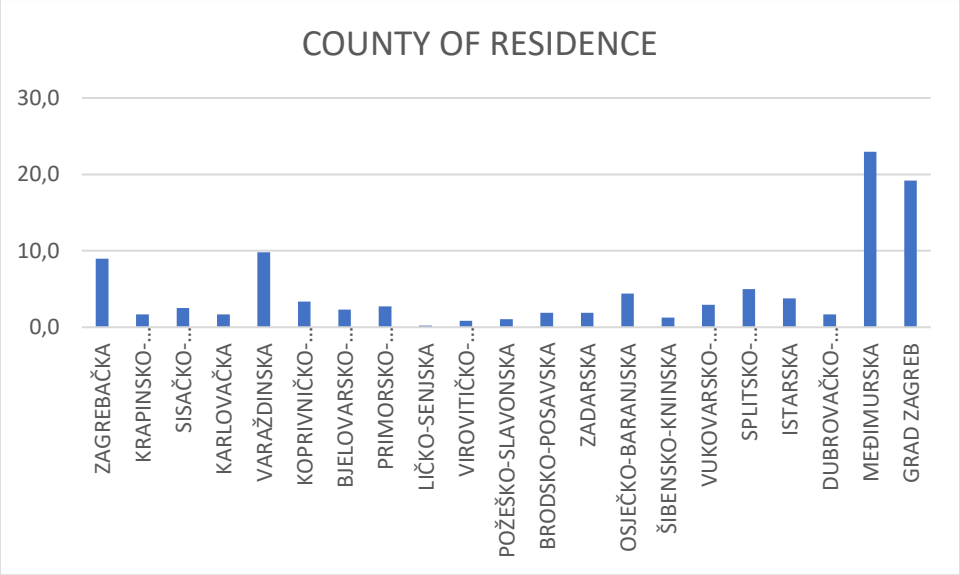
19% of respondents lived abroad for more than 2 months.

Most respondents have a monthly budget of less than HRK 2,000.00 or €265.45 (28.9%), while the smallest number of respondents (8.2%) have a monthly budget above HRK 10,001.00 or €1,327.36 (Graph 5).



Graph 5 Personal monthly budget

Most respondents reside in Međimurje County, followed by the city of Zagreb and Varaždin County (Graph 6).



Graph 6 Place of residence by county of respondents

5.2. Knowledge of entomophagy

More than half of the respondents (56.1%) had heard about the consumption of insects. However, a smaller number of respondents know enough about insect-based food. Only a quarter of respondents think they know more than other people about insect-based foods (Table 3).

Table 2 Knowledge of entomophagy

KNOWLEDGE OF ENTOMOPHAGY	1 - I do not agree at all	2 – I mostly disagree	3 – I neither agree nor disagree	4 – I mostly agree	5 – I completely agree	Mean value	Standard deviation
I've heard about eating insects and I know what it is all about	9.5 %	11.1 %	23.3 %	38.8 %	17.3 %	3.43	1.1177
Compared to most other people, I know less about	7.4 %	17.5 %	43.7 %	18.4 %	13.0 %	3.12	1.078

insect-based foods							
I know enough about insect-based foods	34.4 %	35.9 %	18.4 %	8.5 %	2.7 %	2.09	1.053

5.3. Neophobia

Table 4 shows the results of the questions used to measure the respondents' food neophobia. A greater number of respondents are constantly trying new and different foods. Likewise, when it comes to new food, a greater number of respondents have confidence in such food. Despite this, it is important for the majority of respondents to know exactly what they are eating, because otherwise they do not want to try food whose composition they do not know.

Food from other countries is acceptable for a large number of respondents, and when it comes to ethnic food, i.e. food specific to a certain region or culture, such food is not repulsive to the vast majority of respondents.

The respondents showed that they like to try new food to a very large extent at parties and social events. When it comes to novel food, most people are not afraid to try food that they haven't tried before.

Respondents showed to a slight extent that they are not very particular about what food they will eat and a greater number of respondents stated that they will eat almost anything.

Most respondents like to visit restaurants that offer food that is different than the food in Croatia.

Table 3 Neophobia

NEOPHOBIA	1 - I do not agree at all	2 – I mostly disagree	3 – I neither agree nor disagree	4 – I mostly agree	5 – I completely agree	Mean value	Standard deviation
At parties, social events, I am willing to try new food	2.1 %	6.4 %	14.2 %	41.7 %	35.5 %	4.02	0.973
I like food from different countries	1.9 %	10.7 %	22.1 %	35.7 %	29.5 %	3.8	1.040
I like to visit restaurants that serve different food than in my country	5.6 %	10.9 %	20.4 %	35.1 %	28.0 %	3.69	1.154
I am constantly trying new and different foods	4.9 %	19.0 %	29.1 %	32.8 %	14.2 %	3.32	1.085
If I don't know what's in the food, I don't want to try it	13.0 %	19.6 %	24.9 %	25.8 %	16.7 %	3.14	1.276
I'll eat almost anything	13.6 %	20.2 %	19.8 %	32.8 %	13.6 %	3.13	1.267
I am very particular about what food I will eat	15.5 %	21.4 %	27.4 %	25.4 %	10.3 %	2.94	1.225
I am afraid to eat food that I have never eaten before	28.3 %	30.5 %	21.2 %	14.8 %	5.2 %	2.38	1.190
I don't trust new food	23.1 %	35.3 %	27.8 %	10.9 %	2.9 %	2.35	1.041
Ethnic food looks too weird for me to try	29.7 %	34.4 %	25.4 %	8.2 %	2.3 %	2.19	1.026

By analyzing the mean values of the results obtained from the FNS, the respondents were divided into two groups. The total mean value of the results of all respondents is 25.03, which means that respondents whose mean FNS score is 10-25 are categorized as neophiles, while those respondents whose mean FNS score is 25.01-50 are categorized as neophobes.

Of the total number of respondents, 54.6% were categorized as neophiles, while 45.4% were categorized as neophobes (Table 5).

Table 4 Division of respondents into neophiles and neophobes

	Frequency	Percent
Neophiles	281	54.6 %
Neophobes	234	45.4 %
Total	515	100 %

5.4.Attitudes on insects as food

Table 6 shows the results of attitudes about insects as food.

Respondents mostly agree with the statement that insect-based food is a good alternative source of protein with a mean value of 3.46; followed by the statement that insect-based food contains important nutrients and is therefore good for consumption with a mean value of 3.32; followed by the statement that the consumption of insect-based food is disgusting with a mean value of 3.29. The statements with which respondents agree the least is the statement that people should not consume insects with a mean value of 2.28; and with the statement that they are interested in insect-based food with a mean value of 2.41.

Table 5 Attitudes about insects as food

ATTITUDES ON INSECTS AS FOOD	1 - I do not agree at all	2 – I mostly disagree	3 – I neither agree nor disagree	4 – I mostly agree	5 – I completely agree	Mean value	Standard deviation
Insect-based foods are a good alternative source of protein	5.6 %	5.2 %	41.6 %	33.0 %	14.6 %	3.46	0.992
Insect-based food contains important nutrients and is therefore good for consumption	6.8 %	4.7 %	48.2 %	30.7 %	9.7 %	3.32	0.956
Eating insect-based food is disgusting	9.9 %	17.3 %	27.2 %	24.9 %	20.8 %	3.29	1.251
Eating insect-based food is healthy	8.2 %	7.4 %	55.3 %	23.1 %	6.0 %	3.11	0.928
Eating insect-based food is just as acceptable as any other conventional food; such as meat	11.7 %	18.1 %	31.1 %	27.2 %	12.0 %	3.10	1.180
Insects are considered carriers of disease and are	14.4 %	26.6 %	43.5 %	10.3 %	5.2 %	2.65	1.018

not suitable as food							
In general, my attitude towards the consumption of insect-based food is positive	26.4 %	22.7 %	28.2 %	14.6 %	8.2 %	2.55	1.249
I am interested in insect-based food	34.4 %	23.5 %	17.9 %	15.1 %	9.1 %	2.41	1.335
Humans should not consume insects (insect-based food)	30.3 %	27.0 %	32.0 %	5.6 %	5.0 %	2.28	1.107

5.5. Willingness to try insects as food

In order to investigate the willingness to taste a certain product that contains insects, the respondents were presented with three common products; chips, biscuits and hamburgers.

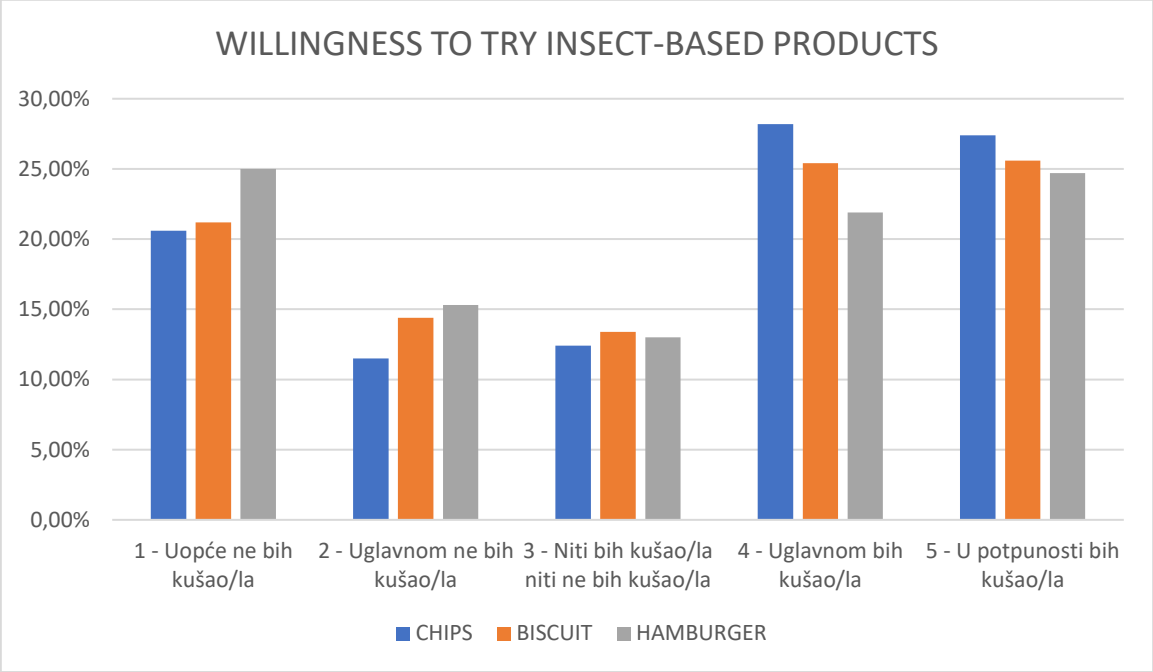
When it comes to chips that have insects in their composition, more than 55% of respondents would mostly or completely taste such a product. 12% of them are reluctant, while around 32% of them would not try such a product.

Biscuit that has insects in its composition would also be tasted by the majority of respondents, 51%, 13.5% of them are reluctant and 35.5% of them would not taste such a biscuit.

Almost 55.5% of respondents would also try an insect-based hamburger, 13% of them are reluctant in this case as well, and 40% of them would not at all taste such a hamburger (Graph 7).

Based on the results, it can be concluded that the willingness to taste products that contain insects in their composition is highest with chips, then with biscuits and finally with

hamburgers. Although there is a difference between the respondents' willingness to taste products that contain insects in their composition, regardless of the type of product, the willingness to taste such products is very similar. Respondents show willingness to try all three different products in an almost equal percentage.



Graph 7 Willingness to try insect-based products

5.6. Influence of neophobia on the attitude about insect-based food

Comparing the neophilic and neophobic groups of respondents, there is a significant difference between the two groups in relation to attitudes towards insects as food. As expected, neophiles show more positive attitudes towards insect-based food than neophobes (Table 7).

Table 6 The influence of neophobia on the attitude about insects as food

	NEO_SEGMENT	Mean	Significance
In general. my attitude towards the consumption of insect-based food is positive	neophile	2.94	0.000
	neophobe	2.09	
I am interested in insect-based food	neophile	2.83	0.000
	neophobe	1.91	
Insects are considered disease carriers and are not suitable as food	neophile	2.44	0.000
	neophobe	2.91	
Eating insect-based food is disgusting	neophile	2.95	0.000
	neophobe	3.71	
Eating insect-based food is healthy	neophile	3.32	0.000
	neophobe	2.86	
Eating insect-based food is just as acceptable as any other conventional food. such as meat	neophile	3.39	0.000
	neophobe	2.75	
Insect-based food contains important nutrients and is therefore good for consumption	neophile	3.53	0.000
	neophobe	3.06	
Insect-based foods are a good alternative source of protein	neophile	3.66	0.000
	neophobe	3.21	
Humans should not consume insects (insect-based food)	neophile	2.01	0.000
	neophobe	2.61	

5.7. Influence of neophobia on the willingness to try insect-based food

When comparing the neophilic and neophobic groups of respondents, there is a significant difference between them regarding the willingness to try insect-based food. Neophiles show a greater willingness to try such food compared to neophobes (Table 8).

Table 7 Influence of neophobia on willingness to try

	NEO_SEGMENT	Mean	Significance
CHIPS_willingness to try_3	neophile	3.80	0.000
	neophobe	2.71	
BISCUITS_willingness to try_3	neophile	3.69	0.000
	neophobe	2.61	
HAMBURGER_willingness to try_3	neophile	3.64	0.000
	neophobe	2.36	

5.8. Sociodemographic characteristics and willingness to try insect-based food

5.8.1. Gender and willingness to try insect-based food

The chi-square test (Table 9) showed that there is a statistically significant difference in the willingness to taste insect-based food between men and women. Men are more willing to try such products than women. As many as 69% of men would taste chips with insects, while among women it is only 50.6%. Men show a slightly lower willingness to taste the other two products (62.0% and 62.7% respectively for biscuits and hamburgers), but still significantly more than women (46.8% and 40.4%). The low willingness of women to try hamburgers is particularly visible, possibly due to the type of product.

Table 8 Correlation between gender and willingness to try insect-based food

		1 - I would not try it at all	2 – I would mostly not try it	3 – I would neither try it nor I would not try it	4 – I would mostly try it	5 – I would completely try it
Chips	Male	14.1%	4.2%	12.7%	34.5%	34.5%
	Female	23.0%	14.5%	12.0%	26.0%	24.6%
		Chi-Square value 20.077; p = 0.000				
Biscuits	Male	14.8%	6.3%	16.9%	28.9%	33.1%
	Female	23.5%	17.8%	11.7%	24.3%	22.7%
		Chi-Square value 19.545; p = 0.000				
Hamburger	Male	15.5%	7.7%	14.1%	28.9%	33.8%
	Female	28.7%	18.6%	12.3%	19.1%	21.3%
		Chi-Square value 25.986; p = 0.000				

5.8.2. Place of residence during childhood or adolescence and willingness to try insect-based food

Place of residence during childhood or adolescence (city or rural area / small town) and willingness to try insect-based products are not related to each other. There is no difference in the willingness to try insect-based products, considering whether the respondents grew up in a city or in a rural area (Table 10).

Table 9 Correlation between place of residence and willingness to try insect-based food

		1 - I would not try it at all	2 – I would mostly not try it	3 – I would neither try it nor I would not try it	4 – I would mostly try it	5 – I would completely try it
Chips	City	22.0%	11.4%	12.1%	26.9%	27.7%
	Rural area or small town	19.1%	11.6%	12.7%	29.5%	27.1%
		Chi-Square value 0.872; p = 0.929				
Biscuits	City	22.7%	14.4%	12.1%	24.6%	26.1%
	Rural area or small town	19.5%	14.3%	14.7%	26.3%	25.1%
	City	Chi-Square value 1.480; p = 0.830				
Hamburger	Rural area or small town	27.7%	14.0%	12.1%	22.0%	24.2%
	City	22.3%	16.7%	13.9%	21.9%	25.1%
		Chi-Square value 2.452; p = 0.653				

5.8.3. Education and willingness to try insect-based food

Likewise, the level of education is not related to the willingness to try insect-based products (Table 11).

Table 10 Correlation between education and willingness to try insect-based food

		1 - I would not try it at all	2 – I would mostly not try it	3 – I would neither try it nor I would not try it	4 – I would mostly try it	5 – I would completely try it
Chips	HIGH SCHOOL	19.1%	11.8%	18.4%	28.7%	22.1%
	UNDERGRADUATE DEGREE	25.2%	8.4%	11.9%	25.9%	28.7%
	GRADUATE DEGREE	18.7%	14.4%	9.6%	28.7%	28.7%
	POSTGRADUATE DEGREE	15.8%	0.0%	10.5%	36.8%	36.8%
		Chi-Square value 15.410; p = 0.220				
Biscuits	HIGH SCHOOL	19.9%	14.0%	20.6%	22.1%	23.5%
	UNDERGRADUATE DEGREE	25.2%	13.3%	10.5%	24.5%	26.6%
	GRADUATE DEGREE	20.1%	15.8%	10.5%	28.7%	24.9%
	POSTGRADUATE DEGREE	10.5%	10.5%	15.8%	26.3%	36.8%
		Chi-Square value 13.251; p = 0.351				
Hamburger	HIGH SCHOOL	25.0%	15.4%	15.4%	22.1%	22.1%
	UNDERGRADUATE DEGREE	28.7%	14.0%	12.6%	18.2%	26.6%
	GRADUATE DEGREE	23.9%	16.3%	12.0%	24.4%	23.4%
	POSTGRADUATE DEGREE	10.5%	10.5%	15.8%	26.3%	36.8%
		Chi-Square value 7.434; p = 0.820				

5.8.4. Monthly budget and willingness to try insect-based food

Considering the respondents' monthly budget, there is no difference between respondents in their willingness to try insect-based products (Table 12).

Table 11 Correlation between monthly budget and willingness to try insect-based food

		1 - I would not try it at all	2 – I would mostly not try it	3 – I would neither try it nor I would not try it	4 – I would mostly try it	5 – I would completely try it
Chips	<2.000,00 kn	24.2%	9.4%	14.1%	24.8%	27.5%
	2.001,00 -5.000,00 kn	19.0%	14.0%	12.0%	29.0%	26.0%
	5.001,00 -7.500,00 kn	19.3%	13.6%	16.4%	26.4%	24.3%
	7.501,0 -10.000,00kn	20.2%	10.7%	3.6%	35.7%	29.8%
	>10.001,00 kn	16.7%	7.1%	11.9%	28.6%	35.7%
	Chi-Square value 15.591; p = 0.482					
Biscuits	<2.000,00 kn	26.2%	14.1%	12.8%	20.8%	26.2%
	2.001,00 -5.000,00 kn	18.0%	18.0%	14.0%	25.0%	25.0%
	5.001,00 -7.500,00 kn	19.3%	15.0%	17.9%	25.7%	22.1%
	7.501,0 -10.000,00kn	20.2%	11.9%	7.1%	33.3%	27.4%
	>10.001,00 kn	19.0%	9.5%	11.9%	26.2%	33.3%
	Chi-Square value 14.383; p = 0.570					
Hamburger	<2.000,00 kn	30.9%	14.8%	11.4%	20.1%	22.8%
	2.001,00 -5.000,00 kn	22.0%	18.0%	13.0%	20.0%	27.0%
	5.001,00 -7.500,00 kn	25.0%	16.4%	16.4%	21.4%	20.7%
	7.501,0 -10.000,00kn	20.2%	13.1%	9.5%	27.4%	29.8%
	>10.001,00 kn	21.4%	11.9%	14.3%	23.8%	28.6%
	Chi-Square value 11.041; p = 0.807					

5.8.5. Life abroad and willingness to try insect-based food

Respondents who have lived abroad for more than 2 months are significantly more willing to try insect-based products than respondents who have not lived abroad for more than 2 months (Table 13).

Table 12 correlation between living abroad and willingness to try insect-based food

		1 - I would not try it at all	2 – I would mostly not try it	3 – I would neither try it nor I would not try it	4 – I would mostly try it	5 – I would completely try it
Chips	YES	26.5%	8.2%	6.1%	22.4%	36.7%
	NO	19.2%	12.2%	13.9%	29.5%	25.2%
	Chi-Square value 12.367; p = 0.015					
Biscuits	YES	25.5%	11.2%	9.2%	17.3%	36.7%
	NO	20.1%	15.1%	14.4%	27.3%	23.0%
	Chi-Square value 12.453; p = 0.014					
Hamburger	YES	25.5%	13.3%	7.1%	18.4%	35.7%
	NO	24.9%	15.8%	14.4%	22.8%	22.1%
	Chi-Square value 10.254; p = 0.036					

5.8.6. Age and willingness to try insect-based food

By comparing the age of the respondents and the willingness to taste insect-based chips, the highest willingness was expressed by respondents aged 26 and 30 (mean value 3.58), while the respondents with the least willingness to taste insect-based chips are aged between 18 and 20 g (mean value 2.85).

When comparing the age of the respondents and the willingness to try insect-based biscuits, as with chips, respondents aged 26 and 30 have expressed the highest willingness to try them, while the lowest willingness, is among respondents between 18 and 20 years old.

By comparing the age of the respondents and the willingness to try insect-based hamburgers, the greatest willingness was expressed by respondents between 31 and 35 years old, while the lowest willingness expressed, as with the other two products, was expressed by respondents between 18 and 20 years old (Table 14).

Table 13 Correlation between age and willingness to try insect-based food

Product	Age	N	Mean	Std. Deviation	p-value
Chips	18-20	52	2.85	1.487	**0.052**
	21-25	184	3.23	1.527	
	26-30	89	3.58	1.452	
	31-35	98	3.44	1.479	
	36-40	89	3.35	1.407	
Biscuits	18-20	52	2.79	1.525	**0.173**
	21-25	184	3.14	1.533	
	26-30	89	3.36	1.502	
	31-35	98	3.33	1.427	
	36-40	89	3.30	1.425	
Hamburger	18-20	52	2.48	1.448	**0.052**
	21-25	184	3.08	1.563	
	26-30	89	3.12	1.558	
	31-35	98	3.27	1.503	
	36-40	89	3.10	1.493	

6. Conclusion

Although more than 50% of respondents have heard of the term entomophagy and know what the term means, in general not enough is known when it comes to consuming and using insects for human food.

A little over half of the respondents have been categorised as neophiles which shows that there is room for introduction of novel foods which includes insect-based food as well. Additionally, results indicate that there is also willingness to try such food as more than 50% of respondents have expressed interest in tasting three different products made from insects.

The respondents' attitudes towards insect-based food are largely neutral. However, most respondents feel that insects are a great source of protein if they are used for food and that such food is nutritious, although they are not entirely certain how healthy such food is.

There is significant resistance towards insect-based food as 45% of respondents find it disgusting, i.e. almost half of the respondents do not have a positive attitude towards insect-based food. Despite that most respondents still do not feel that people (other than them) shouldn’t consume insect-based food.

As would be expected, neophilic group of respondents expressed a more positive attitude towards insects as food. Accordingly, results also show that when comparing neophiles and neophobes, neophiles show a greater willingness to try insect-based food.

When comparing different genders, men are more likely to be willing to try products made from insects when compared to women. This is also confirmed in previous research (Sogari et. al, 2017).

When it comes to the place where the respondents were raised, those who were raised in urban areas compared to those who were raised in rural areas are equally willing to try insect-based food.

The level of their education and monthly budget also do not affect the respondents’ willingness to try insect-based food.

On the other hand, respondents' who spent longer than two months abroad are significantly more willing to try insect-based food.

Although statistically there is no significant difference in the age of the respondents who are willing to try insect-based food, the majority of respondents between the ages of 26 and 30 have shown the greatest willingness to taste insect-based food and respondents between the ages of 18 and 20 have shown the greatest reluctance to taste insect-based food.

Based on the results of the research, the following can be concluded:

- There is still insufficient information available about insects used as food
- There is interest to taste insect-based food
- The group which shows the greatest degree of willingness to try such food are men between the ages of 26 and 30 who spent a portion of their life abroad

Based on everything that has been stated, in order to introduce insect-based food into the Croatian market, first the consumers need to be educated on the benefits of insect-based food, which includes personal benefits (nutritive benefits) as well as benefits for the society as a whole (ecological benefits). This was also confirmed in previous research conducted on respondents in Italy. More and better information could lead to better acceptance of entomophagy (Sogari et. al, 2017).

Since there is interest to try such food, tastings, culinary workshops, presentations etc. need to be organised.

Insect-based food that is introduced into the Croatian market should target the middle-aged male population. Insect based products must be more familiar to customers, which also show previous researches (Tan et al., 2015, 2017). Therefore, examples of insect-based products intended for the target group include insect chips, hamburgers, pasta, and even beer.

7. References

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