



DEPARTMENT OF AGRICULTURAL, FOOD AND
ENVIRONMENTAL SCIENCES

COURSE OF DEGREE IN:

“FOOD AND BEVERAGE INNOVATION AND MANAGEMENT”

INSECT REARING FOR FOOD AND FEED IN ITALY: A CASE STUDY

THESIS TYPE: EXPERIMENTAL

Student:

ANDREA AMOROSO

Supervisor:

PROF./DR. RAFFAELE ZANOLI

ACADEMIC YEAR 2019-2020

INDEX

LIST OF TABLES	3
LIST OF FIGURES.....	4
INTRODUCTION	5
THE CURRENT SITUATION	7
THE INSECT SOLUTION.....	9
THE INSECT MARKET	14
INSECT FOR FEED	16
INSECT FOR FOOD.....	22
BARRIERS.....	25
FUTURE DEVELOPMENT NEED.....	28
MATERIAL AND METHODS	30
What is a case study?	31
Why a case study?.....	32
The case study	33
The interview.....	34
The method.....	35
“Cc”	35
“Mb”	36
“Ni”	37
Company history.....	38

Barriers	39
Future scenario	42
RESULTS	44
CONCLUSIONS	46
ANNEX 1	47
BIBLIOGRAPHY	48

LIST OF TABLES

Table 1 - Number of insects species, by order, consumed worldwild.....	9
Table 2 – Efficiencies of production of conventional meat and crickets.	11
Table 3 – Production of GHGs and ammonia per kg of mass gain for three insect species, pigs and beef cattle.	13
Table 4 - World total meat production by region.	16
Table 5 - Forecast of consumers reached in Europe.	22

LIST OF FIGURES

Figure 1 - Spatial distribution of insect food companies in EU.....	15
Figure 2 - Part C of the Annex to Reg. 68/2013 / EU.....	18

INTRODUCTION

This work focuses on a preliminary qualitative analysis of the Italian companies involved in insect rearing and their use for feed and food. The purpose of the research is to go and answer the driving question "How the main actors of the Italian insect-as-feed-and-food sector approach the market, what are their current uncertainties and future expectations? "

The first part of the paper analyzes the current situation and the future challenges that humans will have to face in relations to their food habits. In the same chapter, it will be explained why insects are considered revolutionary and innovative and why they can transform our eating habits going to support a positive change in the natural environment.

Nutritional, environmental, and social aspects linked to insects' rearing and consumption will be shortly summarized. The current and future market prospects for insect in animal and human diet will be explored.

The dissertation will continue listing the various products produced to date by the sector, classifying them in insect for feed and insect for food. Whether they are intended for the production of feed or the formulation of snacks and other products designed for humans (food), insects are perfectly suited to support a natural and nutritious diet for both animals and people.

Within this framework, this dissertation will also introduce the European legislative situation to identify the regulations that characterize a sector that is not yet fully protected and developed from a regulatory point of view. The continuous reworking of the regulations, which aims to develop tailor-made laws for the protection and development of this nascent sector, is perceived as a barrier to emerging businesses. In addition to the difficulties related to the legislative landscape, all the barriers related to the lack of information and definitive research, to the economic-financial and social scenario will also be described.

Space will also be given to the description of the present and future needs that this sector has to reach for have the possibility of affirming and being able to operate without limitations of any kind.

The main part of the dissertation is based on a case study involving early entrants in the Italian insect-for-food-and-feed sector. Data collection was based on semi-structured interviews with the owners and managers of these insect-based businesses. The analysis will

focus on the reasons that led entrepreneurs to enter this new market. We will also show the barriers they have encountered and are still facing. By elaborating the answers, these companies' expectations and prospects will be explored, giving voice to their opinions on possible future scenarios.

Finally, considering all the information proposed, the dissertation will close with the discussion of the results and conclusions.

THE CURRENT SITUATION

According to the estimates reported by the FAO (Food and Agriculture Organization of the United Nations) on the demographic development of the next decades, it has emerged that by 2050 the world population will touch 10 billion people (9.7 billion).

To feed the growing population, food production will have to increase by 70%, putting the food production system under critical pressure (IPIFF, 2019).

However, the production of such quantities will not be possible using traditional methodologies and technologies. What we eat and how we produce it will have to be re-evaluated and new and innovative solutions will have to be used to guarantee adequate, quality, safe and nutritious food.

The increasingly limited resources, such as arable land, the availability of water and all those natural elements necessary for cultivation and breeding, represent a huge challenge. The use of new areas for livestock and agriculture cannot be considered a winning strategy as it is already possible to record the impact of excessive impoverishment of the planet.

The direct consequences of the growing demand for food are deforestation, caused by the continuing need for arable land, the reduction of biodiversity, the increase in the production of greenhouse gases and the impoverishment and pollution of natural resources.

Failure to develop and use new innovative and eco-sustainable methodologies will cause the worsening of climate changes, already considered difficult to reverse, worsening the situation of food availability all over the world (Imathiu, 2020).

Urbanization and globalization are increasingly influencing dietary changes for a considerable part of the population. The increase in the global population is in fact driven by developing countries where there is a constant increase in the demand for animal proteins derived from livestock farming. The growing need for protein, however, does not only concern developing countries, in fact, the European Parliament has stressed that about 80 percent of the European need for protein crops is imported from other countries. This deficit makes the need for proteins derived from cultures one of the most felt problems in Europe (Materia & Cavallo, 2015).

The production of these high biological value proteins represents a challenge for the future, especially if we consider that current production techniques (for example, farming for animal proteins and cultivation for vegetable proteins) not only have a significant impact environmental, but also show a low level of efficiency (Materia & Cavallo, 2015).

The environmental cost associated with these techniques is given by the production of high levels of carbon dioxide, the use of huge quantities of water and also imply important waste disposal problems.

To solve hunger and malnutrition 3 are the strategies suggested by scientists:

integration (short-term mitigation strategy), food fortification (medium-term mitigation strategy) and food diversification (long-term mitigation strategy) (Imathiu, 2020). Although food diversification appears to be the strategy that requires the most time and effort to be implemented, it is also the most eco-friendly and economically feasible option. This is based on the modification of some food choices or the introduction into the daily diet of new nutritious foods, with a low environmental impact, that are easy to produce and available to everyone.

THE INSECT SOLUTION

The growing worldwide demand for animal and plant derived proteins has created the need to seek out new protein sources (Pippinato et al., 2020).

In this context, insects can represent a sustainable alternative. Although today in Western countries it can be considered an unusual protein source and associated with primitive practices (Balzan et al., 2016), the consumption of insects is a food practice followed by more than two billion people around the world.

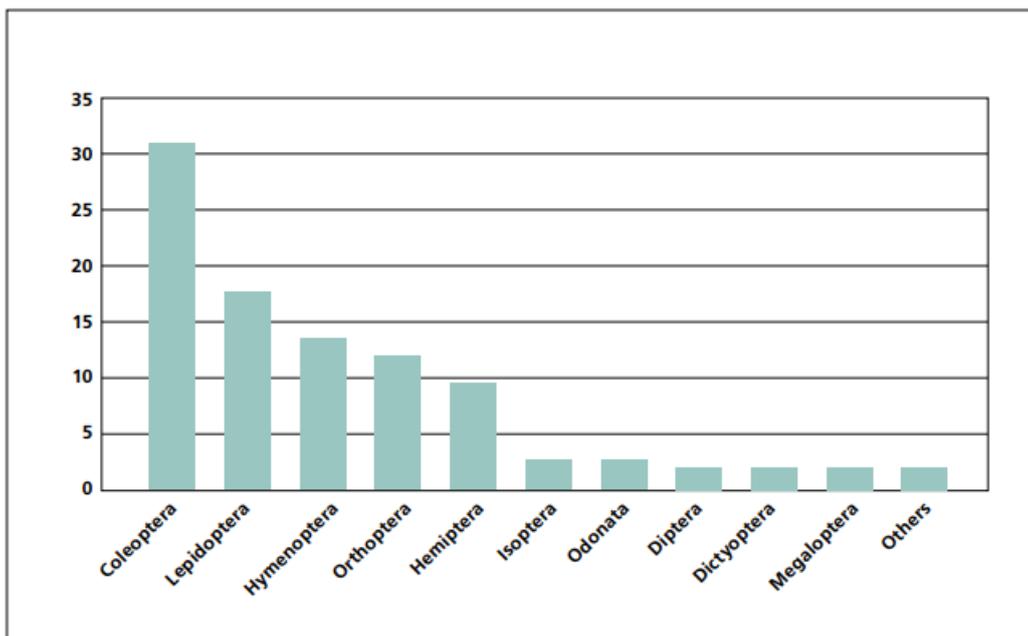
Entomophagy, from the Greek *éntomos*, "insect", and *phāgein*, "eat", as well as being a main and traditional nutritional source of various populations of Asia, Central America and Africa, is also one of the oldest food practices dating back to prehistory (Moore, 2018).

To date, out of a total of over 950,000 known insect species, 1,900 have been considered edible for human consumption (Van Huis, 2013). As can be seen in (Table 1) the edible species

Table 1 - Number of insects species, by order, consumed worldwid.

Note: total species number = 1909.

Source: FAO, 2013.



are distributed within all the classification orders of insect species. The main concentration of edible species is found among beetles (which represent 40% of all known insect species), but a considerable number of species is recorded among Lepidoptera, Hymenoptera, Orthoptera and (FAO, 2013).

The interest in this new protein source, revolutionary of traditional Western diets and a substitute for classic animal and vegetable proteins, was aroused by the multiple advantages that perfectly coincide with the resolution plans of the problems and challenges we face.

Insects can be eaten both raw and processed (roasted, fried, dried, boiled, etc.) and from a nutritional point of view they represent an excellent source of energy, fats, proteins and minerals. Their nutrient composition varies according to the type of insect, stage of the life cycle, substrate used, processing method and sex (Imathiu, 2020). The protein percentage, which represents the main nourishment of insects, varies between 11% and 77% of the dry weight (FAO, 2013) based on the species and the life stage considered. In addition to having a higher biological value than the proteins resulting from livestock and plants, proteins derived from insects are considered a high-value protein source due to their high digestibility (67 - 98%) and their high concentration of essential amino acids (46 - 96%). These values are also incisive for a possible improvement in health, as it has been proven that they are able to reduce the incidence of chronic diseases such as cancer, due to the consumption of animal proteins from red meat (Imathiu, 2020).

The fat content, the second main component, varies from 13 to 33%, with a prevalent concentration of polyunsaturated fatty acids. Their composition is characterized by the presence of linoleic and α -linolenic acids recognized as being beneficial for health and essential for the development of children and infants (FAO, 2013).

Finally we find the micronutrients, consisting of minerals and vitamins. Insects are considered an important source of manganese, copper, selenium, zinc, iron and calcium and in the order of orthoptera (locusts, grasshoppers and crickets) we find significant amounts of phosphorus and magnesium.

Playing an important role in the biological processes of our organism, these mineral sources represent an effective tool in the fight against the "hidden hunger" of developing countries. Here the poorest and most disadvantaged segments of the population register deficiencies and deficiencies that are dangerous for health such as that linked to zinc (affects 17% of the population) and iron (affects 25% of the population) (Imathiu, 2020).

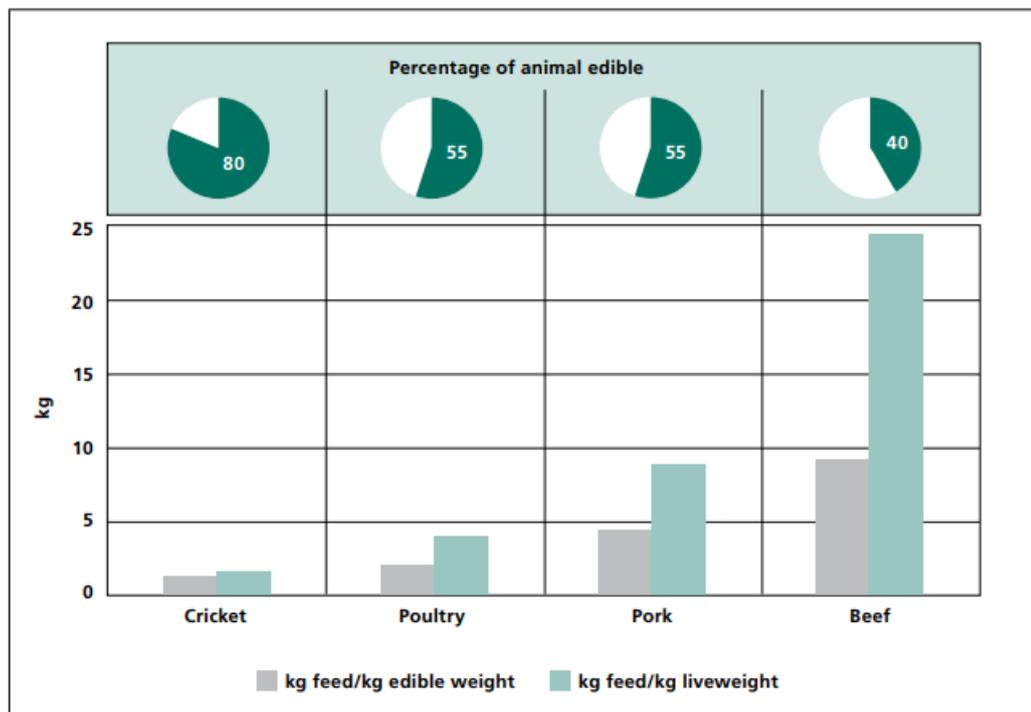
Vitamins are another essential micronutrient that allow you to stimulate metabolic processes and improve the functions of the immune system. In insects we find mainly B

vitamins in high concentrations, such as: riboflavin (vitamin B2), biotin (vitamin B8), pantothenic acid (vitamin B5) and folic acid (vitamin B9), essential for the metabolic processes of our body. We also find, in low percentages, other essential vitamins such as Retinol and β -carotene (vitamin A), tocopherols (vitamin E) and cobalamin (vitamin B12) (Imathiu, 2020). In the same article, it was hypothesized that the concentration of vitamins in the nutritional composition of the insect can be manipulated through the formulation of correct and enriched food substrates for this purpose.

Another point in favor of the use of insects is the fact that they are ectotherms. Not having to thermoregulate their body temperature through the consumption of energy, they have a high conversion efficiency of the substrate into body mass. Their effectiveness in conversion compared to traditional livestock, allows to save important quantities of energy and natural resources, highlighting the precious advantages of this characteristic. Crickets, for example, require 12 times less feed than cattle, 4 times less food than sheep, and half the feed required by pigs and chickens to produce the same amount of protein (Moore, 2018). In addition, another relevant parameter is given by the usable portion on the total mass of the animal. The edible mass of some insects suitable for breeding also reaches 80% of the total dry body mass. Cattle, pigs and chickens, on the other hand, offer only between 40 and 55% of their mass as

Table 2 – Efficiency of production of conventional meat and crickets.

Sources: FAO 2013.



final food for humans, suggesting a significant difference in the production of waste and waste when compared with insects (Imathiu, 2020) (Table 2).

Adopting insects as a new protein source is a strategy that could solve the current challenges related to the climate, but also to the excessive exploitation of agricultural areas and the reduction of forest ones. Having high conversion rates, insects do not need large quantities of feed and can also be sustainably bred on manure, slurry and food waste by converting these substrates into usable nutrients for livestock farming (FAO, 2013). Furthermore, this substitution of the livestock diet reduces the enormous agricultural areas cultivated with protein-rich vegetable cultures, with very high-water requirements, destined for the feed market.

Estimating that in 2050 1.8 billion people will face severe water scarcity crises (FAO, 2013), strategies for conscious and sustainable use indicate insects as a possible solution. According to FAO, the production of 1 kg of beef requires between 22,000 and 43,000 liters of water, 1 kg of pork requires 3,500 liters and 1 kg of chicken requires 2,300 liters. Conversely, although few studies have looked at precise amounts, insects require vastly less water and are able to withstand long periods of drought.

Requiring less space and fewer natural resources, the greenhouse print of the entire insect breeding system is significantly lower compared to normal livestock farms, as are the emissions of greenhouse gases and ammonia emitted directly by the insect itself (Table 3).

The data on greenhouse gas emissions from insects reflect a huge advantage in the fight against climate change, in fact it appears that for every kg of protein produced, the insect produces 2850 times less CO₂ than cattle and 1300 times less than pigs (Sogari, 2015).

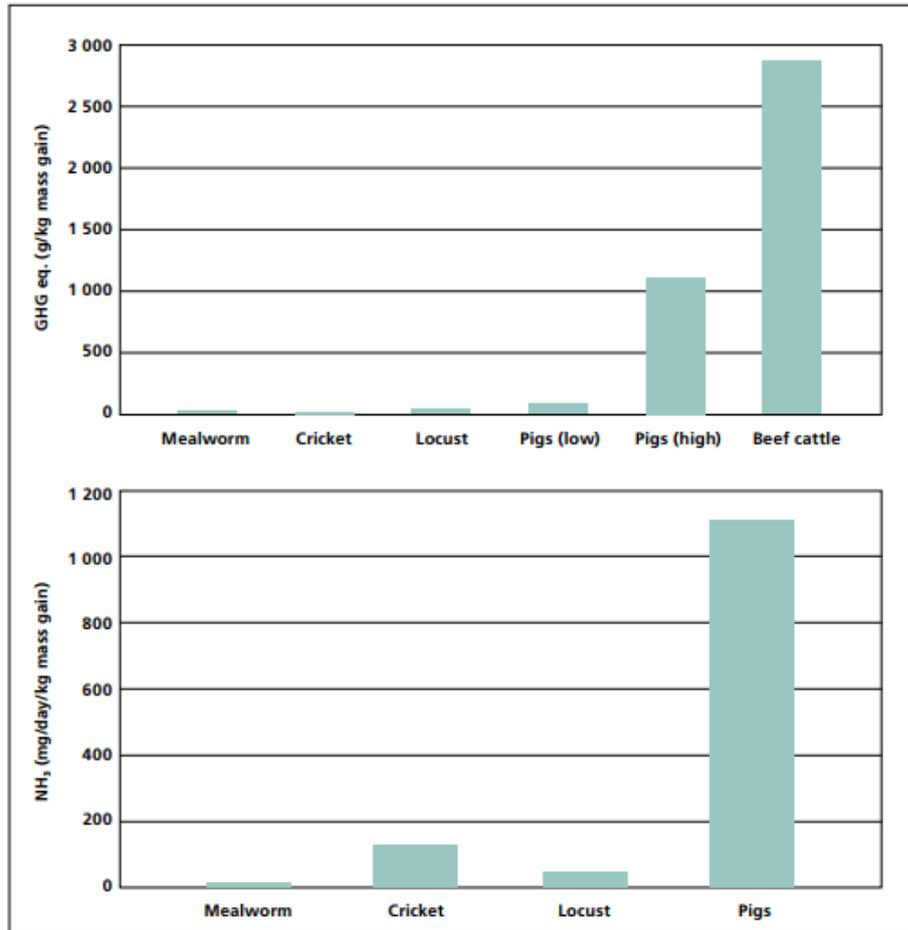
Having a significantly high reproduction rate and a relatively short life cycle, insects represent a large-scale reproducible protein source with the ability to rely on periodic replenishment. Being a low-tech and low-capital investment, the breeding of insects guarantees subsistence to the poor sectors of many populations, where the lack of macro and micronutrients is an important cause of mortality. In these cases, insects not only represent a source of food subsistence, but develop an economy based on home breeding or harvested directly from the wild, offering sustenance opportunities for both urban and rural population (Moore, 2018).

The various advantages listed above underline how insects can be used as a real solution to the growing problems related to overpopulation, scarcity of resources and the worsening of climate change. Taking these values into account, the United Nations has identified insects as

a tool to directly address the first three sustainable development goals (no poverty, zero hunger and good health and well-being) (Imathiu, 2020).

Table 3 – Production of GHGs and ammonia per kg of mass gain for three insect species, pigs and beef cattle.

Source: FAO 2013.



THE INSECT MARKET

The growing demand for insects as a protein source has recently led to the growth of the mass farming sector at the expense of harvesting directly from the wild (Imathiu, 2020). The insect production market is constantly growing and it is estimated that there will be a 20% increase in the next five years (IPIFF, 2019).

According to market research, the value of the edible insects market is expected to grow at a CAGR (compound annual growth rate) of 26.5% from 2020 to 2027 to reach \$ 4.63 billion by 2027.

This major growth is spurred by the urgency of the current challenges that scientists are interfacing with. Now recognized as a missing link, insects and their affiliated market are riding the wave of the economy thanks to key factors such as: increasing greenhouse gas emissions from livestock and poultry industries, high nutritional value of insects, low environmental impact of their entire life cycle and low risk of transmission of zoonotic diseases (Meticulous Research, 2020).

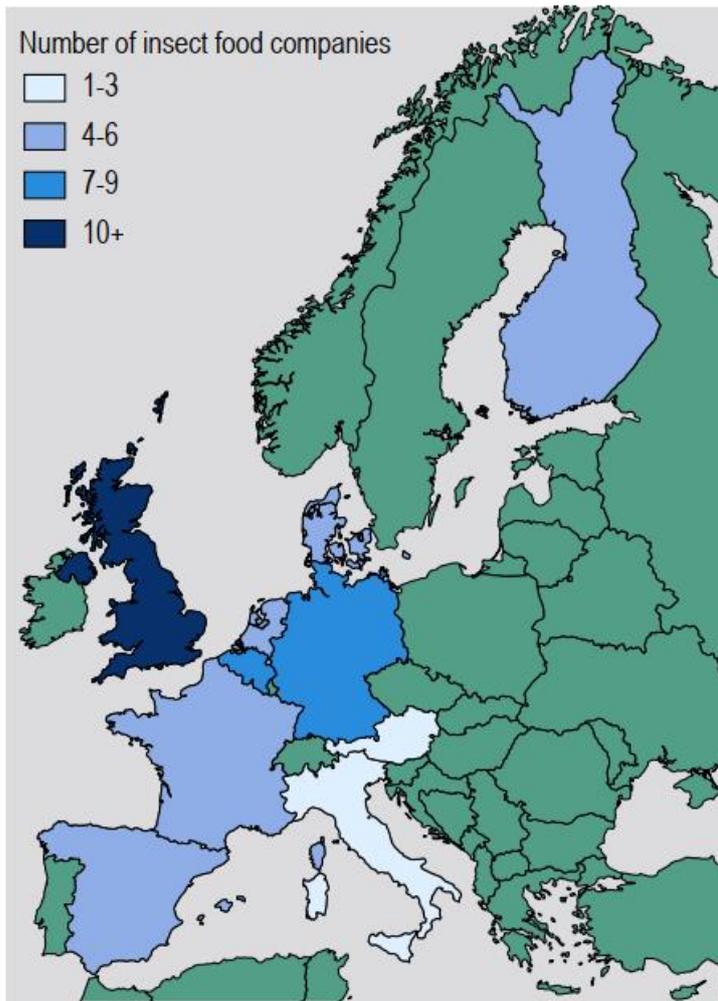
According to an internal survey by the IPIFF (International Platform of Insects for Food and feed), the European growth in insect production is closely correlated with the entry into force of the new regulations of the European Parliament on the subject. In fact, following the EU authorization for the use of insect proteins in aquaculture farms, more than 5,000 tons of insects have been marketed since July 2017. Considering the impending constructive changes in the legislative landscape that controls the marketing and use of insects in different sectors, the market will reach very significant volumes in the coming years, with a realistic estimate of 3 million tons produced by 2030, of which about 10% produced for food applications (IPIFF, 2020b).

The trade channels for edible insects vary by country. In Asian and African countries, there are different sales channels, divided into direct channels (suppliers who sell insects directly to consumers), and indirect short channels (consisting of retailers who buy insects from producers and sell them in local markets and restaurants). However, these commercial channels are mainly based on short supply chains that generate small-scale distribution channels, which however involve both rural markets and activities and urban activities. A

recent trend is the development, especially in urban areas, of supermarkets and convenience stores offering processed insects ready for consumption, restaurants and street vendors.

As for the European Union, the exchange channels are not so uniform, as regulation depends not only on the EU framework, but also on the national laws of the individual countries (Pippinato et al., 2020).

In the European panorama, the core business, especially related to food, is developed in the



countries of northern Europe, with the United Kingdom, Germany and Belgium showing the largest number of activities (Figure 1), followed by the Netherlands, France, Finland and Denmark (Pippinato et al., 2020).

This sectorial geographical development is partly due to a predisposition of Nordic consumers towards these products, but especially thanks to different national legislative regimes that involve safety controls and trade regulations that liberalize the sale of insect-based foods (Pippinato et al., 2020).

Figure 1 - Spatial distribution of insect food companies in EU.

Source: Pippinato et al., 2020.

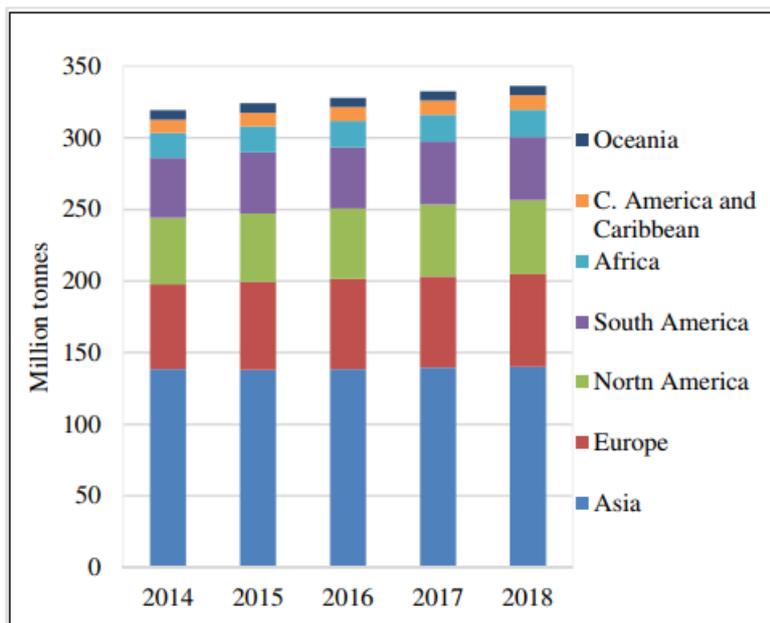
INSECT FOR FEED

In recent years, the demand for animal proteins has increased significantly as a result of the increase in the world population, urbanization and changes in eating habits due to greater availability of food. This growth is recorded globally, with a higher percentage, however, in developing countries, where meat consumption will quadruple thanks to the accessibility to it by new groups of populations (Oecd-fao Agricultural, 2019).

In 2010, world feed production was estimated to be 720 million tons (Halloran & Vantomme, 2012) and then climbed to 870 million tons in 2011, generating revenue of approximately \$ 350 billion (Moore, 2018). From the study of the "2019 Alltech Global Feed Survey" it emerged that world feed production has grown to 1.1 billion tons in 2018, setting a new record (Alltech, 2019). The constant increase in feed production reflects the increase in demand and production of meat. According to FAO data, in fact, world meat production in 2018 corresponds to 336.4 million tons, an increase of 1.2% compared to 2017 (FAO - Food and Agriculture Organization, 2019) (Table 4).

Table 4 - World total meat production by region.

Source: FAO 2019.



Considering this trend, by 2050 the production of meat (beef, pork and poultry) will double compared to current production, posing important challenges for the feed sector, which is called upon to produce safe, protein-rich and, at the same time, sustainable feed. The challenge, in addition to being linked to the quality and safety of feed production, is linked to the increasingly marked competition of resources for human production of food and fuel (IPIFF, 2019).

To date, a high share of animal feed is imported into the EU and considering their impact on the economy and the environment, the use of protein derived from insects could mitigate the problems that the feed sector will have to face.

In the document "The Contribution of Insects to Food Security, Livelihoods and the Environment", FAO highlighted the potential of the use of insects as a new protein source in feed for farm animals (Halloran & Vantomme, 2012).

In light of the challenges and rising feed prices, numerous insect species could play a key role in supplementing or partially replacing plant meal in animal feed. Among them, many have proved so powerful and are already in production, most notably *Hermetia illucens*, *Tenebrio molitor* and *Musca domestica* (IPIFF, 2020a).

Thanks to the reduced need for water and space, thanks to the considerable reduction in the production of greenhouse gases and pollutants, and thanks to their high conversion coefficient that makes it possible to breed them on organic waste, insects are considered an ideal raw material to integrate traditional sources such as corn, soy, wheat and fishmeal.

In addition, with the European production of 3 million tons of insect protein foreseen by the IPIFF for 2030, fewer imports of feed materials would be required, and the need for agricultural land outside the EU would be minimized, saving an area the size of Belgium (IPIFF, 2020b).

According to a 2018 study, a diet based on fermented insects not only equals the nutritional value of plant proteins commonly used in feed, but significantly decreases the presence of certain bacteria (*E.coli* and *Salmonella* spp) in the tract of the cecum allowing a substantial reduction in the use of antibiotics in chickens. The same study also verified that the presence of chitin in the diet of farmed fish improves the performance and health of the animal thanks to an improvement and development of probiotic bacteria in the intestinal microbiota (IPIFF, 2020a).

Within the currently applicable European framework, insects are included among feed materials pursuant to Reg. 68/2013 / E U. Part C of the Annex includes, in fact, among the raw materials "*Terrestrial invertebrates, or parts of them, in all stages of life, other than species pathogenic for humans or animals; treated or untreated, e.g. Fresh, frozen, dried*" (Figure 2).

L 29/48 EN Official Journal of the European Union 30.1.2013

Number	Name	Description	Compulsory declarations
9.15.5	Egg shells, dried	Product obtained from poultry eggs, after the content (yolk and albumen) has been removed. Shells are dried.	Crude ash
9.16.1	Terrestrial invertebrates (?)	Whole or parts of terrestrial invertebrates, in all their life stages, other than species pathogenic to humans and animals; with or without treatment such as fresh, frozen, dried.	
9.17.1	Chondroitin sulphate	Product obtained by extraction from tendons, bones and other animal tissues containing cartilage and soft connective tissues.	Sodium

Figure 2 - Part C of the Annex to Reg. 68/2013 / EU.

According to the same regulation, the insects that can be used as raw material for the production of feed must not belong to pathogenic species for humans, animals and plants and which also respect the microbiological criteria and the limits of contaminants and undesirable substances provided for by the Community legislation for the materials. feed raw materials.

The art. 7 of Reg. 999/2001 / EC containing provisions for the prevention, control and eradication of some transmissible spongiform encephalopathies, regulates instead the processed animal proteins (PAT) deriving from insects, whose administration is currently only allowed to animals from company, to animals other than farm animals and fur animals (so-called Feedban). The exclusion of PAT has the aim of avoiding the possible spread of prions due to bovine spongiform encephalopathy (BSE).

An exception to the feedban was, however, introduced in May 2017 by the Reg. 2017/893 / EU of the European Commission. Indeed, this law has the purpose of modifying Annexes I and IV of Regulation (EC) no. 999/2001 of the European Parliament and of the Council and annexes X, XIV and XV of Regulation (EU) no. 142/2011 of the Commission on the provisions on animal proteins and in order to allow the use of processed animal proteins deriving from insects for feeding aquaculture animals.

The regulation first introduces the concept of farmed insects. These are the insect species identified in Annex II, which can be used for the production of PAP. The species included in the annex are the following:

- Moscow black soldier (*Hermetia illucens*);
- Tenebrone (*Alphitobius diaperinus*) and black miller (*Tenebrio molitor*);
- Cricket (*Gryllodes sigillatus*);
- Silent cricket (*Gryllus Assimilis*).

The inclusion of insects in the category of farmed animals implies that the raw materials used as substrate are subject to the same restrictions as farmed animals.

It follows that for feeding insects it is not possible to use:

- prohibited materials contained in Annex III of Reg. 767/2009 / EC and, among others, faeces, urine, contents of the digestive tract, solid urban waste;
- kitchen and restaurant waste or former food without further processing, other than those indicated in Annex X, Chapter II, Part III section 10 of Reg. 142 / 2'011 / EC;
- PAP (except fishmeal) and products based on blood, gelatin, collagen derived from ruminants and hydrolyzed proteins derived from ruminants (except those derived from hides).

As regards, instead, the by-products of animal origin, only the materials of category 3 referred to in art. 10 of Reg. 1069/2011.

Animal proteins derived from insects and destined for aquaculture animals must be produced in processing plants recognized pursuant to art. 24 of Reg. 1069/2009 / EC on animal by-products dedicated exclusively to the production of products deriving from farmed insects. Furthermore, they must be produced in compliance with the requirements of Annex X, Chapter II, section I. of Reg. 142/2011 / EU and must belong to the species described above. The new regulation also includes specific provisions relating to the storage and transport of processed animal proteins derived from insects, which cannot be stored in containers and transported on vehicles used for the storage and transport of feed other than those intended for aquaculture. Finally, with regard to the labeling of PAPs deriving from insects and compound feeds containing them, it is expected that they are properly labeled in order to indicate the possibility of using them only for feeding aquaculture and fur animals. The law was welcomed by stakeholders, who underlined the need for further research to extend the use of PAP derived from insects to other non-ruminant animals (pigs and chickens). In fact, over the 90% of European insect producer see on poultry insect feed a promising opportunity (IPIFF, 2019).

In Italy, on 5 May 2017, the Ministry of Health published a note containing provisions on the breeding and use of insects for the production of feed. The note, in addition to reconstructing the regulatory framework currently applicable to the breeding and use of insects

in feed and the innovations introduced by the legislation described above, provides interesting clarifications on the use of live and treated foods.

In particular, the note clarifies how the use of live insects is authorized for the feeding of pets or animals not reared for the production of food, such as ornamental, fur, zoo or laboratory food or for other uses. from food (technical uses).

As for the treated insects, other than PAP (e.g. dried insects), their use must be considered admissible for feeding the animal intended for technical uses. Although the treatment must in any case be subject to authorization by the competent authority which guarantees the absence of unacceptable risks for public and animal health.

The note also specifies that operators who breed insects are operators in the feed sector, which fall under the registration obligation pursuant to art. 9 of Regulation 1831/2003 / EC for the activities referred to in art. 5 paragraph 1:

- a) transport, storage and handling of primary products at the place of production;
- b) transport operations for the delivery of primary products from the place of production to an establishment;
- c) mixing of feed for the exclusive needs of the company, without the use of additives or premixes of additives with the exception of additives for silage).

Finally, the note reiterates that pending the issue of the new European provisions, the use of insects in feed must comply with the constraints described above.

The numerous benefits associated with the use of insects prompted the European Commission to ask EFSA to analyze the legal microbiological, chemical and environmental risks for the production and consumption of insects as food and feed. In the document "Risk profile related to the production and consumption of insects as food and feed", EFSA highlighted that the possible presence of biological and chemical hazards in food and feed derived from insects depends on the production method. In fact, the substrate used for their breeding, the phase of the life cycle in which the insects are collected, the species of insects, as well as the methods used for their subsequent transformation must be taken into consideration.

EFSA therefore concluded that when unprocessed insects are fed currently authorized feed substances, the potential for microbiological risks to arise is predictably similar to that associated with other unprocessed protein sources. Regarding the risks related to the presence of prions, a cause of bovine spongiform encephalopathy (BSE) in cattle and Creutzfeldt-Jakob disease in humans, EFSA found that the risks are similar to those related to currently authorized animal protein sources. and the risk associated with unprocessed animal protein

sources insects appear to be the same or less, provided the substrate on which the insects are fed does not contain human or ruminant manure (Finke et al., 2015).

INSECT FOR FOOD

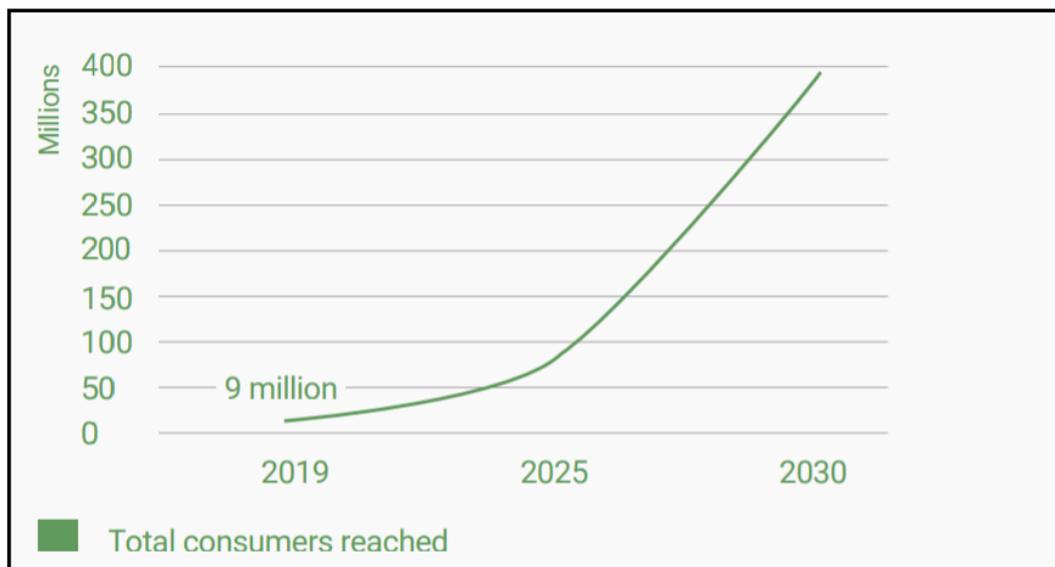
Around 500 tons of insect-based foods were produced in 2019 and these "niche markets" (today) are expected to grow rapidly in the coming years (IPIFF, 2020b).

The use of insects and their derivatives in the human diet is known to be a sustainable and nutritious supplement. In addition, a growing awareness of the population, spurred on by dissemination and training campaigns, is modifying current consumption trends and changing attitudes towards food. This food education is increasing the number of consumers willing to eat insects, registering around 9 million Europeans as consumers of insects and their derived products in 2019.

This segment of the population was mainly reached through the marketing channels currently used mainly by the company website or conferences on trade shows / events. Continuing with these strategies and thanks to the spread of this practice, it is expected that by 2030 a total of 390 million consumers will be reached (Table 5). The increase in consumption is determined by several factors, in particular the planned authorization of insects as a novel

Table 5 - Forecast of consumers reached in Europe.

Source: International Platform of Insects for Food and Feed, 2020.



food, the diversity of products on the market, the availability of the product (e.g. availability in retail outlets) and acceptance by of consumers.

In Table 1 we can see the density of activities that treat insects for human consumption at European level. The total number of European companies involved in the production, processing or sale of insect-based food products corresponds to 59, with a higher concentration in the countries of northern Europe (especially England, Belgium and Germany) (Pippinato et al., 2020).

According to a study by Pippinato et al. on the type of sales channels of European commercial activities, these have been divided into "e-commerce sales" and "physical sales". These two categories can be further divided into different groups.

E-commerce:

"(1) e-commerce and processing, for which the company transforms the raw material itself and sells the finished product; (2) e-commerce and production, when the supply chain is complete and the company also produces the material first itself; and (3) e-commerce and reseller, if the business is only for the resale of third party products. "

The physical sale method, however, has been divided into:

"(1) farm and processing, if they produce and process the raw material directly; (2) restaurant and catering, where the activities concern only the final processing for the customer; and (3) shops, where the activities are dedicated only to sale."

Furthermore, another classification concerned the type of products on the market. As a result, the main categories are 4 and correspond to:

"(1) whole insect, where the product consists of the whole insect, still recognizable in its parts and cooked, dehydrated or frozen dried; (2) flour, in the case of flour or protein powders obtained by grinding the insects themselves; (3) protein bars, in the case of products mainly geared towards sports nutrition, consisting of variable percentages of insect meal, in order to increase the protein content; and (4) other, a category that includes all the different snack formats, protein pasta, meat or spirits not classifiable in the other categories " (Pippinato et al., 2020).

On 1 January 2018, came into force the new Regulation (EU) no. 2283 of 2015 which replaces Regulation (EC) no. 258/1997. This new law specifies and adds new categories of Novel food (a term referring to food products that do not have a history of human consumption in the region or country in question), including insects. In fact, in the new regulation we find the following written:

“However, given the scientific and technological developments that have taken place since 1997, the categories of foods that constitute novel foods should be reviewed, clarified and updated. Such categories should include whole insects and their parts. ”

EFSA, after carrying out in-depth studies on the possible risks associated with a diet based on edible insects, has disclosed its positive opinion on the introduction of this new food in the European diet. However, there is still no Community legislation that protects this food and this creates confusion between producers and consumers. In fact, the legislation currently in force does not prohibit the use of insects as food, nor does it provide for specific legislation that can establish the rules and fundamental principles of safety and nutrition.

Furthermore, Regulation (EU) no. 2283 collides with the EC Regulation 178/2002, which establishes the general principles and requirements of food law, excluding any type of insect from the concept of "food".

Despite these premises, food or dishes containing insects have already arrived in Europe. Many restaurants have already tried to experiment with dishes with insects as the main ingredients and some nations have already moved about it, in fact Holland, Belgium, France and England are the most tolerant states that have already allowed the use of some insects for edible use.

In Italy, on 9/10/2013 the ministry of health issued a circular on the official control of the use of insects in the food sector. This directive prohibits the marketing and use of insects or their derivatives for food purposes, until a specific authorization is issued at EU level in application of Regulation (EU) 2015/2283 (Ministero della Salute, 2008).

BARRIERS

Although the number of consumers who support a diet that involves the use of insects and insect-based products is increasing, it is necessary to identify and analyze all the barriers that are slowing down this process. This is necessary in order to establish and organize targeted strategies that are able to improve and protect the sector and the consumers themselves.

To date, in fact, the edible insects market still encounters significant barriers: first of all, poor acceptability by consumers, fear of failure to comply with hygiene standards that ensure the safety of the food thus produced, absence of laws or regulations that ensure proper functioning of the entire food chain.

the consumption of insects by humans is still uncommon in the West, where for the majority of the population it is considered a culturally inappropriate practice (Van Huis, 2013).

According to scientific studies, a good part of consumers commonly consider insects as pests and carriers of diseases, reacting with disgust at the idea of integrating them into their diet (Tan et al., 2015).

This aversion, however, reflects a barrier linked to cultural traditions, in fact a greater familiarity with insects is instead found in oriental cultures and in those developing countries, where different species of insects are considered traditional specialties, costing more than meat (Van Huis, 2013).

It has been proven that the willingness to accept or appreciate a food can increase, remain stable or decrease with the sole exposure to it, in fact, although many psychological and biological factors regulate food preferences and "aversions", the appreciation of food is mainly acquired through experience (Tan et al., 2015).

Another aspect with significant weight on the low predisposition towards edible insects is given by the lack of information on how they are produced, prepared and on the level of safety (Tan et al., 2015).

The refusal that some people express towards new or unfamiliar foods can be defined by their negative sensory properties (refusals based on "disgust"); if they are believed or known to promote harmful consequences, both in the short and long term ("hazard" based waste); or

for their ideational dimension based on nature or origin (waste based on “disgust”). This response to "the new" is called neophobia (Balzan et al., 2016).

Food neophobia has negative impacts on purchase intentions, attitudes towards new foods and willingness to try, making it the most important factor in determining consumers' willingness to adopt insects as a food source.

Disgust can be a sensation generated as a preventive impulse, that is, before the food is actually tasted, sometimes due to the very nature of the food, its origin and its history. This is because the consumer, as mentioned above, refers to its traditions and culture which identifies the insect far from the traditional concept of food.

in some cases, however, knowing the nature or origin of the substance can also play a role in the acceptance of food as well as knowing the benefits it can bring to health. On the contrary it has been shown by Tan et al. that sometimes the consumer is inclined to accept the consumption of insects when masked in combination with other ingredients (e.g. insects covered with chocolate) or completely unrecognizable after a processing process (e.g. insect meal).

To eliminate the propensity for neophobia and incite neophilia, that is the general human inclination to enjoy a wide range of new and unfamiliar foods, we need to focus on culinary innovation, marketing, education and public policies. In fact, cultural exposure and integration can act as a primary factor in influencing the acceptance of the consumer's food choice. This concept is also highlighted in van Huis's article, which points out that food preferences are not stable and can change over time and the initial disgust with respect to a certain food can be turned into a preference, such as what happened with sushi in the western world.

Another barrier that blocks the development of the entomophagy sector and the commercialization of insects is the lack of clear legislation that protects the market and consumers. In fact, despite the introduction of regulation (EU) no. 2283 of 2015 on the subject of novel food, where insects and insect-based foods are introduced, to date entomophagy and the insect trade cannot be practiced in most European countries. This is likely due to the stringent requirements of a novel food authorization application, supported by substantial scientific research data supporting the safety of the novel food, which may take time to collect and provide evidence to EFSA (Imathiu, 2020). In Italy, no insect-based food is currently officially recognized, while in Europe the first country to include insects in the list of possible foods was Belgium in December 2013, followed immediately after by Holland.

The non-authorization of these products is not only determined by the lack of a doc regulation that protects the sector at European level, but is also caused by the possible health

risks that the marketing of insects entails. Although many studies claim that insects are a safe food source, in the absence of a law that regulates and standardizes procedures for proper breeding, handling, transport and labeling, these risks cannot be underestimated.

The potential dangers associated with edible insects are varied. The lack of legislation and controls on the use of feeding substrates for insects can lead to the accumulation of heavy metals, pesticides and other harmful chemicals that would be transmitted to humans through their consumption. Incorrect management and treatment of farms and insects can lead to the development of mycotoxins, pathogenic microorganisms, parasites and anti-nutrients that are harmful to human health. And finally, another risk related to consumption not regulated by laws is that related to allergens, which even in the case of other foods, can lead to dangerous reactions and consequences in susceptible individuals.

The still unclear legislative landscape causes a lack of standardization of commercial activities and production and processing methods that involve the entire production chain. This lack of protection not only causes difficulties in the management of the company, forced to adapt to incomplete and constantly changing regulations, but also leads to a slowdown in the development and innovation processes, considered a fundamental key to increasing acceptance among consumers.

As van Huis points out, this legislative barrier can only be overcome if the political and research agendas of governments, ministries of agriculture and related bodies begin to recognize the role of the use of insects for human and animal nutrition. The role that the food industry plays in directing society towards new values, such as sustainability and the conscious choice of food, is also relevant.

FUTURE DEVELOPMENT NEED

According to the FAO document “The contribution of insects to food security, livelihoods and the environment”, for an optimal development of the sector of insects used in food and feed it is necessary to deepen some fundamental points. The deepening consists in the study of methodologies and innovations capable of advancing this sector undermined by factors that hinder its development. This is necessary not only to allow the spread of a practice of the human being since the dawn of time, but also to be able to introduce into society a tool capable of changing eating habits that are no longer sustainable today, guaranteeing the possibility of a greener future. Research will have to focus on several aspects, primarily on the safety of both food and feed, but also on consumer perception and acceptance, on the legislative landscape and on the development and technological automation of livestock farming.

With regard to the safety of the use of insects in food and feed, the studies must aim at creating a clear framework that includes detailed information on allergens, risks related to the presence of substances harmful to health (toxins, pathogens, heavy metals, substances chemicals) and nutritional values relating to the different species with a description of the possible benefits related to animal and human health.

As mentioned above, one of the barriers to be faced that hinders development the most is consumer acceptance of this novel food. To do this, several strategies have been identified that can support this effort.

The fundamental key is to educate the population, mainly by explaining the benefits on health and the environment, but also by sensitizing the consumer about the cultures and populations that already practice entomology. Also developing new ways to integrate insects into diets through the creation of insect-based products and database of recipes and possible applications, was also evaluated as an effective way to interact and capture the attention of the consumer.

Particular effort will then have to be made in drafting a body of laws that is able to satisfy all the requisites necessary to protect this new sector which has not yet been fully explored by law.

The first necessary step is the creation of a complete Codex Alimentarius that includes all aspects of the production, processing and use of insects in food and feed. Once a solid starting point has been defined, it will be possible to improve the risk assessment methodologies related to mass farming and collection in nature and to guarantee a fertile soil for new innovations and applications of insects in the most diverse sectors.

Finally, but not least, we find the need to deepen research on the technical aspects related to breeding. An efficient mass farming system is only possible if progress is made in mechanization, automation and processing and logistics to reduce production costs. These innovations will allow to standardize the product, guaranteeing a safe, controllable feed and food with a stable supply, increasing production capacity in Europe. By increasing the scale of production, insect farmers will be able to increase the price competitiveness and stability of their products compared to other sources of protein, allowing them to reach all consumers. An affordable price, in fact, is essential if the aim is to involve the population and eradicate the prejudice associated with insect-based nutrition.

According to the FAO, innovation must also involve 2 factors: storage and treatment methods capable of increasing and controlling the shelf life of the product; scientific research aimed at improving and maintaining the genetic diversity of farmed insects, to avoid colony collapse and improve their characteristics (Halloran & Vantomme, 2012).

MATERIAL AND METHODS

In this research we went to interrogate the players in the entomology sector to determine what their common opinion of the sector and the market is. This is to define a standard profile that can represent the typical Italian company analyzed within a "case study".

The development of an activity linked to entomology generally consists in specializing in one of the initial phases that characterizes the circular economy or sustainable production model. The characteristic phases can be divided into two macro-sectors: the breeding of insects and the processing for secondary products.

Insect breeding can be divided into: breeding as a tool for the disposal of organic waste and breeding for the production of raw materials (live, dried, pulverized insects) for use in the food, feed and biotechnology market.

Even the insect used for the purpose of disposing of organic waste can be used in the creation of food products, but in order to do this, the substrate used to feed the insects must follow strict and precise laws dictated by the regulations in force. The very selective laws and the difficulty in having high quality waste substrates, as required by the laws, cause the differentiation of these two parallel sectors. In fact, generally, the insects that are raised in these unselected or non-uniform substrates with the laws are destined for the extraction of biocomponents for biotechnological study.

The re-elaboration of the insect-based raw material can have multiple objectives. Mainly the market is divided into the production of flours and feed for farms and domestic animals and the production of food or additives intended for human consumption. There is also another constantly growing innovative market based on the use of insects and is the one of biotechnology and pharmaceuticals. The insect in this field is used for the creation of different products. Among these we find biofuels synthesized through the separation and reprocessing of the lipid fraction of the insect.

Many funds have been made available for the study of biopolymers generated from chitin, the material that makes up the exoskeleton and wings of most insects. And finally, some of the invertebrates under study were selected for the extraction of functional substances used by pharmaceutical companies.

Being still in its infancy, these innovative sectors stimulate continuous research for the improvement of methodologies and the final product. Furthermore, these applications represent a very promising bet for the biotechnology, food and environmental sectors.

Below we will define what a “case study” is, when to use it and how to apply it to our investigation. We will develop the research through the organization and analysis of data extrapolated from multiple survey methodologies.

The elaboration of the profile of the Italian entomological company will follow, illustrated in the results.

Finally, to conclude this document, conclusions will be drawn up to present a current overview of the protagonists of the research within the entomological sector.

What is a case study?

“Case study is not a methodological choice but a choice of what is to be studied. By whatever methods, we choose to study the case. We could study it analytically or holistically, entirely by repeated measures or hermeneutically, organically or culturally, and by mixed methods-but we concentrate, at least for the time being, on the case” (Stake, 1995).

A case study investigates a contemporary phenomenon (the "case") in depth in its context of the real world, especially when the boundaries between phenomenon and context may not be clearly evident. This uses an in-depth and extended example that is used to illustrate a particular topic, such as a particular process, program, event or activity to understand complex social phenomena.

Through the identification of the object of interest allows you to respond correctly to "how" and "why" specific phenomena are found in a given context. The objective is not to generalize the case under consideration, but to study it and accurately describe its characteristics and uniqueness within its specific social and economic context (Sinjab & Sinjab, 2014).

Case studies may integrate both quantitative and qualitative information and may do so from a variety of sources, but will tend to focus on qualitative information to provide an in-depth picture of the issue of interest.

Case studies may be used for a variety of purposes, including the definition of questions and assumptions of a subsequent study that presents a description of an event in its context or that establishes a cause and an effective relationship in that context.

Case studies are generally classified in three ways: exploratory, descriptive or explanatory. An exploratory case study defines the questions and hypotheses of a particular topic, providing the basis for further research or in preparation for a later study.

A descriptive case study, also called illustrative, aims to obtain a complete description of an event within its context, which means that the research report will be highly detailed emphasizing the contextual specificities of the particular case under consideration.

Finally, an explanatory case study investigates the particular results generated by a set of circumstances, establishing a relationship, analyzing and describing which causes produced what effect in relation to the present case.

There are four main steps for organize a case study project. First we have to design the study through the developing of the research questions, for define what we are searching and why. Second, based on the case analyzed, we use a variety of methods such as research interviews, surveys, questionnaires, document analysis or other research methods that are appropriate to their process, for collect data. Third, the data and information that have been collected are going to be analyze and compared, searching for detail characteristics, cause and effective links and possible hypothesis. Finally the case study report is built including findings, data and outline of the context, going to underline also the limitations and problems encountered throughout the study.

Why a case study?

The aim of this research is to illustrate the method called "case study" apply to the entomological sector. This means examining and combining a set of ways of doing research that share the goal of focusing the cognitive investigation on a "situation" that can represent a wider set of problems.

The “situation” of this case study consists in defining the Italian scenario of the entomological sector. In fact, this new growing market is characterized by various perplexities in several aspects that have caused a situation in which businesses find it difficult to establish themselves and develop.

As previously mentioned, scientific sources underline the problem of legislation that does not protect this sector, of poor acceptance by the Western population and low funding coverage. Within this not very stimulating overview, however, we find companies of different sizes that have established themselves, are developing or are embarking on the path of organization to open a business linked to the world of insects. At the European level, the distribution of entomological companies is concentrated especially in some member states (Belgium, France, Holland, and others). This uneven development is probably due to a different management of funding, less prohibitive legislation at the national level and a more liberal acceptance.

The question the research wants to answer are: How the main actors of the Italian entomological sector approach the feed and food market, what are their current uncertainties and future expectations? Moreover, particular importance will be dedicated to verifying and confirming the barriers and risks that a company is forced to face during its birth and development.

The results produced by the case study will define the profile of the typical Italian entrepreneur in order to be able to analyze the problems through a progressive investigation action that defines the historical, environmental and contextual circumstances. The aim is to reach conclusions that have no claim to definitiveness, becoming only a provisional "truth", accompanied by a narration of the facts recorded in an analytical way.

The case study

The descriptive case study we will use is defined as evaluative instrumental. In fact, with the following research we will focus our attention on the characteristic features of a given typical situation in order to confirm the ability of an already existing theoretical model to explain a certain phenomenon in a confirmatory perspective. It is also defined as evaluative because it has the purpose of submitting some information to key subjects to allow them to express evaluations on specific programs or policies.

The unit of analysis used is multiple, in fact two channels were used for data collection: literature and interview. The interview was applied to 5 actors of the Italian scenario belonging to 3 Italian entomological companies characterized by different outputs and visions. The

information collected directly from the interviewees have been used and analytically compared with the contents of the literature to outline the current market scenario in all its aspects.

The interview tool is used in social research in order to investigate a phenomenon by stimulating key interlocutors to express personal opinions, stories or events considered significant. This instrument with specificity, progression and thematic unity also has the advantage of proving to be extremely flexible.

The interview

The characteristic interview of qualitative research is a conversation with a purpose. The goal of this conversation methodology is to gather information about the subject and the environment related to him. The interview is an excellent tool to reach the perceptions and opinions of individuals, to understand the ways in which social situations are defined and to investigate the ways in which social actors build the reality that surrounds them.

The interview used in qualitative research has three main purposes: it can collect information about a certain context or social phenomenon, it can provide empirical data useful for the formulation of hypotheses that affirm or contextualize the case and finally the results obtained, through this technique, they can be used as a database for further research or interviews, even of a qualitative nature (*Gaskell, 2000*).

The interview used for this study is defined as "semi-structured" or "focused" and is divided into a series of questions provided for by the protocol of the case study, which the interviewer can ask without sequential constraints. The goal of this interview may be to confirm certain data that are thought to have already been verified, allowing a more systematic evaluation.

For the conduct of the interviews, permission was requested to use the recorder which allows an accurate analysis of the material, but which in any case did not replace listening by the researcher.

The 10 questions that made up the interview, listed in the appendix, were classified into 3 main groups: Company History, Barriers and Future Scenario. Each group has the goal of responding to the different aspects of the driving demand of the study.

The method

The companies that were interviewed characterize the supply chain. In fact, the first startup questioned called "Cc" aims to create food starting from protein flours purchased from third parties. The second reality "Mb" has as its objective a service for the disposal of organic waste from the agri-food sector, for the production of eco-sustainable and high quality feed. Finally, we interviewed "Ni", whose purpose is to breed insects to be destined for the re-processing market in different forms (live, dried or protein meal).

Below these 3 characteristic categories of the entomological sector will be analyzed and described in order to study the market and the reality of insect companies from different points of view.

Subsequently, the information extracted from the analysis of the individual companies will be used to determine the sector factors brought to light by the interview. Through careful cross-analysis of the data, we will then be able to draw the conclusions of this case study.

“Cc”

This company developed in Northern Italy consists of a Startup founded by three boys of the same age. The owners, Niccolò and Davide, were interviewed to introduce their future company, the objectives and other characteristics of their business.

Both formed from a scientific university environment, the two interviewees became passionate about the topic of the circular economy and sustainable production. During their journey and thanks to their passions, they became interested in the world of insects recognizing in these invertebrates a solution to the growing demand for proteins and the environmental problems with which we have to interface today. In fact, according to Niccolò, being able to be raised in very small areas and having very high yields, the insect represents the missing link for an efficient circulation economy.

Based in Italy, this business aims to develop a high-protein pasta made up of a percentage of *Tenebrio molitor* (mealworm) protein flours. The strategy with which they want to enter the market is to exploit the Italian culinary and food reputation to sponsor a traditional product that meets innovation and the food revolution. In addition, snacks based on dried whole insects

will also be available in the Cc catalog to capture the attention and curiosity of the youngest. While an item like mealworm pasta attracts a target very similar to that of organic products, therefore a clientele attentive to their diet and its impact, whole insects play on the fact of provoking a reaction of attraction and curiosity of the product "new "in the customer.

After an in-depth study of the sector, the owners of CC are convinced that in the next 10 years all the barriers they have encountered will be extinguished and the market will be ready for exponential development. In this period of time, Cc will be able to develop by expanding the range of products and establishing itself not only in the European market, but also in the Asian one.

The vision of this startup is to create a conscious and informed world on the subject of insects, their breeding and their use. As a personal goal, both Niccolò and Davide have declared that they want to found NGOs capable of deepening and spreading insect breeding techniques as a means of subsistence for populations in which food shortages and poverty represent a brake on social development.

“Mb”

The second company contacted was represented by two (Stefano and Mattia) of the three founders interviewed. Also in this case the area in which it has settled is Northern Italy, but the goal is not to produce food for human consumption. Their idea was born thanks to university and work experiences in biomedical and natural sciences. The passion for insects and their professional background have allowed the development of a project that sees insects as a solution to the disposal of organic waste. Living in an area with a high concentration of agri-food companies and livestock farms, they realized that entomology could solve two fundamental problems of local business: the economic and environmental impact of waste disposal and the high cost and impact of feed.

With this model they are able to exploit organic waste for sustainable production with a low environmental impact of feed.

By producing protein flours and fertilizers (derived from the activity of insects on the substrate) Mb turns its attention to a target represented by feed producers, breeders and horticultural companies.

Strongly believing in their project and in the development of the sector, the two interviewees are sure of their future success, or in any case of the success of their idea. The

high number of advantages will make this application a continuously growing business which, within 10 years, will lead the company to produce up to 10t of product per day, securing their position as market leader.

Looking beyond the business linked to their project, the company would like to conduct studies and research on the application of insects to the world of biotechnologies for the generation of biopolymers. And in addition to invest in the research of specific insect genetics to better optimize the production and waste disposal activities.

“Ni”

As the last interview another actor of the entomological sector of Central Italy was asked: José.

His company, founded in association with his brother and a friend, was born not from his studies, but from a family tradition. In fact, the parents, being poultry farmers, passed on to José and his brother the passion for animals and the secrets of the trade. The brothers looking for a solution for the high cost of floured feed came across an article about the use of insects in the Chinese tradition. Initially started as a search for information for personal interest, this project soon turned into a business idea.

Funded by various entities and projects, they have developed 2 parallel companies, one in Italy and one in Spain. The goal is the production of crickets in the form of live insects, dried whole insects and protein flours. After 4 years of research and experimentation for the development of effective breeding methods, they represent the most important company in Italy that produces crickets and proteins derived from them.

Aware of the potential of this activity, they aim to produce a protein flour that can be distinguished from those currently on the market thanks to its high purity and quality. Over the next 10 years, José thinks he can achieve the goal by, in addition, increasing production, personnel and becoming the largest cricket breeding company in southern Europe.

Ni's vision and ultimate goal is to incentivize the development of circular economies to reduce the environmental impact and to sensitize the population to eco-sustainable consumption and production.

Company history

From the interviews carried out it emerged that the interviewees are protagonists of the entomological sector because they find in this discipline a concrete resource capable of representing a solution to environmental and social problems linked to agri-food production. In fact, they claim that insects will represent the solution to the growing demand for proteins, a tool for the development of circular economies, the disposal of waste from the agri-food industry and an example of sustainable consumption.

Another motivation that pushed the interviewees to a first contact with the market was their background in university scientific studies and an already present passion for the world of insects, which allowed them to understand and analyze their potential clearly.

To investigate the choices and paths taken, the interviewees were asked why they decided to develop their business on Italian soil. Different responses to this question were recorded. In fact, one of the interviewees, whose product is a pasta based on insect protein flours, said that as a company headquarters, Italy is an excellent springboard thanks to the possibility of being able to exploit the worldwide fame that this state has in the food sector. However, the same interviewee also acknowledged that Italy still does not guarantee the basis for optimal development, in fact, due to too high production costs and lack of confidence in the nascent sector, they were forced to agree with German pasta factories. In fact, in Germany this market is more valued and the stakeholders are willing to develop collaboration strategies with entomological companies.

The second interviewee, on the other hand, having as objective the development of a circular economy system aimed at the disposal of organic waste of agricultural and organized distribution through the use of insects, recognizes Italy as a very fertile ground. In fact, based in Emilia Romagna and in particular in the heart of the Po Valley, this Start-up sees the potential reflected in another Italian sector, the agri-food sector. The high concentration of agricultural and agri-food companies in the plain produce very high amounts of organic waste, which from the interviewee's point of view, consist of untapped opportunities capable of being the fuel of a circular and sustainable economy.

Finally, José settled in central Italy for two main reasons, the family and the support of companies and institutions that believed in the project and invested. In Europe there are many states that have believed in the entomological sector and have adopted policies to allow its development. Italy, on the contrary, remained at a “larval stage” which slowed down this development. With the imminent change in legislation at European level, José sees a possible

advantage in developing his business in Italy. Considering himself an Italian pioneer, he can make the most of a future boom in the market, especially the Italian one, being ready to ride the wave of success.

Barriers

Particular attention was given to the questions that explored the scenario of barriers affecting the business. Mainly, the barriers have been divided into 2 categories: the barriers encountered during the organization and before entering the market and those encountered during the development of the business.

The limitations highlighted by the interviewees coincide with each other. During the organization of the company, the barriers encountered by entrepreneurs are mainly related to legislation, the market, information on the sector and the social aspect.

As for the legislative landscape, the answers provided by the entrepreneurs met expectations. In fact, with a still unclear and specific system of laws on the subject, companies are forced to adapt to the continuous changes that can give rise to administrative and production problems. However, the opinion is also shared that in the very near future this barrier will be overcome, thanks to a revision of the laws that regulate the livestock sector at European level.

In response to unclear legislation, the entomology sector market is also showing problems, according to respondents. This in fact, both from the point of view of customers and from the point of view of stakeholders, shows imbalances. The high cost of production, caused in turn by a lack of standardization, forces manufacturers to charge high prices and thus limit their customers to a niche market. This is the experience of Cc who, producing a variant of pasta with insect protein content at a much higher price (4-5 € per 500g) than the classic product, was forced to add cheaper products (using locusts as a snack) in order to reach the most diverse targets of the population. Another difficulty highlighted by the second interviewee from Mb, is linked to the world of feed, in which he would like to specialize. Large-scale distribution, in fact, is willing to accept the entry of a producer only if this has high credibility, but with the general problems related to the world of insects, which do not guarantee stability and homogeneity in production, this request is often difficult to prove.

The lack of data on the market introduces another obstacle, that of information. In fact, the interviewees complain of a lack of information both on the characteristics of the insects themselves and on the standardization of farming and production methods. This lack of information forces companies that want to approach the market to have to perform various tests and experiments before they can find a satisfactory and adequate methodology for production. This can cause the project to die prematurely due to lack of funds to run trials or due to failure to discover the right methodology. The testimony of this can be found in the dozens of Italian companies that have failed to establish themselves in the Italian professional reality by failing. Another question asked was to know what was the level of collaboration and sharing of information by existing and already developed companies and what was the availability of free information on the web. The answers showed that the information available on the Internet is linked to scientific articles, illustrative videos of companies already in the sector and information from experts and hobbyists. The scientific articles were helpful and used as a starting point for all respondents, even if they did not provide any information on business development. While videos and information from social media and other companies' sites were too evasive or inaccurate, they were still considered a constructive resource. Some of the protagonists of the interview also added that university consultancy was considered useful, especially those specialized in this sector such as Milan, Turin and Wageningen.

As regards the exchange of information between the already existing realities of the sector, various opinions were recorded. According to Cc, the willingness to publish the results of internal research and development methodologies is not characteristic of all companies. In some cases the discoveries are jealously guarded, both for fear of possible competition, and for the hard work and resources spent on research. Companies that have failed, from the other side, are no longer within the market and are willing to pass information on to new entrepreneurs.

Stefano, founder of Mb, has had more than one exchange of information with entomological companies already active, both in Italy and in Europe. From his experience he has defined European companies as very available, without discriminating against Italian companies. Despite having found good partners in Italy, he emphasizes the presence of exceptions linked to a mental closure to the idea of making groups and mentalities more difficult to take root on, which tend to be scared by new technologies rather than intrigued by them.

José finally acknowledges the exceptions presented by Stefano and states that the only way to accelerate the development of the sector is to lobby, since the nascent sector is large enough to guarantee the success of all the companies concerned.

The lack of information also causes two other effects that should not be underestimated. Firstly, some stakeholders such as retailers tend to lose faith in insect-based products as they fail to estimate when the industry boom will happen. Secondly, the lack of awareness on the subject foments one of the main obstacles linked to insects, namely the lack of acceptance and the sense of disgust that part of the world population feels towards these invertebrates.

According to Mattia and Stefano, social barriers, linked to the refusal of the insect as food for humans and / or animals, represent one of the primary barriers. People are unwilling to change their eating habits, especially when it comes to the introduction of insects. This mentality is also reflected in animal nutrition, especially that relating to domestic quadrupeds. CC, on the other hand, while acknowledging the presence and importance of this problem, showed a more optimistic view. Having organized awareness events where he proposed the tasting of his product, he explained that there is a growing awareness among the population and that the slice of consumers who already accept insects is sufficient to be able to support the market.

However, respondents agree that this barrier is more marked in Mediterranean countries with a strong culinary tradition than in northern European countries where insects are already a reality of restaurants and supermarkets.

In this study, the analysis of the barriers that can slow down or prevent the development of a company already in the sector are not based on the entrepreneurial experience of all the interviewees. Only Ni has been a company in the sector for several years, while in the other cases they are startup owners about to enter the market. The data is therefore based on Ni's personal-professional experience and the opinion of the other two companies. Although Cc and Mb are taking their first steps, they are aware of the problems they will have to face and are determined to prepare in advance to be more efficient in managing the company.

According to their answers, an already productive company that has overcome the first difficulties has to pay attention only to two timeless barriers, the laws and the market. Obviously these two problems are closely related to each other. The uncertainty of the legislative landscape causes market instability and these two factors force companies to work dynamically, but not always effectively. The difficulties generated by these aspects can cause a loss of confidence in and of the market which can lead to a crisis that could be fatal for the company.

Another obstacle that can be encountered is the competition for entry into large organized distribution. The difficulty in affirming one's brand and the presence of a few leaders who dominate the sector makes life difficult for new companies. These are easily overridden by the difference in production costs and reduced popularity.

Future scenario

The last set of questions was intended to explore the perception of the future of the sector and of the company itself.

Certainly all the interviewees hope for a bright future for their businesses, in fact they claim that in the next 10 years they will be able to make ends meet and become leading companies in the Italian sector and able to develop millions in turnover. It is common belief the fact that by 2030 all the barriers and difficulties related to the uncertainty of the sector will be leveled and that there will no longer be limits that hold back the market. With this in mind, they predict that insects will be available to everyone and at a low price and that even the production of feed will be re-evaluated and enhanced. Mattia from Mb, however, proved skeptical about social barriers. Although the acceptance of insects will improve thanks to the gradual advertising and introduction of insects into daily life, it estimates that the practice of entomophagy will require a longer timeframe corresponding to 30 years from today to be fully incorporated into culinary traditions. This point of view differs from that of Niccolò and Davide who, working in the food sector, does not believe that such an extended period of time is necessary and indeed manages to glimpse even today a constant growth in acceptance and a reduction in the sense of disgust .

Subsequently, as a last question, the interviewees were asked how they would like to develop their business in a probable future scenario in which the laws protect companies and in which there are no barriers of any kind. In the first case, the pasta producer has shown an interest in founding a non-governmental organization or OGN with the aim of developing farming techniques aimed at the establishment of circular economies adaptable to third world countries to guarantee sources of subsistence where entomophagy is already a reality. Furthermore, he would also be interested in founding an information body to raise awareness of sustainable consumption and environmental protection. Similarly, Josè also shares the idea

of developing totally circular and sustainable economies on which to base the production of energy and food for the future.

The second manufacturer, on the other hand, aims more at expanding its horizons through research and development of new businesses. In fact, initially proposing itself as a company for the sustainable disposal of organic waste and for the production of animal feed, it has as its final objective a bioengineering project. This plan consists in the study and production of organic polymers derived from the extraction of chitin, the main constituent of most insects. Although he believes that the development of this project is for the near future, he is currently gathering useful information and thanks to this, he believes that this practice will represent the future and the revolution of natural materials.

RESULTS

The scenario that emerged from the points of view and experiences of the players in the sector, allowed us to explore the typical profile of an Italian entomological company. Our typical entrepreneur is an individual related to certain themes and training. Only those who are truly aware of the potential of insects, thanks to university or work training courses, are able to invest in a business idea. This is not an opportunity for entrepreneurs eager for an easy income. The production of insects requires a lot of study, experimentation and innovation for the discovery and development of new methodologies. From the experiences described above, it is clear that no one enters the market before having spent years studying the right strategy. The soil still not very fertile, from several points of view, makes the bottom slippery and dangerous for the companies that decide to take this path. In fact, the entrepreneur is generally driven by his passion for insects or by the need to find a solution to the current lack of efficient circular economies.

The first barrier it encounters is linked to economic availability. For the experimentation and study of methodologies, the entrepreneur needs non-repayable loans that are not always easy to find. Despite this, the echo of this new sector manages to attract some sponsors. These, interested both in joining a new and promising sector in its birth and attracted by the notoriety in vogue linked to the eco-sustainability of projects, are the typical investors of our company.

Once the funds have been found for the organization of the activity, the entrepreneur, taking into account the legislative limitations and market demands, must define his production objective. By selecting the right insect to use, the right production methods and the right product to attack the market, he is ready to start his business.

At this point, the lack of information, forces the new company / startup to undertake a period of experimentation to develop an effective methodology.

The legislative barriers, even though being considered a brake on the development of the company, do not worry the typical owner who is aware of the future improvement of the situation. In fact, despite the prohibitions that prevent the application of entomology in some fields, the entrepreneur, in anticipation of the modification of these regulations, prepares by experimenting and testing future innovative applications.

The public opinion of the population still skeptical or frightened by the idea of a diet based on insects is a tangible barrier for our typical company. Of course it is a more bitter reality for the production of food, but its influence is also perceived in animal feed. Nonetheless, the entrepreneur who has explored the subject is also aware that traditions are not impossible to change with the right communication and with the necessary time. Especially with organizations known worldwide, such as FAO, EFSA and others, as promoters of this revolution and with the awareness that billions of people today feed on insects from the origin of evolution, the scenario of a powered Europe to insects it is neither impossible nor too far in time.

In conclusion, our company represents the model of Italian food innovation. The innovation is not limited only to the introduction of insects into the everyday diet, but is aimed at highlighting the environmental and social benefit that derives from it.

The final corporate goal is to expand its production horizon, involve more entities and associations and devote attention to innovative projects to discover new applications of insects.

CONCLUSIONS

The present study has represented a first attempt to investigate and analyze, through a systematization of literature and an empirical analysis of the testimonies of the actors in the sector, the Italian situation of the insect-as-food-and-feed sector.

Much remains to be done and many issues should be resolved, but more factors point out that insect-based practice will soon be part of our reality. This is suggested by the nutritional and environmental benefits, the commitment of the authorities to develop new laws and strategies organized by institutions and companies to increase acceptance among consumers.

Although for many this may continue to be a bizarre novelty and does not accept, in time it will become part of our traditions, eliminating any doubt of their vital function in society.

Despite the initial problems, the companies that are facing today's barriers will succeed in establishing themselves, paving the way for new businesses and innovations that can reintroduce this centuries-old tradition in daily life. Thanks to their efforts and their voice, it will be possible to identify obstacles and find out where the existing framework needs to be improved in order to begin a new era. The era of insects, where these little animals will represent the fibers of modern society.

ANNEX 1

INTERVIEW QUESTIONS

1. Why did you decide to operate in the entomology sector?
2. Why did you start your company in Italy?
3. For the opening and development of the company, did you turn to industry experts or did you rely on available sources / guides / articles or experience and personal knowledge?
4. What are the relationships with other companies at the level of supply chain collaboration and information exchange?
5. What is the final product of your company?
6. What is your target and what sector does your business fall into?
7. What were the barriers and difficulties you encountered initially? How were they dealt with?
8. What are the current barriers and difficulties that hinder the development of the company?
9. What are your future expectations and how do you see yourself in 10 years?
10. Imagining a scenario where there are no barriers and where the laws protect this sector, how would you implement your business? What innovations would you be interested in?

BIBLIOGRAPHY

Alltech. (2019). *Alltech Global Feed Survey 2019*. <https://www.alltech.com/press-release/2019-alltech-global-feed-survey-estimates-world-feed-production-increased-3-percent>

Balzan, S., Fasolato, L., Maniero, S., & Novelli, E. (2016). Edible insects and young adults in a north-east Italian city an exploratory study. *British Food Journal*, 118(2), 318–326. <https://doi.org/10.1108/BFJ-04-2015-0156>

FAO - Food and Agriculture Organization. (2019). Meat market review. *Food and Agriculture Organization of the United Nations, March*, 1–11. <http://www.fao.org/3/ca3880en/ca3880en.pdf>

Finke, M. D., Rojo, S., Roos, N., van Huis, A., & Yen, A. L. (2015). The European Food Safety Authority scientific opinion on a risk profile related to production and consumption of insects as food and feed. *Journal of Insects as Food and Feed*, 1(4), 245–247. <https://doi.org/10.3920/JIFF2015.x006>

Food and Agriculture Organization of the United Nations. (2013). Edible insects. Future prospects for food and feed security. In *Food and Agriculture Organization of the United Nations* (Vol. 171).

Gaskell, G. (2000). *Individual and group interviewing*. 38-56..pdf. (n.d.).

Halloran, A., & Vantomme, P. (2012). The contribution of insects to food security, livelihoods and the environment. *Fao*, 1–4. www.fao.org/forestry/edibleinsects

Imathiu, S. (2020). Benefits and food safety concerns associated with consumption of edible insects. *NFS Journal*, 18(November 2019), 1–11. <https://doi.org/10.1016/j.nfs.2019.11.002>

IPIFF. (2019). *The european insect sector today: challenges, opportunities and regulatory landscape IPIFF vision paper on the future of the insect sector towards 2030*. 16.

IPIFF. (2020a). *IPIFF - Building bridges between the insect production chain, research and policymakers*. <http://library1.nida.ac.th/termpaper6/sd/2554/19755.pdf>

IPIFF. (2020b). *The insect sector milestones towards sustainable food supply chains*.

May, 1–24. <https://ipiff.org/the-insect-sector-milestones-towards-sustainable-food-supply-chains/>

Materia, V. C., & Cavallo, C. (2015). Insetti per l' alimentazione umana: barriere e drivers per l' accettazione da parte dei consumatori. *Rivista Di Economia Agraria*, 70(2), 139–161. <https://doi.org/10.13128/REA-18004>

Meticulous Research. (2020). *Edible Insect Market*. <https://www.meticulousresearch.com/pressrelease/184/edible-insects-market-2027>

Ministero della Salute. (2008). *Informativa in merito all'uso di insetti in campo alimentare con specifico riferimento all'applicabilità del Regolamento (UE) 2015/2283 sui "novel food."* 1–6.

Moore, D. (2018). Insects as food and feed. *Food Science and Technology (London)*, 32(1), 22–25. https://doi.org/10.1002/fsat.3201_7.x

Oecd-fao Agricultural. (2019). *Chapter 6. Meat*. 166–179.

Pippinato, L., Gasco, L., Di Vita, G., & Mancuso, T. (2020). Current scenario in the European edible-insect industry: A preliminary study. *Journal of Insects as Food and Feed*, 6(4), 371–381. <https://doi.org/10.3920/JIFF2020.0008>

Sinjab, M., & Sinjab, M. (2014). Case Study. In *Five Steps to Start Your Refractive Surgery: A Case-Based Systematic Approach*. https://doi.org/10.5005/jp/books/12235_9

Sogari, G. (2015). Entomophagy and Italian consumers: An exploratory analysis. *Progress in Nutrition*, 17(4), 311–316.

Stake, R. E. (1995). Stake 1995 ch 5 case studies chapter. *Strategies of Qualitative Inquiry*, 134–164.

Tan, H. S. G., Fischer, A. R. H., Tinchin, P., Stieger, M., Steenbekkers, L. P. A., & van Trijp, H. C. M. (2015). Insects as food: Exploring cultural exposure and individual experience as determinants of acceptance. *Food Quality and Preference*, 42, 78–89. <https://doi.org/10.1016/j.foodqual.2015.01.013>

Van Huis, A. (2013). Potential of insects as food and feed in assuring food security. *Annual Review of Entomology*, 58, 563–583. <https://doi.org/10.1146/annurev-ento-120811-153704>