UNIVERSITÄT LEIPZIG

EXPLORING THE PRODUCTION AND EXPORT POTENTIAL OF CRICKET POWDER IN COSTA RICA

Master thesis

for the attainment of the academic degree of 'Master of Business Administration in Small and Medium-Sized Enterprise Development'

International SEPT Program, Leipzig University

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Date of assignment of topic: 22.04.2020

Date of submission: 30.09.2020

sept
small enterprise promotion + training

Acknowledgments

First, I would like to express my gratitude to DAAD for giving me the opportunity to study in Germany and for financing the field research of the present study in Costa Rica.

Special thanks to CITA for supporting my research and for financing the stakeholder's workshop. I am very grateful for the support of an incredible team of professionals: Prof. Dr. Oscar Acosta, Lic. Ana Maria Quirós, MSc. Pilar Fallas, MSc. Amaryllis Quirós and the students Erika Halsband and Cristiana Gonzalez. Without you, the workshop would not have been possible!

I would also like to express gratitude to my supervisor Prof. Dr. Utz Dornberger for supporting my interest in the topic of edible insects. Additional thanks to Prof. Dr. Md. Un Nabi for his kind advise on my research proposal, as well as Dr. Alba Valenciano for her support during the development of my research.

Special thanks to all interviewees for their time and willingness to participate in the study and the participants of the workshop for their cooperation and great engagement during the activities. Your insights will contribute to develop new opportunities for edible insects in Costa Rica and the rest of the world.

I am especially thankful to Global Bugs Asia for allowing me to visit their production plant, for their openness and unprecedented willingness to share their knowledge.

Last but not least, I am grateful to my family, specially to my mom, for their support on all the new projects I encounter even when it involves eating insects! To my beloved friends from SEPT for giving me one of the best times of my life and supporting my journey into the edible insects. And of course, my amazing friends in Costa Rica for supporting me even from the distance.

Abstract

Costa Rica is a tropical country with perfect environmental conditions to raise crickets, thus a possible creation of a large-scale cricket powder production hub is seen as an economic opportunity for the country. The aim of the present study was to explore the potential of producing and exporting cricket powder in Costa Rica, understanding if it is feasible to comply with the product and production requirements of the international market. A qualitative research was performed through semi-structured interviews to technical experts, producers and local entrepreneurs, a visit to a cricket powder production plant in Thailand and a 1-day stakeholders' workshop in Costa Rica.

Results show that Mexico, the United States and Europe are potential markets for Costa Rica. The main buyers are food and pet food producers with an average demand of 0,5-2 tonnes of cricket powder per month. The most important product requirements identified are the protein content, a gluten- free product and a neutral aroma. For the production, it is required to have an enclosed facility, with temperature and humidity control, a proper food safety and quality management system in place, with a standardized feed and water disposing system.

It is concluded that the current ecosystem in Costa Rica does not allow to meet the market and process needs required for commercializing cricket powder. Challenges like the current low production capability (micro level), the lack of technical experts on mass-producing crickets (meso level), the lack of specific regulation on insect production (macro level) and the poor knowledge on edible insects from a society perspective (meta level) must still be overcome. However, it is expected that in 5 years Costa Rica will be able to produce and export a minimum of 2 tonnes of cricket powder per month. The main identified opportunities that would allow such a production are the existent local knowledge on rearing insects (micro level), existence of well-established academic, research, and export promotion support institutions (meso level), government SME support programs (macro level) and the local expertise on exporting butterflies (meta level).

The creation of a producer's association, more research and training on edible insects and appropriate legislation are proposed as necessary strategies to develop an adequate ecosystem to produce cricket powder on an industrial scale.

Keywords: cricket powder, edible insects' production, systemic competitiveness, feasibility, Costa Rica

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List of Abbreviations and Acronyms

Abreviation/Acronym	Spanish Original	English Version
AUGE	Agencia Universitaria de Gestión del Emprendimiento	University Agency for the Entrepreneurship Management
AFFIA	-	Asian Food and Feed Insect Association
BSF	-	Black Soldier Fly
btb	-	Business to business
btc	-	Business to customers
CACIA	Camara Costarricense de la Industria Alimentaria	Costa Rican Chamber of the Food Industry
CADEXCO	Camara de Exportadores de Costa Rica	Chamber of Costa Rican Exporters
CITA	Centro Nacional de Ciencia y Tecnología de Alimentos	National Centre of Food Science and Technology
CINA	Centro Nacional de Investigación en Nutrición Animal	National Centre for Research in Animal Nutrition
CINDE	Coalición Costarricense de Iniciativas de Desarrollo	The Costa Rican investment Promotion Agency
COMEX	Ministerio de Comercio Exterior	Ministry of Foreign Commerce
CONAGEBIO	Comisión Nacional para la Gestión de la Biodiversidad	National Commission for the Biodiversity Management
CONICIT	Consejo Nacional para Investigaciones Científicas y Tecnológicas	National Commission for Scientific and Technological Research
CR	Costa Rica	Costa Rica
CRIC	-	Costa Rican Insect Company
CVO	Certificado Veterinario de Operación	Veterinary Certificate of Operation
ENU	Escuela de Nutrición	School of Nutrition
FAO	-	Food and Agriculture Organization of the United Nations
FDA	-	Food and Drug Administration of the United States of America
FDI	-	Foreign Direct Investment

FUNDES	Fundación para el Desarrollo Sostenible	Foundation for the Sustainable Development
GIZ	-	German Academy for International Cooperation
GFSI		Global Food Safety Initiative
GMP	-	Good Manufacturing Practices
HACCP	-	Hazard Analysis and Critical Control Points
INDER	Instituto Nacional de Desarrollo Rural	National Institute for Rural Development
INFOCOOP	Instituto Nacional de Fomento Cooperativo	National Institute of Cooperative Promotion
IPIFF	-	International Platform of Insects for Food and Feed
ITCR	Instituto Tecnológico de Costa Rica	Tecnical Insitute of Costa Rica
MAG	Ministerio de Agricultura y Ganadería	Ministery of Agriculture and Livestock
MEIC	Ministerio de Economía, Industria y Comercio	Ministry of Economy, Industry and Commerce
MICITT	Ministerio de Ciencia, Tecnología y Telecomunicaciones	Ministry of Science, Technology and Telecomunications
MINAE	Ministerio de Ambiente y Energía	Ministry of Environment and Energy
PROCOMER	Promotora de Comercio Exterior	Promoter of Foreign Commerce
PROINNOVA	Unidad de Gestión y Transferencia del Conocimiento para la Innovación	Innovation Knowledge Management and Transfer Unit
PYMEs	Pequeñas y Medianas Empresas	Small and Medium Enterprises (SMEs)
R & D	-	Research and Development
SBD	Sistema de Banca para el Desarrollo	Development Bank System
SENASA	Servicio Nacional de Sanidad Animal	National Service for Animal Health
SINAC	Sistema Nacional de Areas de Conservación	National System of Conservation Areas
UCR	Universidad de Costa Rica	University of Costa Rica
USD	-	United States Dollars

CHAPTER 1: Introduction

1.1. Background: Insects, the food of the future[1]

According to a report of the World Economic Forum (Waite *et al*, 2018), the main challenge humanity will face to sustainably feed 10 billion people by 2050 is related to three main gaps: how to produce 56% more food, without using more land and by lowering CO2 emissions in 67%.

To close these gaps and based on recent studies, the Food and Agriculture Organization of the United Nations (FAO) states that alternative sources of proteins must be utilized, specifically cultured meat, seaweed, fungi, and insects (Van Huis *et al*, 2013). The latter, edible insects, are proposed as one of the most sustainable solutions for feeding the world population in the near future.

Various studies have demonstrated that insects have a well-balanced nutrient profile, are great sources of proteins (not only in quantity but also in quality), are high in polyunsaturated fatty acids and most are rich in micronutrients and vitamins (Van Huis *et al*, 2013; Rumpold and Schlüter, 2013). For instance, Rumpold and Schlüter (2013) report that when compared to traditional animal protein like beef, pork, chicken and lamb; termites, grasshoppers, caterpillars, weevils, and houseflies are better protein sources by weight and that the protein of the house cricket Acheta domesticus was superior to soy protein. Furthermore, iron and calcium content in insects is reported to be much higher than in beef, pork, and chicken. For instance, 100 g of caterpillars on average supply 335% of the minimum daily required amount of iron and almost 100% of the daily required amounts of vitamins for humans and three silkworm pupae are supposed to be as rich in nutrients as one chicken egg (Rumpold and Schlüter, 2013).

Not only are insects a great source of nutrition for human, but they are also presumed to consume less resources in comparison to conventional livestock. Although the environmental impacts and feed conversion rates vary with insect species and cultivation methods, Shelomi (2016) states that insect rearing requires less feed, water, and land to produce equivalent amounts of protein than traditional livestock. Insects also have a higher fecundity (e.g. the common house cricket lays up to 1,500 eggs over a period of about a month) and a shorter life cycle (they reach adulthood within a matter of days), are mostly omnivorous, can be raised on organic waste (Rumpold and Schlüter, 2013), and emit less greenhouse gasses and other wastes (Shelomi, 2016).

For these reasons, insects are proposed by FAO (2018) as a potential sustainable source for protein production, either for direct human consumption or indirectly in recomposed foods and as a protein source into feedstock mixtures.

[1] This extract of the thesis was already published in Bermudez-Serrano (2020).

1.2. Rationale[2]

Consumption of edible insects by humans, so-called "entomophagy" has been practiced for thousands of years. In the present, entomophagy is exercised traditionally in 113 countries all over the world and it is believed that 2,111 species of insects (Jongema, 2017) are consumed by about 2 billion people, mainly in the developing world (Van Huis *et al*, 2013). Moreover, the human being has been utilizing insects for industrial purposes for more than 5000 years for example by producing silk, wax and dyes, food ingredients and medicinal products, such as bee honey, food coloring and as pharmaceuticals e.g. propolis, royal jelly, and venom from bees (Van Huis *et al*, 2013).

Insects are traditionally eaten mainly in developing countries in Africa, Latin America, and Asia. In Latin America, Costa Neto (2016) reports that Mexico, Brazil, Colombia, Venezuela, Ecuador and Peru are the main countries with a habit of consuming insects due to their biological and ethnical diversity.

Interestingly, although the tradition of entomophagy was not present in the Western world, in the last few years, the topic has started to capture public attention worldwide and there has been a resurgence of the sale of insects in Europe and North America (Fellows, 2014). Consequently, many entrepreneurs around the world have taken advantage of the opportunities in the market and have launched their insect-based food start-ups (Engstrom, 2019; Pascucci, Dentoni and Mitsopoulos, 2015).

The future seems to be promising since, according to Meticulous Research, the global market for edible insects may almost triple between 2018 and 2023, reaching $1.18 billion, while output capacity has risen significantly since late 2017 as the industry draws new investment (Globenewswire, 2018). Thus, there is a market opportunity to produce edible insects in a large scale in order to supply the international market. Considering the economic potential and market opportunities that the exports of insect powder present, it is of special interest to analyze how a tropical country, in this case, Costa Rica, can take advantage of the international edible insect trend, by creating and developing an insect powder production hub that contributes to the economic growth of the country.

Costa Rica is well known among nature lovers since it possesses one of the highest densities of biodiversity of any country in the world, accounting for only 0.03 percent of the earth's surface (51.100km2) but containing nearly 5 percent of the world's biodiversity (CINDE, 2020). Due to its location in the tropics, the weather conditions make it possible for insects to grow naturally. However, Costa Rica is one of the countries in Latin America where the tradition of entomophagy was lost and thus the rearing of insects is not common.

Currently, there are some local private and public initiatives aiming to introduce edible insect-based products into the local and international market in Costa Rica. However, researchers agree that there are still important constraints facing a possible development of an entomology-based food

[2] Part of this extract was already published in Bermudez-Serrano (2020).

industry worldwide, mainly due to consumer acceptance, mass production requirements, selection of species and lack of regulations (Rumpold and Schlüter, 2013). In fact, according to several researchers, the main challenge for entrepreneurs willing to commercialize edible insect products is the most relevant one: the availability of the raw material; specifically, assuring they have a continuous supply of good quality edible insects.

Since edible insects are considered a radical innovation, market constraints could have a bigger impact on the success of a start-up (Pascucci, Dentoni and Mitsopoulos, 2015). Thus, investigating the viability of a project for producing edible insects is of special importance in a context where uncertainty is high. Main challenges must be identified by entrepreneurs before entering the market, so that they can come up with innovative solutions to overcome them. To make the decision to start a business related to the production of cricket powder in a country like Costa Rica, where entomophagy is not traditional, it is crucial to first understand the market needs and if the required resources are available in the country to sustainably produce and supply the international market with quality products.

Considering that the insect-based food sector is novel, there is a lack of research related to the economic implications for the production and export of edible insect powder, especially in developing countries. Therefore, the present study explored the feasibility of establishing a large-scale cricket powder production in Costa Rica, in order to supply the growing international market. Of special interest was first to understand what are the market needs and the technical requirements when it comes to this innovative product, in terms of product and production requirements. With this information, it was then assessed if the local entrepreneurial ecosystem has the necessary conditions to make such a project viable.

The obtained results will help entrepreneurs, investors and public authorities make better decisions related to the establishment of an insect-based industry in Costa Rica. Moreover, it will contribute to provide scientific information to the field of business and economics related to the edible insect production in Latin America and the rest of the world.

1.3. Central question and objectives

The central question investigated was:
Is it possible to create a large-scale edible cricket powder production in Costa Rica to supply the international market of food producers?

To answer this question, the following objectives were followed:

1. To understand the market needs and product requirements related to the supply of cricket powder for food production.

2. To identify the main requirements for a cricket powder production process as part of an international supply chain.

3. To explore the feasibility of producing edible cricket powder on a large scale in Costa Rica considering the existent local entrepreneurial ecosystem.

1.4. Scope of the research

This study is focused on the application of insect-powder for the edible food industry, meaning specifically for human consumption. Thus, the analysis will not necessarily include the application for the feed industry, which may have other specifications and requirements.

Although there are several insect species that can be produced for human consumption, the present study was focused on the production of cricket powder since according to an exploratory expert consultation, this species is the most common currently industrialized for human consumption.

It is not the purpose of this research to provide detailed financial information about the production of cricket powder, but rather to understand if there are sufficient conditions in Costa Rica that will sustain such an enterprise. Therefore, the focus of the research will be directed towards understanding the main needs and requirements for the production of cricket powder, regarding the existent market and then, assessing if the necessary conditions exist in the country that make such a project viable.

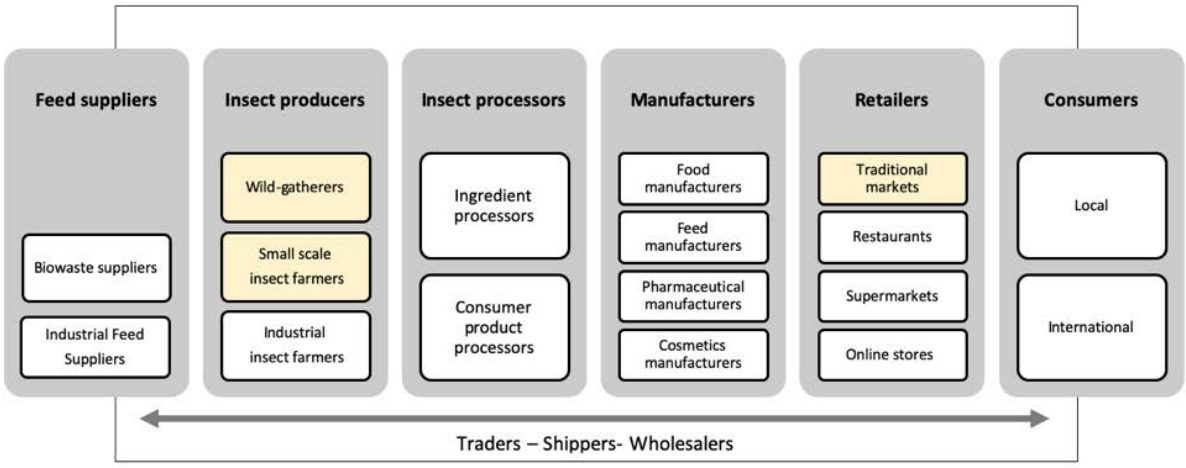
Lastly, the perception of the end customer for the edible insect food products will not be assessed in the research since this is a very complex topic that must be separately investigated.

Chapter 2: Theoretical Framework

2.1. The edible insect supply chain

A food supply chain involves all industries collaborating to provide final consumers with foods and its scope extends from farms (farmers), as the first origins of food products, to fork (consumer), as the last point of consumption (Sakali *et al*, 2016). To be able to analyze the potential production of edible insects, it is first important to understand how the supply chain works and who are the main actors involved. Figure 1 schematizes the international insect-based supply chain.

Figure 1.Main actors in the edible insect supply chain



Source: Reproduced from Bermudez-Serrano, 2020

As explained by Bermudez-Serrano (2020) and schematized in figure 1, the edible insect value chain usually begins with the feed suppliers, who provide either organic waste or industrial feed to the insect farmers. Then, the author includes wild-harvesters and farmers in the category of insect producers. Wild-harvesters are defined as the individuals that gather insects from nature, who can also be called "collectors", while farmers are the ones that cultivate insects and they can be divided in small- and large scale depending on their production capacity. According to Caparros-Megido *et al*. (2018), "small scale" refers to those that produce around 50 kg per year, while "large scale" means several tonnes of insects produced annually. Bermudez-Serrano (2020) states that whole insects produced by collectors and small farmers are usually gathered by intermediaries to be sold in larger quantities in bigger markets. Usually, wild-harvesters, small insect farmers and traditional markets are mostly related to countries where edible insects are traditionally consumed (Ramos-Elorduy *et al*., 2006; Van Huis *et al*., 2013).

In the figure, the term "insect processors" refers to the companies that transform whole insects into value-added products (like insect powder, protein bar, cookies, etc.) or ingredients (like insect

protein, insect oil and/or chitin). These ingredients are sold to the manufacturers in different sectors to produce food products, animal feed, pharmaceuticals or cosmetics (Bermudez-Serrano, 2020).

Commonly, the insect-based products are distributed by traders, shippers and/or wholesalers to be sold to the final consumer through different channels, such as traditional markets, restaurants, supermarkets and online stores (Bermudez-Serrano, 2020).

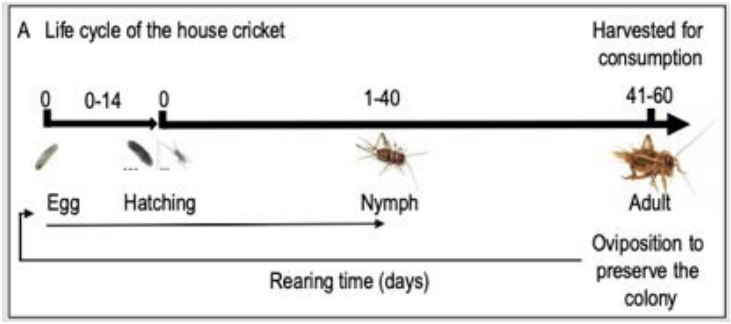
2.1.1. House cricket and cricket powder

The most common insect species reared for human consumption are beetles, crickets, locust and grasshoppers, caterpillars and bees and wasps (Van Huis & Tomberlin, 2018). Crickets occupy the largest segment (31.6%) in the world market for edible insects, and it is estimated that they will continue to dominate it (Meticulous Research cited in De Sousa, Warren and Rekoma, 2018). Some of the most common species that are grown with the purpose to produce food are crickets like *Acheta domesticus, Gryllodes sigillatus, Gryllus assimilis, G. bimaculatus,* and *G. locorojo*. Of these, the most common is *Acheta domesticus*, also known as "house cricket" (Cortez *et al*, 2016).

The main reason to eat crickets is their high nutritional value. The protein content of the house cricket is reported to be 20-25 g/100 g fresh weight, while the lipid content is 4-7 g/100 g fresh weight (Fernandez-Cassi *et al*, 2019). Regarding their fat composition, the house cricket has 29-31% of polyunsaturated fatty acids. In addition, due to their composition, crickets can be considered a valuable source of vitamins (Rumpold and Schlüter, 2013).

Figure 2 summarizes the life cycle of the house cricket.

Figure 2.Life cycle of house crickets



Source: Reproduced from Fernandez *et al* (2019)

As can be observed, crickets have three main stages: egg, nymph and adult. The average time from the egg to the harvested adults ready for consumption can last between 41 and 60 days. the incubation period, that is the total days from lay to hatch varies between 11-15 days, while the time to maturity (days from hatch to maximum body weight) can be 32-49 days (Mott, 2018). The fecundity is reported as 340-1060 eggs per female (Fernandez *et al*, 2019).

Once harvested, crickets can be dried and grounded to produce a fine powder, called cricket powder. Cricket powder was identified as the cricket by-product with the greatest potential in the international market due to its higher annual growth rate, due to the lack of willingness to eat whole insects in western countries, a high shelf life and availability in low season, as well as a wide range of applications in various food products (FUNDES, 2019).

In this respect, experts suggest that producing insect-based ingredients (e.g., cricket powder) rather than insect-based processed foods (e.g., protein bars manufactured with cricket powder) may facilitate the use of insect-based ingredients in home food preparation (Hammerman, 2016).

In addition, there are other food applications that have not been exploited yet and that could represent a business opportunity in the near future, such as functional and medicinal properties. According to Rumpold and Schlüter (2013), insects and insect proteins can be used as texturizing food ingredients as well as ingredients of protein-rich meat replacing products. Moreover, it is suggested that the nutraceutical properties of insects should be promoted, since it has been reported that insects have immunological properties, analgesics, diuretics, antibiotics, anesthetics, antirheumatics and aphrodisiacs (Ramos-Elorduy, 2005).

2.2. Mass production of edible insects: a radical innovation in the agri-food sector

Although there is a long tradition of eating insects and they have been produced in large quantities in Asia, Pascussi *et al* (2015) consider that insect-based food products are a radical innovation in the agri-food industry since insects have not been massively produced for human consumption in Western societies and using them as a source of ingredients for food products brings a fundamental change to the current food consumption habits, breaking with traditional eating behaviors especially in the Western world.

The authors argue that insect-based products are not just a minor incremental extension of current food products, but more of a ground-breaking concept, since in order to mass-produce them, there is a need for technology which is a combination of brand-new knowledge, skills, and equipment (Pascussi *et al*, 2015). This description complies with the definition of Kasmire *et al* (2012), who state that radical innovations have a high degree of novelty, either totally or substantially new, and usually, they establish whole new fields of study, make dominant rival technologies or processes obsolete, and disrupt the status quo (p.347).

In this context, Pascussi *et al* (2015) consider relevant to understand the concept of radical innovation when analyzing the creation of a new company or supply chain in the edible insect sector, since the related dynamics may be more complex than by a usual incremental innovation, especially considering that innovation in the agri-food industry combines innovative technology with social and cultural innovation. In this line, the authors suggest that due to both cultural and psychological issues

related to insect-based food products, risks of consumer rejection and failures is even higher than other "technology-based" radical innovations.

Consequently, the authors state that in order to verify if an idea is a valuable opportunity, entrepreneurs need to invest in comprehensive research and investigate organizational as well as market feasibility. Accordingly, when assessing the feasibility of a new venture opportunity, entrepreneurs must look at four basic areas: 1. the dynamic of the team, 2. the availability of resources, 3. knowledge and information and 4. ability to generate revenue (Pascussi *et al*, 2015).

2.3. Main challenges to the mass production of insects[3]

Traditionally, in the tropics, insects are either harvested from nature or produced in small scale farms. Generally, the farming takes place in small scale production units and depends on the weather condition, since insects are harvested mostly during the rainy season (Van Huis *et al*, 2013). In Mexico, for instance, the main actors for the collection are indigenous people, since they are the ones that have traditionally eaten insects (Ramos-Elorduy, 2006). Meanwhile, in Thailand there are approximately 20 000 small and medium cricket farmers. However most of them do not have adequate food safety management systems in place (Hanboonsong *et al*, 2013).

In order to take insects to the tables of the world population, mass production techniques are needed. Nevertheless, may authors agree that this is one of the main constraints affecting the novel edible insect sector. In fact, the main challenge for entrepreneurs willing to commercialize insect products in a large scale is the most relevant one: the availability of the raw material; specifically, assuring they have a continuous supply of good quality edible insects. This challenge is mainly caused by the lack of mass production technologies (Van Huis *et al*, 2013; Rumpold and Schlüter, 2013).

Among the first attempts to farm insects for mass production were Kok, Lomaliza, & Schivahare (1988), who demonstrated that it was technically feasible to mass-produce insects for human consumption by industrial methods. Nevertheless, the processes have not been totally automated yet, mainly because the methods for mass producing insects vary extensively depending on the biology of the insect, location, and resources available for use in establishing a mass-production facility. For instance, factors like temperature or humidity, variation in light and feed quality can directly affect the productivity and are critical for assuring the adequate production of the eggs of the harvested insects to be later used as food or feed (Van Huis & Tomberlin, 2018).

Some entrepreneurs have been able to develop technological innovation related to mass-rearing systems. For example, Entomofarms uses cardboard dividers to house the nearly 100 million crickets they raise (Rossman, 2018) (see Figure 3). Another example is Aspire, a global leader in the edible insect markets based in the United States and Ghana. In 2017, the company opened a 25,000 square-

[3] Part of this extract of the thesis was already published in Bermudez (2020).

foot R&D center and is planning to reach 250,000 square feet by the end of 2019 (Peters, 2017). The company is using pioneering technology, including robotics and automated data-collection to farm insects (Aspire Food Group, 2016). In general, research and investment are growing in order to come up with better technologies for insect mass production.

Figure 3.Cricket rearing in Entomo farms, Canada

Source: Reproduced from Rossman (2018)

Nonetheless, Van Huis *et al* (2013) state that total automated rearing equipment is still scarce and even when there are a few industrial-scale start-ups rearing mass quantities of insects, the current production systems are expensive and many patents are still pending. Moreover, Rumpold and Schlüter (2013) report that due to a high necessity for manual labor, the mass production of edible insect protein in Europe is expensive and its price is comparable to meat. For example, Van Huis *et al*. (2013) reported that mealworms are nearly three times more expensive than pork and about five times more expensive than chicken.

Furthermore, the lack of appropriate regulation is also one of the main obstacles to mass produce edible insects. Nowadays, food safety and quality are one of the main concerns of consumers and a lot of attention is placed on these topics in the international food supply chain. In this regard, insect-based food products are not the exception. However, in many countries, insects are still not perceived as approved food products and thus, are not included in the legal framework. At the national and international levels, standards and regulations acknowledging the use of insects as ingredients for food and feed are rare (Van Huis *et al*., 2013). This situation is considered by investors to be a major barrier (Kelemu *et al*., 2015) and was also described as the greatest obstacle to insects entering the European food chain (Belluco *et al*., 2015).

Considering that as many food products, insects can represent a health risk to consumers, due for example to microbial contamination, allergic reactions, contents of natural toxic chemicals or contamination with pesticides, it would be helpful to count on proper legislation, standards, labelling and other regulatory instruments for the production, use and trade of insects (Van Huis *et al*., 2013; Rumpold and Schlüter, 2013). However, there is still a big challenge to properly include insects as

food. For instance, until 2017, European legislation was very conservative about new food or new ingredients. The first challenge for edible insects entering the European food chain was the Novel Food Regulation (258/1997) in force until the end of 2017, which made it almost impossible to import edible insects and its products to Europe (Belluco *et al*., 2015).

Lack of regulation is not only a problem related to food safety, but it also affects the market dynamics, especially in the developing world. In this respect, Ramos-Elorduy *et al*. (2006) state that the lack of regulations and established norms usually lead to irrational exploitations and/or inadequate and ineffective collection and promotes the formation of monopolies and intermediation. Moreover, it can cause a poor conservation or maintenance of the resource, which puts many species in risk of extinction.

Finally, along with the lack of mass production technology and regulation, the low demand for edible insects in the Western world also affects the development of an insect-based food industry. This is mainly caused by the general aversion to consuming edible insects. Extensive research has been conducted on this topic (especially in Europe) and generally levels of customer acceptance of insects as food are found to be low (House, 2016). Hence, many authors agree that education of the public as well as image improvement of edible insects needs to be performed in order to establish and increase consumer acceptance (Rumpold and Schlüter, 2013).

Chapter 3: Conceptual framework

Two main conceptual frameworks were used to answer the central question, mainly the feasibility analysis and the systemic competitiveness approach. The feasibility analysis was followed for the first two objectives, to identify market and process requirements, while the systemic competitiveness approach was used to explore the current Costa Rican entopreneurship[4] ecosystem and thus evaluate the feasibility of starting such a project in the country.

3.1. Feasibility analysis

Many business experts agree that before any new enterprise or method of producing and marketing a product is initiated, it should be determined whether it is viable (Schermerhorn, 2012; Hofstrand & Holz-Clause, 2009a). Therefore, a feasibility study is conducted with the main focus to answer the question of "should we proceed with the proposed project idea?". With the answers obtained it can be determined if the business idea is not viable, and thus save time, money and unnecessary efforts (Hofstrand & Holz-Clause, 2009a).

As Hofstrand & Holz-Clause (2009b) put it, the feasibility study is a mean to investigate if the business venture is viable and outlines and analyzes several alternatives or methods of achieving business success, while helping to narrow the scope of the project to identify the best business scenario(s). The authors also mention other benefits for conducting a feasibility study, such as: to identify new opportunities during the investigation, it provides quality information for decision-making, and helps to secure funding from investors and lending institutions. In summary, conducting a feasibility study increases the chances of success by addressing and mitigating factors early on that could affect the project (Hofstrand & Holz-Clause, 2009a). Thus, is it a critical step in the business assessment process.

Feasibility studies can be applied to any kind of business and projects. However, the content, methodology and the elements to be included in conducting a feasibility study vary considerably according to the type of business analyzed and the kind of market opportunities identified (Hofstrand & Holz-Clause, 2009a; Schermerhorn, 2012). In the case of agribusiness projects, one of the most important questions to be answered in the project evaluation stage is whether production at the required scale is technically feasible (Fellows, 1997). Thus, determining the technical requirements of the business is critical. In this sense, according to Schermerhorn (2012), a feasibility study for an agribusiness project can be divided into two major phases: an analysis of directly influencing factors and an analysis of environmental conditions. The first analysis can be divided into market determination, raw product supply and the production process.

[4] Entopreneurship refers to an entrepreneurship related to edible insects

According to Schermerhorn (2012, p.3), analyzing market potential for a product involves determining current and potential consumption of the product, types and locations of available markets, types of available distribution systems, ways the market can be entered, types of buyers within the market, types of selling arrangements used and the level of prices charged for the product.

Availability of raw materials is crucial for any production project. Thus, it is an essential element of the feasibility analysis in agribusiness projects. According to Schermerhorn (2012) and Hofstrand & Holz-Clause (2009a) the factors that need to be considered when analyzing raw product supply are: estimation of the amount of raw materials needed; availability of requirements: investigation of the current and future availability and access to raw materials; and assessment of the quality and cost of raw materials.

In addition, this stage of feasibility study assesses specific facility needs, capital requirements and cost and quantity of the labor needed. Here, special attention must be placed into the required technology to compete in the sector (see table 1 for more detail) (Schemerhorn, 2012). Also, the investigation of the availability of facilities and services that are essential to create an acceptable environment in which the plant can operate and its management and labor force can live is key, such as applicable taxes or sanitation regulations (Schermerhorn, 2012).

Based on the reviewed literature (Schermerhorn, 2012, Hofstrand & Holz-Clause, 2009a, Fellows, 1997), the following table shows the main elements to be analyzed in a technical feasibility study for an agro-industrial production project.

Table 1. Elements to be included in a technical feasibility analysis for an agribusiness project

(Source: own elaboration based on literature review)

<table>
<tr><th>Market needs</th><th>Raw materials supply</th><th>Facility needs</th><th>Suitability of production technology</th><th>Availability and suitability of site</th><th>Other inputs</th></tr>
<tr><td>Determination of the current and potential consumption</td><td>Estimation of the amount of raw materials needed (including packaging).</td><td rowspan="4">Estimation of the size and type of production facilities.</td><td>Investigation and comparison of technology providers</td><td>Access to raw materials and transportation</td><td rowspan="3">Investigation of the availability of labor including wage rates, skill level, etc.</td></tr>
<tr><td>Types of available distribution systems</td><td rowspan="3">Investigation of the current and future availability and access to raw materials.</td><td>Determination of reliability and competitiveness of technology (proven or unproven, state-of-the-art, etc.).</td><td>Access to labor and production inputs (electricity, natural gas, water, etc.)</td></tr>
<tr><td>Ways the market can be entered</td><td rowspan="3">Identification of limitations or constraints of the technology</td><td>Analysis of possible environmental impacts.</td></tr>
<tr><td>Types of buyers within the market</td><td rowspan="2">Assessment of the quality and cost of raw materials</td><td rowspan="2">Investigation of the need for related buildings, equipment, rolling-stock, etc.</td><td>Identification of regulatory requirements.</td><td rowspan="2">Assessment of the potential to access and attract qualified management personnel.</td></tr>
<tr><td>Selling arrangements and price</td><td>Exploration of economic development incentives.</td></tr>
</table>

As outlined in Table 1, many elements have to be studied in a feasibility analysis. However, it is crucial to first understand what is needed in the market and then, investigate if the proposed project has the technical and environmental resources to supply the existing market with the required products in the quantities needed.

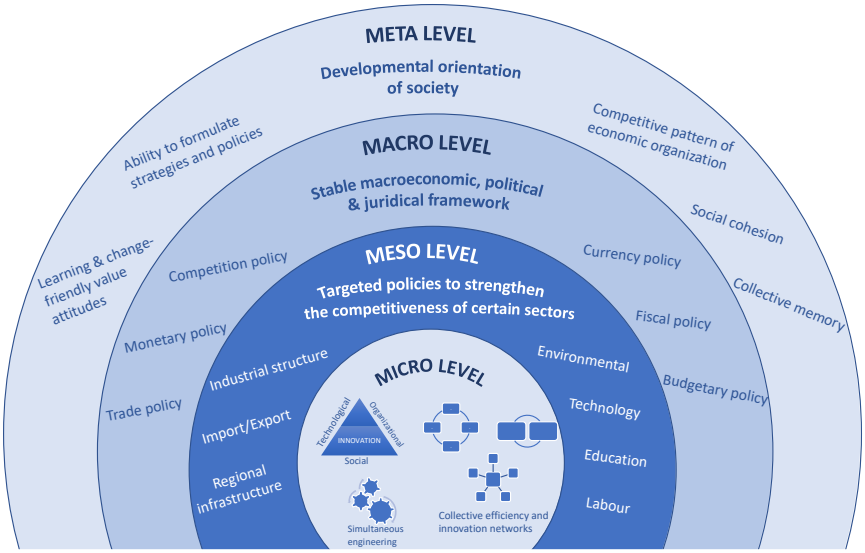
3.2. The systemic competitiveness framework

In addition to the technical feasibility, the entrepreneurial ecosystem is a critical factor to determine if a project is viable in a specific context. In this case, the ecosystem was analyzed from a systemic competitiveness approach based on the works of Esser, Hillebrand, Messner and Meyer-Stamer (1996). Under this framework, the economic development of a sector or country is not based only on micro or macroeconomic conditions, but rather on different interlinked variables, as part of a system. The term "system" is understood as a pattern of actors, institutions, organizations and policies which are inter-linked through complex feedback mechanisms and which, taken together, create a coherent entity, an economic system which is different in every local context (Meyer-Stamer, 2005).

In this context, differences in economic performance cannot be linked causally to isolated key factors (such as an industrial policy or technology transfer), but these factors are embedded in a given system, and they will work well because a number of other factors support them (Meyer-Stamer, 2005). That means that the same economic policy will not necessarily work in Latin America only because it was successful in Europe, basically because the economic system and the stakeholders and their relationships are different in these two contexts. That is why in order to evaluate economic performance, it is necessary to analyze the system as a whole and not just some of its components.

The systemic competitiveness approach identifies four analytical levels for investigation: the micro-, meso-, macro- and metalevel. Under this framework, different key factors and their roles must be identified in every level in order to understand the dynamics of the analyzed economic system (Meyer-Stamer, 2005), according as represented in Figure 4.

Figure 4. Determinants of the Systemic Competitiveness Framework



Source: Own elaboration adapted from Meyer-Stamer (2005)

The meta level analyzes the developmental orientation of the society and includes aspects such as a society's capacity for integration and strategic action. Some factors to be analyzed in this level are: socio-cultural factors, scale of values, basic patterns of political, legal and economic organization, strategic and political capability, social cohesion, collective memory and learning and change-friendly value attitudes (Essert *et al*, 1996).

The macro level analyzes the macroeconomic, political and legal framework. Some of the factors included in this level are: the budgetary policy, the currency policy, fiscal policy, competition policy, trade policy, monetary policy (Essert *et al*, 1996). Some of the typical organizations present in this level are Ministry of Finance and the Central Bank and top level-peak associations in the non-government side (Meyer-Stamer, 2005).

The meso level focuses on the examination of a support structure that promotes, supplements and furthers the enterprises efforts. At this level, the policies to strengthen the competitiveness of certain sectors are key. The factors to be analyzed here are: Industrial structure, environmental policies, educational policy, technology policy, import/export policy (Essert *et al*, 1996). Some of the typical organizations at this level are: Centers for Research and Development, public education and training institutions, SMEs promoting agencies and development banks. On the non-government side chambers, associations, foundations and NGOs are usually present (Meyer-Stamer, 2005).

The micro level focuses on the enterprises and their interactions. In general, successful countries have a large number of enterprises, many of them interlinked in mutual assistance networks which aim to achieve simultaneously efficiency, quality, flexibility and speed of response. Factors analyzed in this level include: managerial capability, entrepreneurial strategies, innovation management and the interaction between suppliers, producers and users (Essert *et al*, 1996).

In general, according to Esser *et al* (1996), the most competitive countries have basic structures of legal, political and economic organization, the social capacity for organization and integration and the capability of the actors to achieve strategic interaction (at the meta level); a macro framework that requires the enterprises to be more efficient; a support structure that promotes, supplements and furthers the enterprises efforts (at the meso level) and a high number of enterprises interlinked to achieve competitiveness (at the micro level).

3.3. Research Model and Key issues investigated

The focus of the research was directed towards understanding the main market needs and requirements for the production of cricket powder in a tropical country, regarding the existent international market and then, assessing if the necessary conditions to make such a project viable exist in Costa Rica.

Figure 5 presents a graphic scheme of the selected research model. As can be seen, it was based on three subsequent steps: 1. Understanding the market needs. 2. Identifying Production Requirements and 3. Exploring the feasibility in Costa Rica. The results from steps 1 and 2 were the input for the exploration of the feasibility.

Figure 5. Research Model

Source: Own elaboration

In order to answer to the main research questions, several concepts were explored. These key issues will be defined in the present section.

3.3.1. Market needs for cricket powder

In order to understand if the project is feasible one of the first things that needs to be determined is the size of the market and its needs, thus the potential demand and product requirements by buyers are among the main issues investigated.

3.3.1.1. Potential demand

The current and potential demand from the clients were investigated, who are the companies willing to buy cricket powder, how the cricket powder is usually sold and distributed and what is the price the clients are willing to pay.

3.3.1.2. Product requirements

This study begins with the premise that although insect-based foods are now a niche industry, there is potential for wider use in mainstream food products worldwide. Considering the edible insect supply chain producers of insect-based products usually buy the raw material from an insect farmer (see Figure 1). As any commercial transaction, the buyer will generally ask for specific product requirements. The buyer usually determines these requirements according to regulation and the expected quality desired in the final product. Thus, it is crucial that the seller understand these requirements in order to provide the specific product clients are looking for. The main focus was to understand what the market needs in relation to the prospect cricket powder.

a. **Quality requirements:** Specific product requirements, such as basic physical attributes (size, weight, form), sensory characteristics (taste, aroma, color, etc), packaging standards as well as chemical and microbiological standards (microbial count, pH, etc) are key quality requirements for common food products or raw materials. These quality requirements were investigated.

b. **Food Safety Requirements:** The food industry has special requirements concerning food safety in order to assure that consumers are safe. To help processors achieve food safety, there are a series of guidelines and standards to comply with, such as the HACCP (Hazard Analysis and Critical Control Points) and GFSI (Global Food Safety Initiative) standards. It was important to understand if clients require cricket powder producers to comply with any of these international standards, which would then have a direct impact on the processing requirements.

3.3.2. Requirements for the Production of cricket powder

As stated by several experts, mass production of insects as food is more complex than expected. According to Tomberlin (2018), the methods used for mass producing insects vary depending on their

biology, the location and the resources available for use. Therefore, it was of special interest to identify what are the specific requirements to consider when planning a cricket powder mass production, which includes farming the crickets and then processing them into a powder.

3.3.2.1. Farming crickets

In order to obtain the cricket powder, first, the crickets have to be farmed. Thus, the following requirements were investigated:

-what specific technology/equipment is needed to rear the crickets
-the characteristics of the required facilities (area, infrastructure, etc)
-what are the required environmental conditions
-the required raw materials and supplies
-what specific skills are needed by the personnel.
-approximate investment required

3.3.2.2. Obtaining the cricket powder

Once the crickets are reproduced, the next step is to process them into a powder. To understand the main requirements for this process, the following issues were investigated:

-what are the necessary steps to obtain the powder
-what specific technology/equipment is needed to process the crickets into a powder
-the characteristics of the required facilities (area, infrastructure)
-the required raw materials and supplies
-what specific skills are needed by the personnel
-and the approximate investment required

The collected information on the process requirements was then used to perform an objective assessment of the feasibility of such a production in Costa Rica.

3.3.3. Feasibility of producing and exporting cricket powder in Costa Rica

The feasibility concept was analyzed from two points of views: 1. The local capacity to comply with the current market and production requirements (at the micro level) and 2. The capacity of the entrepreneurial ecosystem to support such a project. In this context, the main objective was to define the pattern of stakeholders, institutions, organizations and policies which are inter-linked in the ecosystem. Thus, the four analytical levels of the systemic competitiveness approach (Meyer-Stamer, 2005) were investigated: the micro-, meso-, macro- and metalevel. In each level, the main opportunities

and challenges were investigated. The following elements were analyzed as part of the systemic competitive analysis of the edible insect entrepreneur ecosystem in Costa Rica (Meyer-Stamer, 2005):

3.3.3.1. The Micro Level: Technical feasibility of local Entopreneurs

It was important to understand what the current level of production is and how it complies with the market and production requirements identified. In addition, the current cricket farmers, manufacturers, consumers, and markets, and their interrelations were investigated. Here it was important to understand what the main local actors in terms of farming crickets are and how they interact between each other.

3.3.3.2. The Meso Level: Technical support

Of special importance was to understand the available support institutions and technical knowledge related to edible insect farming in Costa Rica.

3.3.3.3. The Macro Level: Regulatory feasibility

The regulations that apply to produce and export cricket powder from Costa Rica to the selected international markets was investigated. Of special interest was to understand if there are specific local regulations that apply to the production and commercialization of edible crickets and cricket powder in Costa Rica and how this could affect a possible development of the industry.

In addition, the public policies related to entrepreneurship promotion were investigated, regarding trade policies, economic stability, investment support and fiscal policy that may affect the project.

3.3.3.4. The Meta Level: social acceptance

Elements analyzed in the meta level include public opinion towards edible insects, government and non-governmental actors' interactions and common vision towards edible insects, as well as cultural traits that may affect the project.

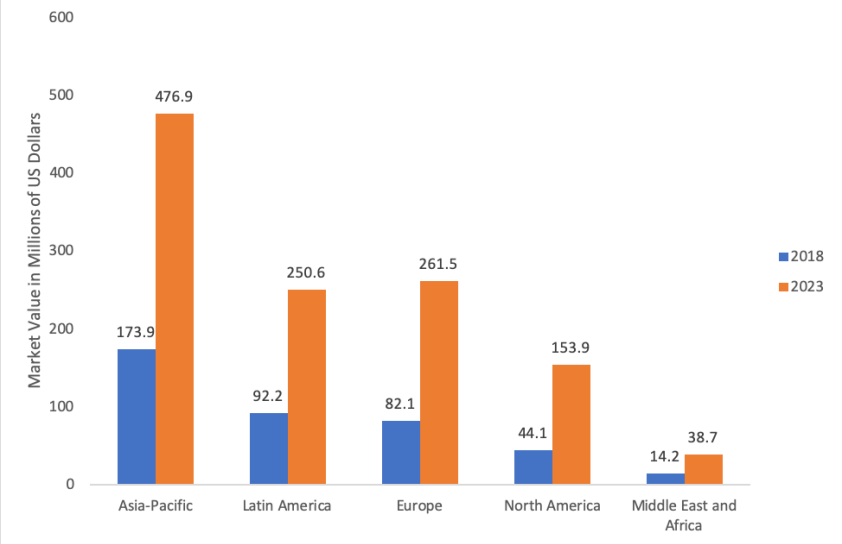
Chapter 4: Empirical Framework

4.1. The Growing Edible Insect Market[5]

As reported by Meticulous Research, the global market for edible insects may almost triple between 2018 and 2023, reaching $1.18 billion and output capacity has risen significantly since late 2017 (De Sousa, Warren and Rekoma, 2018). Accordingly, the IPIFF states that the growing demand for high protein food for sport nutrition, dietetic food or in food supplements creates further opportunities for edible insects and although these are niche markets now, they are forecasted to grow rapidly in the next few years (IPIFF, 2019b).

As shown in Figure 6, in 2018 Asia-Pacific had the largest market value of edible insects worldwide accounting for 173,9 million US dollars, while Latin America was in second place with 92,2 million US dollars. According to the estimation, the Latin American insect market is expected to almost triple compared to 2018, reaching 250,6 million dollars in 2023, almost one quarter of the expected worldwide market value and very close to the estimated European market (261,5 million US dollars). Mexico represents the most dynamic market of edible insects in Latin America, where the demand of edible insects is that high, that the supply is insufficient (Ramos-Elorduy, 2006).

Figure 6. Market value of edible insects worldwide in 2018 and 2023, by region (in million US dollars)



Source: Own elaboration based on Meticulous Research, 2018 cited in De Sousa *et al.* (2018)

[5] This extract was already published in Bermudez (2020).

It is noticeable that the North American region is expected to undercome a significant growth in global edible insect market, primarily due to growing demand for environmentally friendly high protein diets, aversion to highly processed foods, and growing concern about meat production (Globenewswire, 2018).

Meticulous Research used a clear segmentation of the edible insect market, dividing it in the following categories by insect type, product type, application and geography. In the insect type different edible insects are included such as crickets, mealworms, black soldier flies, buffalos, grasshoppers, ants, silkworms and cicadas. The products are divided in whole insects, insect meal, insect powder, insect protein bars and protein shakes, insect baked product and snacks, insect confectionaries, insect beverages, insect oil, and others; while the application may be for human consumption, animal nutrition, or cosmetics and pharmaceutical (Globenewswire, 2018).

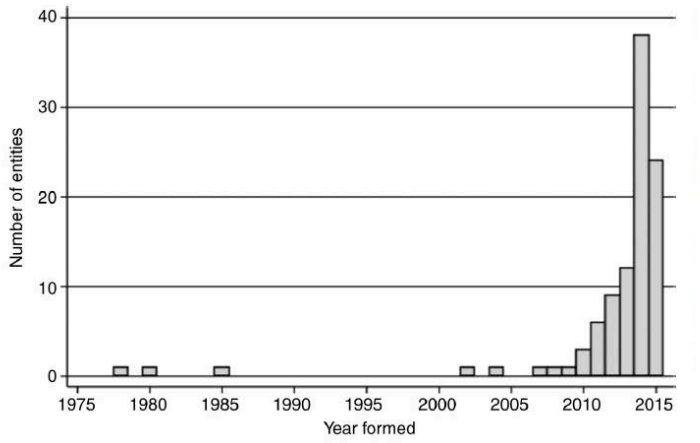
In terms of the product type, the whole insects commanded the largest share of the international market in 2017 according to the market research, mainly due to their easy availability, less cost when compared to processed insects, and unavailability of the processing techniques in some regions (Globenewswire, 2018). Accordingly, Di Magliano (2016) reported that final products of insects rearers consist 73% of whole dry insects and 14% of insects' raw materials, such as proteins, fats, chitin, or amino acids, which are usually used as ingredients for feed products.

Considering the market value of insect-based snacks, protein bars and powder in the U.S, the latter is expected to represent the largest value in 2023, followed by snacks (Globenewswire, 2018). Thus, the production of insect powder or flours is a very promising activity since it has the highest share of market value and is expected to increase by 2023.

4.2. The international entopreneurial ecosystem

Entopreneurs are defined by Engstrom (2019) as "companies, organisations and individuals who either are working on an edible-insect product, are planning to deliver one or are just advocating the benefits of eating insects". Insect farming and other related businesses are also included in the definition. As Dossey *et al*. (2016) reported, the number of insect-based startups significantly increased between 2010 and 2015 (see Figure 7). By 2015, the authors could identify a total of 122 insect-based food companies, insect farms, insect-based animal feed companies, and insect industry advocacy organizations, while ten years before, there were less than 5.

Figure 7. Growth of the insect-based food industry 1975-2015



Source: Reproduced from Dossey et al. (2016)

In the recent years and thanks to the efforts of the FAO and other research organizations in bringing the potential of edible insect food to the public attention, investment and funding for entopreneurs has risen specially in Europe and the United States. For instance, Strickland (2017) reports that in 2016 $6 million were invested into the edible insect industry in the US, a six-fold increase over 2015.

European investors are also showing interest in the edible insect market as show the 15 million euros funding for InnovaFeed, a France based biotech company. According to the company, this funding will go towards the construction of their second industrial site, which will have capacity of 10,000 tonnes per year (Byrne, 2018). Accordingly, the IPIFF (2019b) reports that by September 2019, a total of more than €600 million was raised by European insect producers through investments and are expecting to raise more than €2.5 billion by the mid-2020s. In Latin America, Alba Rodriguez, a 24 young entopreneur received a $40k funding to further develop her grasshoper-based cookies start-up "Gricha" after starting it in 2015 (Arteaga, 2017).

Di Magliano (2016) depicted in a map how the edible insect industry is developing (Figure 8). According to their findings, in 2016, 59% of the companies were located in Europe, 32% in North America and 9% elsewhere. Thus, it is clear that Europe is leading the edible insect market in the world. For instance, the IPIFF reports that over 6,000 tonnes of insect protein are produced in Europe annually and by 2030, the organization expects it to be around 3 million tonnes (IPIFF, 2019b).

Figure 8.Geographical location of companies in the edible insect market, divided by sector

Source: *Reproduced from Di Magliano (2016)*

Although Europe is leading the start-up scene of edible insects, Thailand is the most dynamic market on production of edible insects in the world. There, insect production is very well established. In 2013, there were 20 000 cricket farmers reported in Thailand. However, 30 years ago the situation was very different. Cricket farming in Thailand was initially started in 1998. The farming technology was developed by entomologists at Khon Kaen University and then disseminated to interested farmers nationwide, through training courses. In addition, strategies to promote public awareness of cricket farming and their consumption were implemented in order to increase the market demand for crickets. For instance, small scale cricket farms were introduced to students at primary schools and cricket cooking fairs and competitions were organized for public awareness promotion (Hanboonsong *et al*, 2013).

In Latin America, the situation is very different. Bermudez-Serrano (2020) criticizes the fact that the region is been left behind of the international edible insect market even though it has a long tradition of eating edible insects and it is currently the second biggest market according to Figure 6. The author analyzed the current entrepreneurial ecosystem in Latin America and reported a total of 28 companies producing edible insects in Latin America. Of these, there are 26 companies working specifically in the food sector. The countries with most identified entrepreneurships in the region are: Mexico, who is leading the list with 13 start-ups, Costa Rica with 4 and Brazil wit 3 companies. The author argues that apart from the three companies classified as 'professional insect farmers', the rest are rather small and infant entrepreneurships. However, Brazil has the biggest and most established company in the region: Nutrinsecta (Bermudez-Serrano, 2020).

Although the sector of edible insect products is still infant, there are some initiatives aiming to bring standardization and quality and safety assurance to the players in the market. One of these initiatives is the International Platform of Insects for Food and Feed (IPIFF), the EU non-profit organization, which according to their official website (IPIFF, 2018), represents the interests of the insect production sector towards EU policy makers, European stakeholders and citizens. It is composed of 52 members and the main objective is to promote the use of insects for human consumption and insect-derived products as a top tier source of nutrients for animal feed. The offices are located in Brussels, Belgium (IPIFF, 2018).

Another active organization in the sector is the AFFIA, the Asian Food and Feed Insect Association, "which main aim is to bring industry and research stakeholders from the insects' sector in a collaborative movement towards the development of entomoculture, entomophagy and their related activities (AFFIA, 2019). According to their website, the association is located in Thailand and currently has 9 industry members and 2 associate members.

Also, in 2016 the North American Coalition for Insect Agriculture (NACIA) was created. According their official website, "NACIA is an organization for growing the Insects for Food & Feed Industry and its role is to educate and help build awareness and acceptance for insects as a solution to up-cycle nutrients back up into the food chain. It was first founded as the North American Edible Insect Coalition (NAEIC) but then the name was changed to better reflect the broader diversity of species and applications for insects and insect products (NACIA, 2019).

In Latin America the only active organization promoting edible insects is the Brazilian Association of Insect Farmers (ASBRACI) which was created in 2015. The Association has a Facebook page (Asbraci Associação Brasileira dos Criadores de Insetos) and organized the first Brazilian Congress on Insects for Food and Feed in November, 2019.

4.3. Costa Rica: a development success

The Republic of Costa Rica is a country located in Central America, between Panama and Nicaragua, bordering the Caribbean Sea and the North Pacific Ocean. It comprises 51 100 km^2 of territory and has a population of 5 million inhabitants. Costa Rica exhibits a tropical and subtropical climate, with a dry season from December to April and a rainy season from May to November with an average temperature of 24 C the whole year (CIA, 2020).

The World Bank (2020) classifies Costa Rica as a development success story, mainly because of the steady economic expansion it has experienced as an upper middle-income country for more than two decades. This development is mainly a result of a strategy implemented in the 80's related to openness to foreign investment and gradual trade liberalization. Its recent economic performance has established it as one of the most prosperous economies in the Latin American region, with a certain

degree of macroeconomic stability achieved thanks to a combination of political stability and social contract (Monge-Gonzalez, 2016).

The country's Gross Domestic Product (GDP) is US$60.55 billion, one of the highest in the region and its strong human development are also a reflection of the success of the country in recent decades, contributing to place the country up the global ranks, higher than the other countries in the region (World Bank, 2018). The literacy rate is 97.9 percent (CIA, 2020) and higher education is dominated by five public universities: the Universidad de Costa Rica, the Universidad Estatal a Distancia, the Universidad Nacional de Costa Rica , the Instituto Tecnológico de Costa Rica and the Universidad Técnica Nacional (Monge-Gonzalez, 2016).

Costa Rica is also seen as a global leader for its environmental policies and accomplishments, mainly thanks to the innovative program of Payments for Environmental Services that has been successful in promoting forest and biodiversity conservation and has helped the country build a "Green Trademark" (CIA, 2020). Costa Rica is thus the only tropical country in the world that has reversed deforestation (The World Bank, 2020). As of 2011, 51.5% of the total land was comprised by forest (CIA, 2020).

Since the mid 1980s, Costa Rica has followed a growth model based on both promotion of domestic export activities and the attraction of FDI in high-tech sectors focusing on export markets. These efforts have allowed the country to progressively shift its export composition from primary products to high-tech manufacturing and more sophisticated services (Monge-Gonzalez, 2016). The top five exported products are medical devices (30%), bananas (8,7%), pineapple (8,4%), food products (4,1%) and coffee (2,4%) (COMEX, 2020). According to the Ministry, Costa Rica mainly exports to the United States (42%), European Union (20,7%) and Central America (20,2%).

Additionally, due to its great biodiversity (5% of the world's total), Costa Rica is internationally considered as a key destination for ecotourism. Thus, the tourism sector is highly relevant for the country's economy (CIA, 2020).

In terms of foreign direct investment (FDI), CIA (2020) described Costa Rica as an attractive destination due to its political stability and relatively high education levels, as well as the incentives provided in the free-trade zones. Accordingly, the country has attracted one of the highest levels of FDI per capita in Latin America.

Despite its relative economic success, Monge-Gonzalez (2016) state that the country still needs to achieve high and sustainable growth rates that would ensure a higher level of economic and social development. The country is still pending efforts in improving income distribution and reducing the percentage of the population living below the poverty line to increase opportunities for radical innovations (Monge-Gonzalez, 2016). In addition, there are still challenges that hinder its competitiveness such as poor infrastructure, high energy costs, bureaucracy and weak protection of investors (CIA, 2020).

4.3.1. Entopreneurship in Costa Rica

Costa Rica is one of the countries in Latin America where entomophagy was lost. However, in the last years there have been some small initiatives to revive the consumption of insects among the population. The Museum of Insects of the University of Costa Rica is one of the main actors in the field, since it has been promoting the consumption of edible insects during the past 10 years. In addition, a few entrepreneurs have started rearing and selling edible insects and processed products, such as Grillos en Costa Rica, Costa Rica Come Insectos, CRIC and Gricket House. And surprisingly, Costa Rica was listed as the second country in Latin America with most entopreneurships after Mexico (Bermudez-Serrano, 2020).

Lately, the National Research Centre for Food Science and Technology (CITA) obtained public funding for the project titled: "Insect consumption and its application in food matrices in Costa Rica: challenges and opportunities of a potential strategy for strengthening national food security"[6]. The main objective of the project is to encourage the consumption and production of insect-based foods in the country.

[6] http://www.cita.ucr.ac.cr/insectos

Chapter 5: Methodology

5.1. Description of research approach

The research was exploratory due to the scarcity of previous works on the topic. As stated by Robson (2002), an exploratory study is a valuable means of finding out "what is happening; to seek new insights; to ask questions and to assess phenomena in a new light" (p. 59).

In order to answer the proposed research questions, the qualitative approach was selected. Contrary to the quantitative research that uses numbers as data, the most basically definition of qualitative research is that it uses words instead (Braun and Clarke's, 2013 cited in Merrian, 2016). A qualitative design is about understanding a phenomenon and how people interpret it, how they construct their worlds and the meaning they give to their experiences (Merrian, 2016).

5.2. Data Collection methods

Several qualitative methods were used to extract the data in the different stages of the research, mainly desk review, in-depth interviews, observation through a production plant visit and a focus group discussion. The main data collection methods used are depicted in Figure 9.

Figure 9. Different data collection methods used in the research

Source: Own elaboration

5.2.1. Key Informant Interviews (KII)

Key informant interviews were used as the research method to answer objectives 1 and 2. The use of key informants is a common practice in the business research. This technique means asking the person contacted to act in an informant role. As Goetz & Lecompte (1984) describe, key informants are individuals who possess special knowledge or status, who are willing to share their knowledge and skills with the researcher and who have access to perspectives or observations denied to the researcher. It is assumed that selected informants have thorough knowledge and ability to articulate it (Seidler, ,1974). Thus, they were not selected randomly, but were chosen on the basis of "theory and/or data

driven" criteria first, understanding who had access to the required data, and "personality" criteria second, in terms of who is able and willing to share the information (Heyrman & Goedhuys, 2018).

Semi-structured interviews were carried out, meaning that the interviewer generally starts with a few specific questions and then follows the individual's tangents of thought with interviewer probes (Cooper, 2014). The initial semi-structured questionnaires can be found in Annex 1 and 2.

5.2.2. Case study (facility visit)

In order to gather more detailed information about the process of cricket powder production, as well as the main challenges and opportunities related to it, a case study was analyzed.

A case study is an in-depth description and analysis of a bounded system (Merrian, 2016). It is defined by Robson (2002) as "a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real-life context using multiple sources of evidence". Thus, case studies are a frequent tool for exploratory research since it helps answering the 'why?', 'what?' and 'how?' type questions. The case study usually combines individual and/or group interviews with record analysis and observation (Merrian, 2016). The objective is to gather multiple perspectives of a single organization, situation, event, or process at a point in time or over a period of time (Cooper, 2014).

5.2.3. Focus Group Discussion

A focus group was selected for addressing the third objective. A focus group is defined as a group of people (typically 6 to 10 participants), led by a trained moderator, who meet for 90 minutes to 2 hours. Group dynamics principles are used by the facilitator or moderator to focus or guide the group in an exchange of ideas, feelings, and experiences on a specific topic (Cooper, 2014).

The focus group discussion falls into the category of action research. According to Merrian (2016), action research not only seeks to understand how participants interpret a phenomenon, but it also aims to engage them in the process in order to solve a practical problem. One of the principals of action research is that it is oriented toward some action or cycle of actions in which researchers and participants engage to improve practice (Merrian, 2016).

Consequently, the design of an action research typically develops during the study trough a cycle of planning, acting, observing and reflection. The researcher initially plans what participants are going to do first, then participants act or implement what was planned, afterwards, they observe what happened and in the fourth phase they reflect on what the next actions will be as a result of the data they have collected and analyzed (Merrian, 2016).

The focus group discussion was organized as a 1-day workshop (see detailed description in section 5.6.1).

5.2.4. Desk review

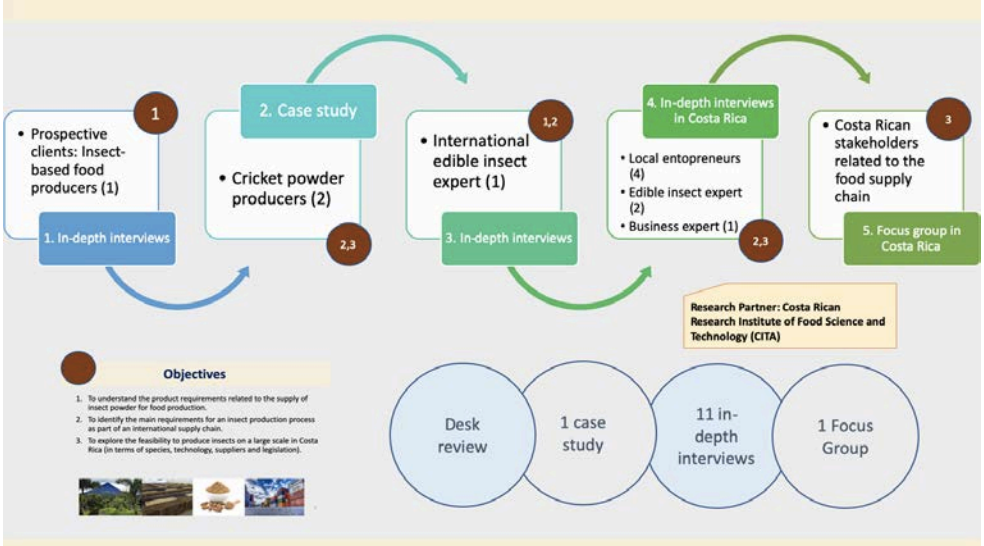
A desk review was performed to gather the necessary technical information related to the production of cricket powder, such as technology, processing stages and food safety requirements. Secondary data was gathered in order to strengthen the conceptual framework and better analyze the results of the previously described methods.

5.3. Description of population and sample

Since the main objective of the research is to discover, understand and gain insights about the cricket powder production and supply chain, the selected sampling is non-probability and purposeful (also known as purposive), meaning that the researcher arbitrarily selected participants from which the most can be learned, according to their characteristics, experiences, attitudes or perceptions (Merrian, 2016; Cooper 2014).

Different samples were used for each of the three methods described previously. A schematic description of the used data collection methods as well as the sample design is presented in Figure 10. In summary, the research was composed of 1 case study, 11 in-depth key informant interviews and one focus group discussion. As seen in the diagram, every one of these techniques was used to address the different objectives of the research.

Figure 10. Outline of the sample and data collection methods

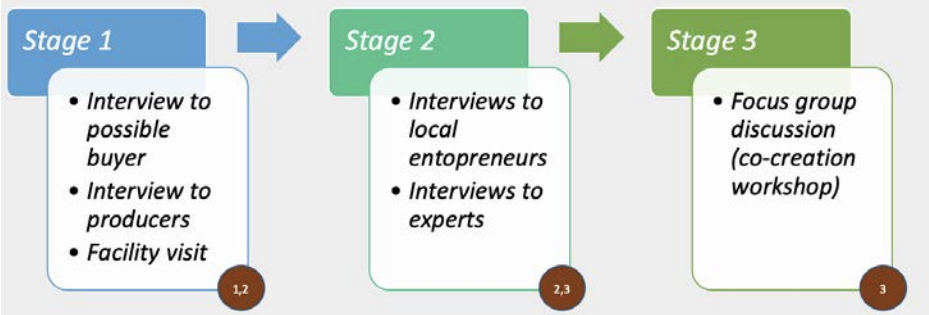


Source: Own elaboration

The activities performed during the field research were organized in three main stages (Figure 11). The red points symbolize the research objectives related to each stage. In Stage 1 interviews to a possible buyer and current industrial producers were performed, as well as a visit to a cricket processing facility. Stage 2 is focused in objective 2 and 3, where local entopreneurs and experts in edible insects

were interviewed. Finally, stage 3 includes the coordination of the focus group discussion in Costa Rica.

Figure 11.Outline of the field research



Source: Own elaboration

A complete list of the interview partners is available in Annex 4. The selected samples are described in the following sections.

5.3.1. Sample for Stage 1

5.3.1.1. Possible buyers

The target group for the first Key Informants Interviews (KII) were insect-based food producers in Latin America, Western Europe or North America, considering that these are the prospective buyers of the cricket powder. The selected population were the companies producing insect-based food products, such as crackers, granola insect bars or snacks, for which they need to buy insect powder, and ideally cricket powder. A quota sampling was performed, with the aim to interview three business owners to get the insights about the requirements they demand for the cricket powder. However, only one of the contacted companies was willing to participate in the research. The selected company asked to remain anonymous. The company is a start-up that produces insect-based snacks and is located in Berlin, Germany.

5.3.1.2. Producers' interviews and facility visit

One of the aims of the research was to analyze the production requirements for crickets in a tropical country. According to Engstrom (2019), there are 44 start-ups rearing insects for human consumption around the world. Of those, only seven are located in tropical countries. Other three companies were identified by the researcher, accounting for a total of 10 companies producing insects in an industrial scale in tropical countries. Of those, only 5 rear crickets. The sampling was performed in a purposive way, selecting at least one company out of these five that would allow the researcher to perform an interview to one co-founder and a visit to the processing facility. It was required that the company has at least 2 years in the market and it had to be located in a tropical country. The final

selection depended on the willingness of the company to be part of the research. Thus, in this case a convenience sampling was used, meaning that the researcher selected any pre-selected company willing to allow the plant visit and observations.

The selected company for the case study is Global Bugs Asia, a cricket powder production facility located in Hua Hin, Thailand and funded by two Swedish entrepreneurs.

In addition, another company located in Vietnam (producer 1) that was sampled accepted to be interviewed without a facility visit. Thus, two interviews were conducted and one facility visit.

5.3.2. Sample for Stage 2: Interviews to entopreneurs and experts

Table 2 summarizes the interviews conducted during stage 2 of the research.

Table 2. Description of interview subjects in Stage 2

Interview No.	Code	Position	Company	Description	Location	Interview Type	Interview date
4	Local technical expert 1 **(LTE 1)**	Biologist Technician	Costa Rican Museum of Insects, University of Costa Rica	Biologist pioneer in promoting edible insects in Costa Rica	Costa Rica	In person	13.11.19
5	Local Entopreneur 1	Co-Founder	Gricket House	Entrepreneurship producing energy bars with cricket powder for the local market	Costa Rica	In person	21.11.19
6	Local Entopreneur 2	Co-Founder	CRIC (Costa Rican Insect Company)	Local start-up aiming to export cricket powder to the international market	Costa Rica	In person	29.11.19
7	Local Entopreneur 3	Founder	Grillos en Costa Rica	Entrepreneur producing and selling crickets on a small scale	Costa Rica	In person	02.12.2019
8	Local Business expert	Program Coordinator	AUGE	Incubator business coach for entrepreneurs	Costa Rica	In person	02.12.19
9	Local technical expert 2 **(LTE 2)**	Head Entomologist	Butterfly Experimental Garden, University of Costa Rica	Expert in entomology	Costa Rica	In person	Part 1: 05.12.19 Part 2: 13.12.19
10	Local Entopreneur 4	Founder	Costa Rica Come Insectos	Pioneer entrepreneur producing and selling edible insects in the local market	Costa Rica	In person	19.01.2020
11	International expert	Founder and Consultant	Entovegan	Promoter of edible insects	Thailand	Skype call	05.02.2020

5.3.2.1. Sample of Local and International Experts

Considering that the tradition of entomophagy was lost in Costa Rica, there are not many experts on the topic of edible insects. However, there are two biologists that were pioneers in the field, since they started rearing and consuming insects around 10 years ago. Federico Paniagua (LTE 1) works as biologist technician in The Museum of Insects of the University of Costa Rica. Ricardo Murillo

(LTE 2) works as Head Entomologist of the Experimental Butterfly Garden of the University of Costa Rica. Federico and Ricardo were considered as local experts.

In addition, and in order to understand the business ecosystem and the support entrepreneurs can get in Costa Rica, a local business expert was interviewed. The expert works as program coordinator at the Agency for Entrepreneurship Management of the University of Costa Rica (AUGE), which acts as an incubator of business ideas.

The purposive sampling was used in order to gain insights from an international expert in edible insects, considering there are not many business experts in the field (most of them are academics focusing on entomology studies). Thus, a business expert, Josh Galt, was selected and recruited. Josh has been working in the field of edible insects around 10 years, first as avid consumer of insects and then as promoter and business consultant for companies and investors in the field.

5.3.2.2. Sample of Local entopreneurs

Through a preliminary research, 2 entrepreneurships were identified in Costa Rica producing cricket-based products. The founders of these business were initially sampled as local entopreneurs to get insights of their main challenges and opportunities. However, through the snowball sampling, 2 more entopreneurs were identified and included in the sample. In total four local entopreneurs that rear crickets were interviewed in Costa Rica.

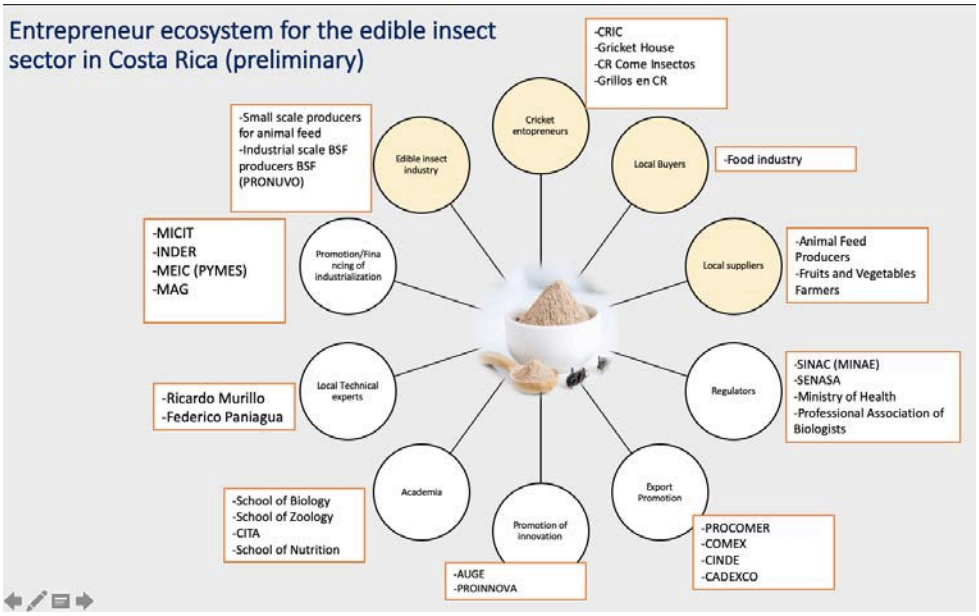
5.3.3. Sample for the Focus Group Discussion

The sample for the focus group discussion were key stakeholders related to the food industry and the infant edible insect sector in Costa Rica, specifically:

- Current entopreneurs
- Food Association Representative
- Local Technical Experts
- Public authorities: Ministry of agriculture, Ministry of Economic Affairs, Ministry of Health, Chamber of Commerce
- Representatives of the agri-food industry (private companies)

This sampling was performed using mainly the snowball technique, meaning that the participants were referred by the interviewees according to their knowledge of the business ecosystem related to the edible insect in Costa Rica. Additional research was performed to select key stakeholders that were not mentioned by the interviewees, focusing on key actors from the public and private sectors. With the gathered information, a preliminary entrepreneur ecosystem chart was created after the first interviews in Costa Rica were performed (see Figure 12).

Figure 12. Preliminary entrepreneur ecosystem for the edible insect sector in Costa Rica



Source: Own elaboration

According to this chart and considering the budget limit (defined by the research partner, CITA), a total of 28 stakeholders were selected for the workshop (see complete list in Annex 5), in order to have a maximum of 25 attendants (considering cancellations and no shows). The final number of participants was 23. The original attendance list is available in Annex 7.

5.3.4. Additional interviews

Once the main results of the research were obtained, additional interviews were performed to better analyze the findings. In this case it was important to get the insights of international expert in the edible insect sector, as well as a possible investor.

The information of the interviewees is summarized in Table 3. All interviews were performed via Skype.

Table 3. Description of additional interviews performed

Code	Name	Position	Institution	Description	Interview date	Duration
Possible Investor	Anonymous	CEO	Anonymous	Businessperson interested in investing in the edible insect sector in Latin America	11.05.20	60 min
AFFIA Representative	Anne Dequerry	President	Asian Food and Feed Insect Association (AFFIA)	Association of insect producers in Asia	18.08.20	30 min
IPIFF Representative	Joash Mathew	Scientific Affairs	International Platform of Insects for	Association of insect producers in Europe	02.09.20	60 min

			Food and Feed (IPIFF)			

5.4. Research partner

Located in San José, Costa Rica, the National Research Centre for Food Science and Technology (CITA) was created in 1974 and since 1996 was consolidated as a national interdisciplinary center dedicated to research, human resources training and scientific and technological assistance of the national agri-food production sector. The main objective is to investigate and develop knowledge in food science and technology in close connection with the agri-food sector to innovate, increase their competitiveness and generate high quality food (CITA, 2019).

The business model encompasses a close interaction between the academic sector, the local food industry and the government institutions. Thanks to this established network, knowledge can be generated and transferred to enhance national production, increase its competitiveness and develop new technological options that facilitate commercialization in a globalized world (CITA, 2019).

The CITA is organized into four processes: Research, Analytical Services, Consulting and Training, all of them working under a quality management system that ensures the fulfillment of the needs of the agri-food sector. The Center has international certification under the ISO 9001 standard and the accreditation of a good part of its analytical tests of the Costa Rican Accreditation Entity, ECA, under the INTE-ISO 17025 standard (CITA, 2019).

In recent years the development of the center has focused on the generation of innovative products and technologies that seek the nutritional and functional quality of agri-food products. One of these initiatives is the project titled: "Insect consumption and its application in food matrices in Costa Rica: challenges and opportunities of a potential strategy for strengthening national food security"[7]. The main objective of the project is to encourage the consumption and production of insect-based foods in the country. Thus, the present research will be one of the outputs of the national project launched by CITA.

5.5. Research timetable

The study lasted approximately twelve months, starting with the process of formulation of the thesis design and concluding with the corresponding submission to the academic board. Table 4 provides a summary of the research process.

[7] http://www.cita.ucr.ac.cr/insectos

Table 4. Research process (Own elaboration)

Year	**Year 2019**						**Year 2020**							
Place	Leipzig, Germany			South East Asia	Costa Rica				Leipzig, Germany					
Month	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Activity															
Thesis Proposal and Approval															
Data Collection (field research)															
Data Analysis															
Thesis Writing															
Final Thesis Submission															

5.6. Outline and location of the field research

The field research started in Germany on September 19th, 2019 from where, the researcher travelled to three different countries, as shown in Figure 13. The first destination was South East Asia in October 2019, specifically Vietnam and Thailand in order to visit the industrial cricket powder producers. Finally, the researcher travelled to Costa Rica from November 2019 to February 2020, where Stage 2 and 3 were conducted.

Figure 13.Different locations of the field research

Source: Own elaboration

5.6.1. Description of Stage 3: Workshop with stakeholders in Costa Rica

The focus group discussion was organized as a 1-day workshop that took place on January 21st, 2020. The activity was titled: Co-creation Workshop: "Exploring the challenges and opportunities for the production and export of cricket powder in Costa Rica". The main objective of the workshop was to gather the main actors of the local entrepreneur ecosystem to jointly explore the possibilities of producing and exporting cricket powder in Costa Rica.

The venue of the workshop was Hotel Parque del Lago, located in San José, Costa Rica. All the related expenses were paid by the University of Costa Rica, as part of the budget of the project B9611 "Consumo de insectos y su aplicación en matrices alimentarias en Costa Rica: retos y oportunidades de una estrategia potencial para el fortalecimiento de la seguridad alimentaria nacional"[8], coordinated by CITA.

5.6.1.1. Invitations and planning

On December 16th 2019, invitations started to be sent via email to the selected participants (see Annex 5 for the detailed list). Participants were contacted via phone and email to assure they received the invitation and explain the purpose of the workshop. The Project DESCUBRE, a joint Comission of PROCOMER and COMEX, supported the initiative of the workshop by sending invitations to key public agencies. On January 15th, once confirmations were received, a preparatory document was sent to the participants, explaining the background and objective of the workshop as well as outlining the agenda (see Annex 9).

In addition, a guidance document with a detailed script for the whole day was elaborated (see Annex 10). The aim of this document was to assure objectives of the activities were met in the appropriate timings. All the activities of the day were detailed and explained, so that the moderators (see Annex 6) could prepare accordingly and follow the instructions during the workshop.

5.6.1.2. Plenary session and Tasting

The detailed agenda of the workshop is available in Annex 8. Considering that not all participants had knowledge about the edible insect sector, three expert talks were presented during the morning session. These talks were directed towards giving an overview of the edible insect sector and the preliminary results of the research project in question.

The first presentation was held by Ing. Ana María Quirós, academic and researcher of CITA on the project B9611. The title of the talk was: Opportunities and challenges of edible insects in the world. The main objective was to give an overview of the state of the edible insect industry. The second presentation was in charge of Eliso Kotsieva, consultant of Fundación para el Desarrolllo Sostenible

[8] *Insect consumption and its application to Costa Rica food items: challenges and opportunities of a potential strategy for the national food security.*

(FUNDES). The topic was Edible Insect Supply Chain Opportunities (Study Descubre 150). The objective was to explain the main results of the Study Descubre 150 (explained in section 3.5.1).

Finally, the researcher presented the preliminary results of Stage 1 and 2 of the present study, in order to give participants with insights on the market and production requirements for industrial cricket powder.

An edible-insect tasting session was organized in the morning break. Entopreneurs exhibited their products and provided explanations to the curious participants (see Figure 14).

Figure 14. Participants tasting edible insects during the workshop

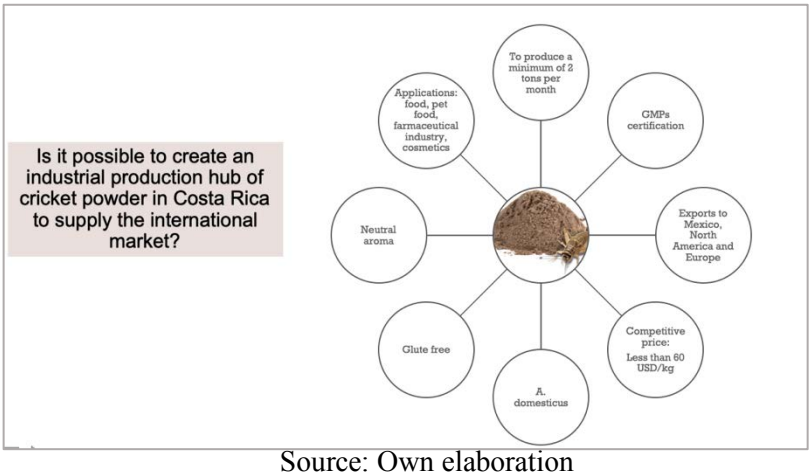
Source: Pictures taken during the workshop

5.6.1.3. Scenario for the Focus Group Discussions

During the afternoon session, a focus group session was moderated based on the design-thinking approach. A scenario was presented to the participants, as main thesis for the discussions (

Figure *15*). This scenario was based on the preliminary results gathered in Stage 1 and 2.

Figure 15. Scenario for the focus group discussion



Source: Own elaboration

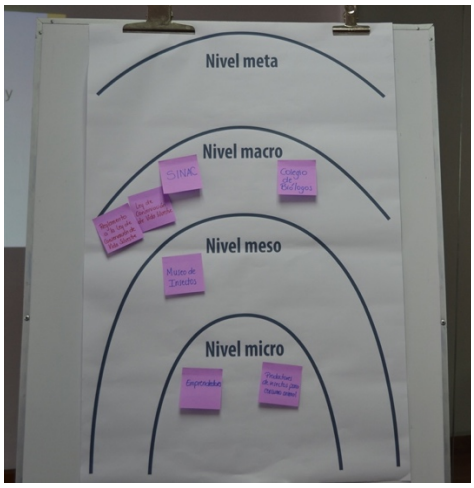
With this scenario in mind, three focus group discussions were organized during the afternoon session plus a feasibility question activity, each of which had a specific objective.

5.6.1.4. Activity 1: Descriptive Stakeholders Mapping

The objective of this activity was to map the key actors in the entrepreneur ecosystem related to edible insects in Costa Rica, considering the four levels of the systemic competitiveness approach.

Participants were divided in four groups considering their knowledge and expertise, namely: technical, regulation, innovation, and production/exports promotion. A complete list of the groups can be found in Annex 11. Each group was assigned a post-it color. Participants were asked to write on post-it's the key actors and elements they could identify for each systemic level related to the edible insect industry in Costa Rica. Then, each group had to paste their post-its in the common map. Some examples were posted already in the common map by the moderator, in order to orient the participants (see Figure 16).

Figure 16. Stakeholders map draft for Activity 1



Source: picture taken during the workshop

Each group had 30 minutes to discuss, write their findings on the post-its and paste these on the map.

5.6.1.5. Activity 2: Identifying challenges and opportunities

The objective of this activity was to jointly identify the main challenges and opportunities related to the production and export of cricket powder in Costa Rica. The same groups as Activity 1 were kept. Participants were asked to write on post-it's the main challenges and opportunities in each systemic level related to the scenario of the workshop (see Figure 17). They had a total of 24 minutes to discuss and brainstorm.

Figure 17. Brainstorming session during Activity 2

Source: picture taken during the workshop

Afterwards, they were asked to categorize the weight of each challenge and opportunity already identified, by pasting a colored dot on each post-it, where red meant "heaviest", yellow "not that heavy" and green "lightest". For the challenges, this coding would be related to how difficult it would be to surpass that challenge, while for the opportunities, it should be understood as how important that opportunity would be for achieving the desired scenario. A total of 10 minutes was assigned to pasting the colored dots. After completing the tasks, a member of each group presented the results of the activity to the rest of the participants.

5.6.1.6. Feasibility Question

A straightforward question was asked to participants, regarding the feasibility of producing and exporting cricket powder in Costa Rica. The objective here was to understand if the participants visualize a cricket powder industry in Costa Rica as feasible and in what period of time. Three pieces of paper were located on the floor, containing the following statements: "No, it is not feasible", "Yes, it is feasible in less than 5 years" and "Yes, it is feasible in more than 5 years".

Participants were presented with the following question: Do you think it is feasible to produce and export cricket powder on an industrial level in Costa Rica? In order to answer the question, participants had to locate themselves on one of the available statements. The responses had to be given individually. After each participant was properly located, according to their answer, a picture was taken to show where they were standing.

5.6.1.7. Activity 3: Strategy ideation

The main objective of this activity was to propose possible strategies to develop a cricket powder industry in Costa Rica. Participants were reassigned to new groups, in order to have

interdisciplinary teams. A detailed list of the groups can be found in Annex 11. Each group was presented with a package of materials, that included a set of Legos, a set of Legos Serious Play Series, paper, images, colored post-its, pens, scissors and other sketching materials (see Figure 18).

Since the idea was to boost creativity by using the materials, a warm-up exercise was performed. Participants were asked to create an innovative umbrella in only 10 minutes. After this initial warm-up, participants were asked to co-create a strategy to achieve the desired scenario. Ideally the strategy had to explain, what must be done, how and when. A total of 1 hour was assigned for the ideation session.

Figure 18. Materials used for the strategy ideation activity

Source: picture taken during the workshop

Afterwards, one representative of each group presented their sketch to the rest of the participants, who then had the chance to comment on the main challenges they identify on the presented strategy.

5.6.1.8. Media management and Summary Report

The Department of Press of the University of Costa Rica was present during the focus group discussion, in order to do a media coverage of the workshop. The researcher and some participants were interviewed in order to write an article for the local media.

After the workshop, the researcher elaborated a summary report and sent to participants. Summaries of the plenary session, pictures and key contact information were included. This document is available in Annex 13.

5.7. Data Management

All conducted interviews were audio recorded (with the permission of the interviewees) to facilitate the processing of the data. When possible also pictures of the production areas were taken, after permission was granted from the interviewees.

After the data was collected, the responses of the interviews were transcribed in their original language (either Spanish or English), and successively translated to English when applicable. Afterwards, the transcriptions were revised in order to assure coherence with the original data source, and later entered into the software tool MAXQDA (Version 20.0.8; 2020) for the posterior analysis. A pseudonym was assigned to each one of the interviewees, as a means to protect the right to confidentiality.

In the case of the facility visit, only pictures of the outside of the facility were allowed and notes were taking during the visit.

The maps and tables created in Activities 1 and 2 of the workshop were transcribed into Excel tables. In the case of Activity 3, the presentations of results from the four groups were recorded and transcribed. Additionally, the closing discussion of the workshop was recorded and transcribed. The different transcriptions were then entered into the software tool MAXQDA (Version 20.0.8; 2020) for the posterior analysis.

Considering that the participants of the workshop were not very knowledgeable with the systemic levels presented, the data gathered in Activity 1 and 2 of the workshop was revised by the researcher to make sure that the information included by the participants for each level corresponded to it. Whenever this was not the case, the data was reassigned to the correct level.

For Activity 2, the challenges and opportunities identified by the groups were listed and reorganized according to each systemic level. Similar concepts from different groups were listed only once and assigned a numeric value according to the frequency and weight. Color red was assigned a value of 10, color yellow, 5 and color green a value of 1. With the weighted values, the main constructs were schematized in a graph using Excel.

For Activity 3, recordings of the presentations of each group were used to complement the graphic data and list the main elements listed in the different strategies.

5.8. Data Analysis

The data was analyzed following the qualitative content analysis approach for the analysis of text, by "allowing categories to emerge out of data and on recognizing the significance for understanding the meaning of the context in which an item being analyzed (and the categories derived from it) appeared" (Bryman, 2004, p. 542).

The coding system was categorized using the systemic competitiveness framework using each systemic level as main categories: meta-, macro-, meso- and micro level. Each subcode was then listed according to the main concepts investigated.

Chapter 6. Results: Understanding Market and Production Requirements

6.1. Understanding Market Needs

Important information related to the main market needs for cricket powder could be collected through the conducted interviews and secondary data, such as the market research report of Meticulous Research and the Study Descubre 150, which results were presented on the plenary session of the workshop and aims to boost innovation in agriculture, as well as find new goods and export markets for Costa Rica, based on global macro trends. In the study, edible insects were selected among the top 10 products with more export potential for Costa Rica (FUNDES, 2019). The following sections describe the main results.

6.1.1. Current Demand

According to the information mentioned by the interviewed producers, the main buyers of cricket powder are food producers who manufacture insect-based food products such as cookies, granola bars or flour and pet food producers, who manufacture "gourmet" pet food containing insect protein. Clients are mainly located in Europe (Finland, England, Belgium, Germany) and Asia (Thailand and Japan).

Although these producers are not targeting the American market, FUNDES (2019) reported that Mexico, North America and Europe are main potential markets for Costa Rica. According to this report, in Europe, the main potential buyers are located in the UK, the Netherlands, Denmark and France.

One of the main interesting findings of the interviews was the fact that there is a growing interest from the cosmetic and pharmaceutical industry on buying cricket powder. According to producer 1, this is a very interesting market that is developing specially in Japan.

The possible buyer and current producers were questioned regarding the current client demand of cricket powder. All of them agree that a client can demand between 0,5 to 2 tonnes of product per month.

This goes in line with the investigation of FUNDES (2019) on the reported volumes of exported products in the international market. According to their findings, Thailand exported crickets to Finland, the United States and the United Kingdom in 2018 and 2019. In total, from January to December 2018, Thailand exported 8,15 ton of house crickets to these three countries with a total value of 107, 040 USD. In 2019, the total exported volume was 4,29 ton to the US and the UK with a total value of 60, 941 USD (FUNDES, 2019). According to the report, in September 2019 two imports were registered in the United States, one made by company Six Foods, with a total amount of 290 kg cricket powder coming from the company Jr. Unique Foods ltd in Thailand and the other, with a total of 550 kg dried cricket coming from Dpat Industrial limited in China.

6.1.2. The price

The possible buyer commented that the price of the cricket powder depends on the source, specifically: "European cricket costs 60 euros per kilo. If it comes from Thailand, prices are between 20 and 30 euros." In addition, he mentions that they initially did not start using cricket powder because it is not easy to find an affordable price in Europe, in comparison to buffalo worms, which, according to him, are the most competitive insects in Europe.

Producer 1 also mentioned that the prices of cricket powder vary from 45 to 60 EUR/kg in the international market. Producer 2 stated that the price of cricket powder in Thailand is 60 USD/kg. According to the interviewer, the price of the exported powder in Europe varies according to the volume and the stage of the negotiation: "It depends on how much. Because it's a lot of handling. But it's getting down. If you order more, you would have another price".

These findings are in line with FUNDES (2019), which reported that the price of cricket powder had been stable between 2016 and 2018 with values around 88 USD per kg for retail and the wholesale prices are around 60-70 USD/ kg.

It is important to mention that both interviewed producers stated that the current prices of cricket powder are not affordable and thus, must still be lowered. In the case of producer 2, he mentioned that their goal is to achieve a price of 20 USD per kilo in a couple of years in order to be competitive, while producer 1 states that the prices should come down to reach at least 45 USD/kg.

The same concern was stated by the international market expert, when he mentions that due to the production cost of crickets, it will be difficult to bring the price down, and thus, in his opinion, cricket powder will not be easy to commoditize compared to other insect species:

> In terms of commoditizing the ingredients, being able to use it as a food ingredient in tortillas or bread, something that is a staple in the diet, the cost has to come down. You can't be paying 40-60 USD a kilo. It doesn't work and unfortunately that's where crickets are still. (…). As a boutique product is great. It's a premium product and it is going to stay that way, I think. (International expert, personal communication, 2020)

6.1.3. Product requirements

The most common species reared in the market is A. domesticus. Both producers and local entopreneurs were mainly rearing this species.

The products that are being commercialized by the interviewed producers are whole crickets and natural cricket powder (producer 2) and natural cricket powder, defatted cricket powder and cricket oil (producer 1). Producer 2 showed the researcher a sample of the harvested crickets, as well as the cricket powder (see Figure 19). The researcher tasted the samples. The color of the powder was brown

and it had a strong odor. Crickets were crunchy and had a nutty taste. As can be seen, the crickets are packaged in plastic bags, while the powder is packaged in metallic bags.

Figure 19. Dried crickets and cricket powder produced by Global Bugs Asia

Source: pictures taken during the interview

The company produces different products such as natural crickets, BBQ crickets, chilli crickets, ginger lime crickets and the cricket powder (Figure 20). The products exhibited are sold to the local market.

Figure 20. Global Bugs products exhibition

Source: picture taken during the interview

6.1.3.1. Protein content

One of the reasons why edible insects are recommended for human consumption is their high protein content. Local entopreneurs 2 stated that the protein content was the main requirement their clients ask for and it should be between sixty and seventy percent.

Thus, it is critical to assure a minimum protein content according to the client's expectations. That is what producer 1 stated when asked about the main product quality requirements. As he mentions, the content must be certified or validated through chemical analysis. In their case, they outsource this process to an external laboratory and provide their clients with the certificate of analysis.

The possible buyer also mentioned that their current suppliers provide them with all the technical analysis related to the product specifications.

6.1.3.2. Neutral aroma

When asked about the main quality specifications for the cricket powder, the possible buyer mentioned that aroma was very important because of the kind of food products they produced. He mentioned that for him the cricket powder has a very strong aroma, similar to "fish tomato sauce". He even compared the smell to one of the buffalo worms, stating that the latter has a better odor, similar to nuts, which makes it more suitable for the crackers industry. However, according to the interviewee, the cricket is preferred due to its higher nutritional value.

The possible buyer mentioned that this odor depends on the supplier, sometimes being more intense. He stated that at the end, the feed determines the taste and odor of the crickets.

Local entopreneurs 2 quoted one of their clients when saying: "I am not going to buy a product from you if it does not comply with the characteristics that I use. They must have a long shelf life, they must have a reduced odor, a low aroma."

On this topic, local entopreneur 2 mentioned that this is a quality issue that is related to the rancidity and can be controlled through an adequate packaging. Accordingly, local entopreneur 1 mentioned that they were advised by an expert international entopreneur to include a dehumidifier in the packaging and thus, they do not have an odor problem.

6.1.3.3. Gluten-free specifications

Interestingly, the possible buyer as well as the producer 2 mentioned the fact that the market is asking for gluten-free products. Specifically, the possible buyer mentioned that their clients are asking for gluten free products and thus, they have been pushed to start using cricket powder: "We have been asked a lot about gluten free. For that reason, we are thinking of changing to cricket since you do not get neither buffalo worms nor mealworms in gluten free."

According to the interviewee the reason behind this is that the buffalo and mealworms are being fed with oats, wheat and spelt, which contain gluten and thus, the reared insects may have a gluten content that is higher to the permitted 20ppm.

6.1.3.4. Traceability to the feed

Due to the critical effect of the feed on the nutritional value, taste and odor of the crickets, the clients expect the producers to have a quality system that assures all products can be traced back to the feed. When asked about the main requirement clients are asking for, producer 2 mentioned that:

"So far, it is more about the feed. It is one of the questions coming out. Cause if you say that you are feeding with fishmeal, it won't work".

The cricket powder producer is required to give specific details of the feed that is being used. In this sense, as mentioned by producer 2, using fishmeal is not accepted.

6.1.3.5. Shelf-life

According to the expected shelf life of the product, local entopreneur 2 mentioned that clients ask for a minimum of 1 year.

6.1.3.6. Food Safety requirements

Producer 1 was emphatic that food safety is one of the three critical factors for a cricket powder producer. Thus, every producer has to make sure to comply with the international food safety regulations such as FDA and obtain certifications such as HACCP or BRC. Producer 2 also holds a food safety certification, as was verified during the facility visit. The certification company is Intertek and they obtained a Good Manufacturing Practices (GMP) as well as a HACCP certification.

However, according to local entopreneur 2, none of their possible clients have asked them for a food safety certification yet. Nonetheless, they voluntarily want to have one:

> We know that the definitively HAACP we have to have, the FDA also at an international level, it seems to me that only the Thai government gives a specific certification for the consumption of insects, no one else for the production of insects, but let me tell you if you asked us if we can't sell because we don't have this, the answer is no. (Local entopreneur 2, personal communication, 2019).

6.2. Identifying production requirements

The main findings related to the cricket farming and powder processing were gathered during the facility visit and interview at Global Bugs (producer 2). However, the observations are complemented with the insights of producer 1 in order to broaden the knowledge on the main practices for producing cricket powder in an industrial scale.

6.2.1. Physical structure

During the facility visit, the researcher could observe the layout of the plant, as well as the main processes to farm crickets and later obtain the cricket powder. The production site is approximately 400 square meters. Pictures of the outside of the facility are available in

Figure 21. As can be seen, the plant is totally enclosed and sealed and the surrounding areas are kept clean.

Figure 21. Global Bugs Facility located in Hua Hin, Thailand

Source: picture taken during the visit

Figure 22 shows the plastic containers that are used for rearing the insects. These containers are washed before and after use. Egg cartons are placed in these containers to increase the area for the crickets. The cartons are sealed with a substance which control pests and increases productivity.

Figure 22. Containers used for rearing the crickets (picture taken during the facility visit)

Source: picture taken during the visit

Unfortunately, pictures were not allowed inside of the farm. The farm consists of approximately 20 metallic racks, each with 5 vertical levels. The racks are placed left and right of the main walking hall. There is enough space to walk between the racks. Each level holds containers with different stages of the crickets. There is an additional room where the eggs are kept, where the appropriate conditions are assured so that they hatch in the proper time. The researcher was not allowed in this room. At the opposite side of the entrance, there is a container washing area.

Each plastic container is stacked with egg cartons. On top of the cartons feed and water are placed. The feed consists of a brown powder, which is placed on a plate. The supply of the water is semi-automated and is available for the crickets at all times on a plate.

6.2.2. The process

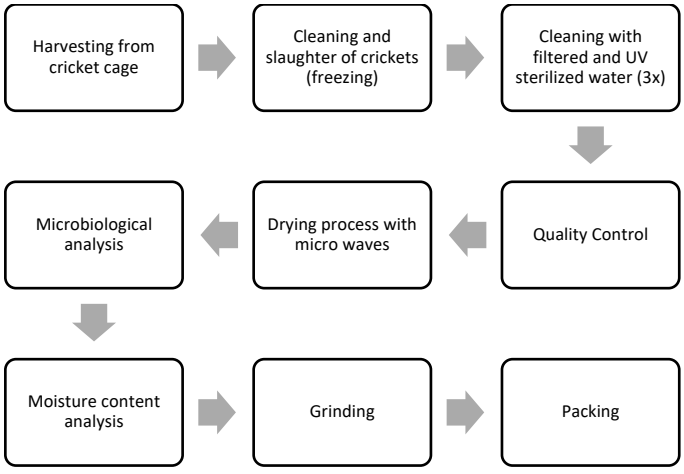
The production models of both producers are very different. Producer 1 works with external cricket producers and then gathers their crickets and centralized the post-processing steps (manufacturing the cricket powder), while producer 2 centralizes all the farming and processing steps in their production facility.

As observed during the facility visit, the process of producing cricket powder has two main steps: the rearing of the crickets, where the result is mature crickets with the desired weight and size, and the post-processing steps to obtain a cricket powder.

At Global Bugs, there is a special area for the egg hatching, where the eggs are taken once placed by the female crickets, to assure appropriate. climate conditions. Once the eggs hatch, the instars are moved to the main farm area and are fed until they grow to the appropriate size. The development of the crickets is monitored to make sure to harvest them in the appropriate time. According to producer 2, the life cycle of their crickets is 35 days, while producer 1 states that they achieve a cycle of 28 days. Both of them mention that the variables that mostly affect the life cycle are the temperature, humidity and the feed and of course the goal is to reduce the life cycle as possible while optimizing growth.

Once the crickets are harvested, they are washed with water and placed in plastic bags to be frozen for 24 hours (slaughter), which according to (Mott, 2018) is a food-safe and humane approach of killing them. The subsequent steps are summarized in Figure 23.

Figure 23.Global Bugs Asia processing steps to obtain cricket powder

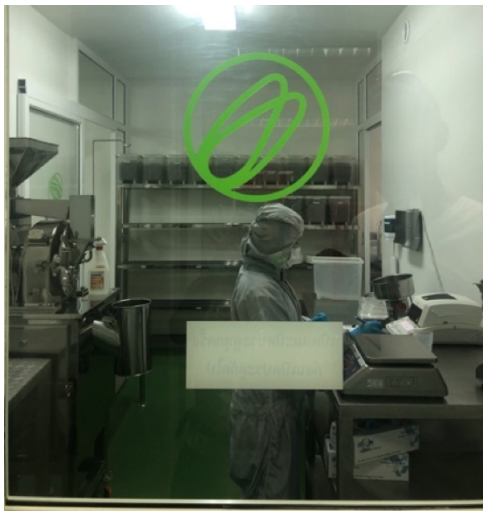


Source: Own elaboration based on the facility visit

As schematized in the figure, once the crickets are harvested, they are frozen for 24 hours, then washed 3 times with water, and finally dried in an industrial microwave dryer (the equipment was made in China). Afterwards, moisture and microbiological analysis are performed before grinding to obtain the powder, which is then packaged. These steps are in line with Mott (2018), who suggests that before further processing, it is necessary to rinse the whole crickets and cooked them completely before consumption to assure food safety (Mott, 2018).

Afterwards, the dehydrated crickets are blended to obtain the powder. The powder is stored in plastic containers in the laboratory area (see Figure 24). Here, the humidity of the powder is monitored. As can be seen in the picture, personnel are wearing protection attire, including gloves and face masks and the equipment used is of stainless steel.

Figure 24. Post processing laboratory



Source: picture taken during the visit

In terms of the total output capacity, producer 2 stated they are producing 5 tonnes of cricket powder per month. Producer 1 did not specify their production capacity but mention that a large-scale production should process at least 10 tonnes of fresh crickets, which would translate into 2,5 tonnes of cricket powder per batch.

There were two employees taking care of the farm while there was another one responsible of the post-processing area. Employees were wearing appropriate attire.

6.2.3. Key Control Points

According to producer 2, the temperature and humidity levels are kept ideally between 30-32 degrees and 50-60 %, specifically. During the visit the researcher verified that the humidity was 51%. In the eggs room, the interviewee explained that temperature is kept at 34 degrees and a higher humidity level is used. Both producers agree that these variables are key for the optimal growth of the crickets.

Regarding the feed for the crickets, both producers mentioned that they developed their feed through trial and error with the help of academic institutions and commercial feed producing companies. They used now a commercial standardized powder feed. Producer 2 mentioned that they use organic waste as part of the formula but did not give more details. However, Cortez *et al*, 2016 and Mott, 2018 report that grains from poultry feed (20-22% protein) are the most common diet currently used for crickets and it has been reported that diets containing from 20 to 30% protein, 32–47% carbohydrate, and from 3.2 to 5.2% lipid were the most satisfactory to rear A. domesticus. Most commercial cricket feed mixes report contents of crude protein less than 20% (Cortez *et al*, 2016). It is important to consider that Acheta domesticus has a 2.1 feed conversion ratio, which means that 2.1 kg dried feed is needed to produce 1 kg of edible product (Cortez el at, 2016).

According to producer 1, water supply is a critical factor, due to the fact that nymphal crickets are so small, they could be trapped in a water droplet and drown. Thus, Mott (2018) recommends that water delivery systems must have a wicking agent such as paper towel, foam, sand, oil or other alternatives. In the case of Global Bugs, it was not possible to observe the water delivery system used for the instars. However, for the more developed stages, water was simply placed in foam plates.

6.2.4. Quality and food safety management system

It was evident that there is a quality management system in place, since personnel kept registers of the temperature, humidity and daily production. The containers were appropriately labeled in order to assure traceability. The farm was built with smooth and cleanable materials. The walls, floor and ceiling were kept clean.

There is a changing room before the main entrance of the farm, where all personnel and visitors have to wash their hands and wear appropriate attire: hair covers, face mask, plastic shoes covers. The floors have drainage and the air is filtered.

6.3. Summary of main findings

The following table summarizes the main findings observed by the researcher in relation to market needs for cricket powder and production requirements.

Table 5 presents the trends related to the potential demand of cricket powder in the international market, extracted from the research performed.

Table 5. Main trends observed for the potential demand of cricket powder in the international market

Key Issue Investigated	Main Observed Trends	Considerations
Potential market	Mexico, North America and Europe	Japan is a growing market, but considering its location it may be difficult to compete.
Main exporters	Thailand and China	-
Average demand	0,5- 2 tonnes per month/client	-
Price	Between 50-60 USD per kg, which is perceived as too high.	To be competitive, the ideal would be to reach less than 45 USD per kg.
Type of buyers	Food producers, pet food producers, cosmetic and pharmaceutical industry.	Considering the scope of the research, the feed industry is excluded.
Type of products	Natural cricket powder, defatted cricket powder, cricket oil	To obtain each type, additional processes are required.

Table 6 summarizes the main findings observed for the quality and food safety producers have to comply with.

Table 6. Main trends observed for the product requirements of cricket powder in the international market

Key Issue Investigated	Main Observed Trends	Considerations
Quality Requirements	The most important requirement is the protein content (at least 60-70%).	The nutritional value must be validated by laboratory analysis.
	Clients are preferring gluten free products.	It is possible to feed crickets with a gluten free diet.
	Avoiding a fishy odor is important	The fishy odor may be due to fat rancidity.
	Traceability until the feed must be assured.	Clients want to know what crickets eat.
Food Safety Requirements	Food Safety Certifications are a plus but not a limiting requirement.	Compliance with GMPs and HACCP are expected.

The data collected from the facility visit and the producers' interviews, allowed to observe some trends related to the production requirements for cricket powder.

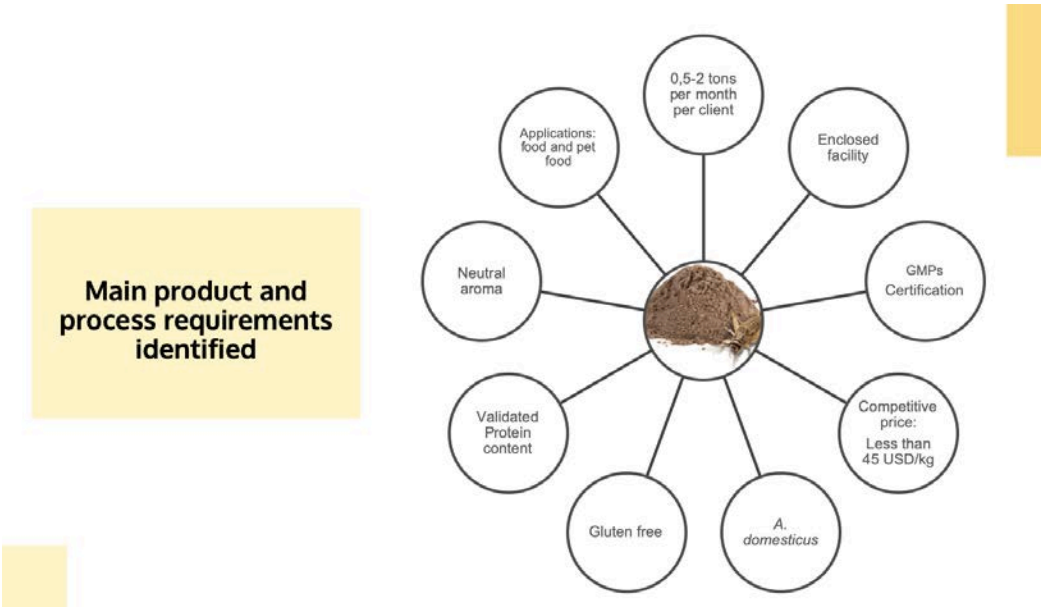
Table *7* summarizes the main trends observed.

Table 7. Main processing requirements to obtain cricket powder, as per the case studies

Key Issue Investigated	Main Observed Trends	Considerations
Plant layout	The main areas are: warehouse, farm, containers washing area, post-processing area, quality laboratory	The farm has a special room for egg development.
Infrastructure	Metallic racks, enclosed facility, smooth walls, floors and ceilings	Cleanable surfaces. It is important to have a sealed area, to avoid entomophagos.
Environmental conditions	Temperature: 30-32 C	For the eggs, temperature and humidity are higher
	Humidity: 50-60%	
Quality and Food Safety Assurance	Compliance to FDA regulation	-
	Hygiene attire available for personnel and visitors	-
	Registers of the production	-
	Appropriate Labeling	-
Personnel	Due Diligence and Project Managements skills are needed	-
	At least 2 operators for the farm 1 for the laboratory area	-
Required Technology	Microwave Dryer, Blender	The microwave was imported from China
Supplies	Plastic containers, egg cartons	-
Feed requirements	The development is performed along with feed companies and academia	It is critical to optimize the process. It requires approx. 1 year of research.
Water requirements	It must always be available	Water can be deadly for instars
Approximate investment	Aprox. 1million USD	-

Figure 25 encompasses the main requirements to be considered if Costa Rican entopreneurs want to immerse in the international cricket powder market. This figure was used as basic ground for the workshop.

Figure 25. Main product and process requirements for cricket powder



Source: Own elaboration

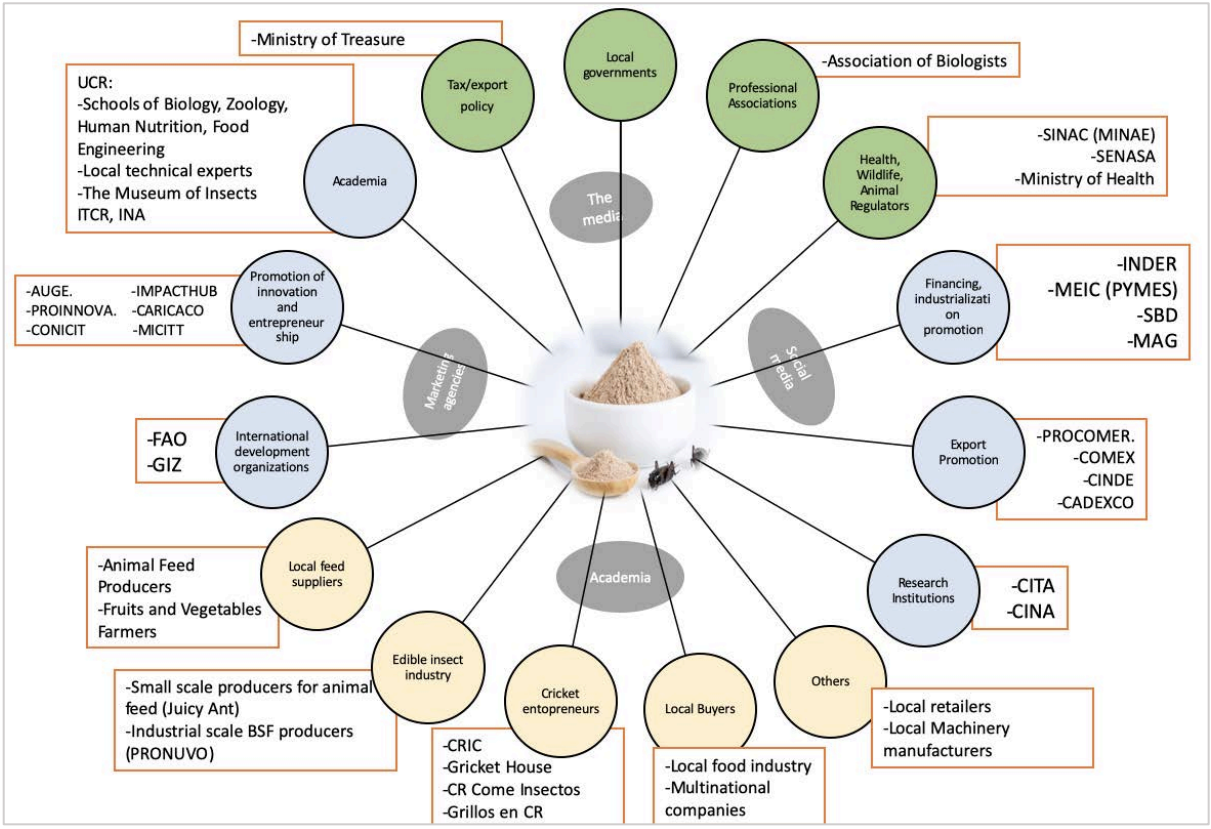
Chapter 7. Results: Exploring the feasibility in Costa Rica

In order to explore the feasibility of producing cricket powder on an industrial scale in Costa Rica, the different systemic levels were analyzed with the purpose to assess the main existent opportunities and challenges. Special attention was placed in the micro level in order to evaluate the level in which the current local production complies with the market needs and production requirements obtained in Chapter 6.

7.1. The Stakeholders Map

In order to analyze the entrepreneurial ecosystem in Costa Rica related to a possible cricket powder production, it was first important to identify the main actors in the ecosystem. Important information was gathered during the interviews and the first activity during the workshop had the main goal to create a comprehensive stakeholders map. Figure 26 shows the main result.

Figure 26. Stakeholders map for the entopreneurial ecosystem in Costa Rica



Source: Own elaboration

In the figure, the stakeholders in the micro level are depicted with a yellow color, those in the meso level with blue, macro level are green and meta level are in the back (grey color). The next

sections summarize and categorize the stakeholders in each level of the systemic competitiveness approach.

7.1.1. The Existent Entopreneurs

Of the identified stakeholders in the micro level, only the local rearers and entofood manufacturer are currently part of the supply chain. All the others included in the map were identified as possible actors by the workshop participants but they are not yet involved in a cricket powder supply chain, which means that the supply chain still needs to be developed.

The oldest existing entrepreneurship is Costa Rica Come Insectos ("Costa Rica eats insects"), which is led by Local Entrepreneur 4. This family-owned insect farm is being in the market for 10 years now and is well recognized not only locally but internationally. CR Come Insectos offers training courses on rearing insects and many of the now entopreneurs have taken the course or have been in contact with them.

In the last years, two entrepreneurships have been in the local and international news, mainly: Gricket House and The Costa Rica Insect Company (CRIC). Gricket House is the only company in Costa Rica producing insect-based food for the local market. The company is run by two young entopreneurs who are selling granola cricket bars to the local market, focusing on the athletes and sport enthusiasts. They started selling their products in the beginning of 2018. According to local entopreneurs 1 they also rear their own crickets to obtain the raw material.

The Costa Rican Insect Company (CRIC) is an entrepreneurship led by two young entrepreneurs in the field of nutrition and marketing. They are rearing crickets and producing cricket powder. Their purpose is to create insect-based products as an alternate solution for food scarcity as well as providing a high-quality nutritional and healthy solution for malnutrition. As noticed in the interviews, CRIC has a very different business strategy and approach than the other existent entrepreneurships, mainly because they are not intending to sell their products in the local market, but rather start exporting large quantities in other countries. While the other entrepreneurs seem to have a more local oriented vision, CRIC co-founders identify their business as a start-up, meaning that it is a rapid growing project.

Interestingly, these three entopreneurships are run by couples (husband-wife or girlfriend-boyfriend). Also, the three started after one of the co-founders had a first experience with insects in the University of Costa Rica, either at the Museum of Insects or taking a course in the School of Nutrition.

There is another entrepreneurship that is active on social media, Grillos en Costa Rica, who rears crickets for human consumption. However, as his founder (local entopreneur 3) mentions, he started it as a hobby and "usually has more losses than revenue".

Juicy Ant is also an insect farm, which co-founder has many years of experience and is very passionate towards rearing insects, as extracted from his participation in the workshop. However, their

approach is more towards selling insects for animal feed or cockroaches for human consumption, not so crickets. Also, PRONUVO is a recent established start-up with an industrial approach currently developing a method for rearing black soldier fly to develop feed for the fishing industry in Latin America.

According to LTE1, he knows approximately 25 other unipersonal insect rearers and "there may be 25 he doesn't know of". However, as he mentions, most of them rear insects to feed their pets or sell them for animal feed. During the workshop, 6 additional unipersonal rearers were identified by the participants, who rear crickets for their own consumption.

7.1.2. The support institutions

When compared to the results of the micro level, it is evident that the data included for the meso level is much more comprehensive, which may imply that there are more established stakeholders in this level than in the micro level. Table 8 presents the actors identified by the interviewees and workshop groups for the meso level.

Table 8.Main identified stakeholders in the Costa Rican meso level

Category	Institution	Responsibility[1]
Export Promotion	Promoter of Foreign Commerce (PROCOMER)	Agency in charge of promoting Costa Rican exportations of goods and services
	The Costa Rican investment Promotion Agency (CINDE)	Private, non-for profit, non-political organization responsible for the attraction of Foreign Direct Investment into Costa Rica
	Chamber of Costa Rican Exporters (CADEXCO)	Groups the local exporters and promotes and helps them in the exports, competitivity and development of international trade
	Ministry of Foreign Trade (COMEX)	Promote commercial relations with other countries
Promotion of science, innovation and entrepreneurship	University Agency for the Entrepreneurship Management (AUGE)	Training and promotion of entrepreneurship
	Innovation Knowledge Management and Transfer Unit (PROINNOVA)	Handles innovative projects from the University of Costa Rica to allow them to have an impact over the socio-productive sector
	IMPACT HUB	It is part of global network that provides entrepreneurs with the services and creative spaces they need to develop their entrepreneurship
	CARICACO	Business incubator and entrepreneurship training academy
	National Commission for Scientific and Technological Research (CONICIT)	Autonomous institution which aims to promote the generation of innovation and knowledge on science and technology

	Ministry of Science, Technology and Telecommunications (MICITT)	Formulate and implement the public policies on science, innovation, technology and telecommunications
The academia	The University of Costa Rica (UCR):	Most renowned public university in Costa Rica forming professionals in different fields and conducting research
	-The Museum of Insects	Gathers different insect collections available for education, research and social work.
	-School of Biology	Forms experts in Biology
	-School of Zoology	Forms experts in Animal Production
	-School of Nutrition	Form experts in Human Nutrition
	-School of Food Engineering	Forms experts in Food Engineering
	Technical Institute of Costa Rica (ITCR)	Forms engineers, scientists and researchers.
	National Learning Institute (INA)	Offers technical training on diverse areas
	Ministry of Public Education (MEP)	In charge of the public policies on primary and secondary education
	Technical experts	Training and research on edible insects
Promotion of industrialization	Institute for Rural Development (INDER)	Governmental institution in charge of the development of the rural communities
	Ministry of Economy, Industry and Commerce (MEIC)	Promote private initiatives and entrepreneurship, SMEs support
Livestock and Agriculture	Ministry of Agriculture and Livestock (MAG)	Supervises and promotes the livestock and agricultural production in Costa Rica
Research institutions	National Centre of Food Science and Technology (CITA)	Research, Training, Consultancy and Analytical services related to food products
	National Centre for Research in Animal Nutrition (CINA)	Its main purpose is to control the quality of the animal feed in Costa Rica
Financing institutions	Public and Private Banks	Provide loans to entrepreneurs
	Development Bank System (SBD)	Contribute to the economic growth, financial inclusion poverty reduction and productive transformation of Costa Rica through financial products that promote development
	Venture Capital, Investment Funds	Provide funding for start-ups
Service companies	Certification companies, external laboratories	Provide services that allow quality and food safety certifications (Ex. NSF International)
International organizations	Food and Agriculture Organization (FAO)	Leads international efforts to defeat hunger through the achievement of food security around the world.
	German Academy for International Cooperation (GIZ)	Offers international cooperation services for sustainable development

1: Information retrieved from the official websites

It is important to consider that not all of the identified stakeholders are currently involved with the topic of cricket powder production. However, these are the institutions that are identified as key stakeholders to contribute to the possible production of cricket powder in Costa Rica.

The institutions mentioned by at least two groups in the workshop are: The University of Costa Rica (UCR), CITA, PROINNOVA, AUGE, The Museum of Insects, Impact Hub and MEIC. The Museum of Insects was the most mentioned institution in the interviews with local experts and entopreneurs.

7.1.3. The regulators

Table 9 summarizes the identified stakeholders for the macro level related to the production of cricket powder in Costa Rica.

Table 9. Main identified stakeholders in the Costa Rican macro level

Category	Stakeholder	Responsibility
Health Regulators	National Service for Animal Health (SENASA)	Supervises and controls the production, transformation and distribution of animal derived products
	Ministry of Health	Regulates and controls food processing establishments and their products
Wildlife protection regulators	Ministry of Environment and Energy (MINAE):	Management, conservation and sustainable development of the elements, goods, services and environmental and natural resources of Costa Rica
	National System of Conservation Areas (SINAC)	Controls de tenancy of wild life
	National Commission for the Biodiversity Management (CONAGEBIO)	Assure the sustainable management of the national biodiversity
Business/export regulators	MEIC	Formulation of the Costa Rican economic policy
	Ministry of Foreign Commerce (COMEX)	Defines, designs and implements the Costa Rican public policies of international commerce and foreign investment
Tax and Customs regulators	Ministry of Treasure	Regulates the Costa Rican fiscal policy
Local governments	Municipalities	Manages the permits for industrial production at the regional level
Professionals	Technical experts	Visits the insect farms to assure they are complying with the law
Professional Associations	Professional Association of Biologists	Regulates the professional tariffs of technical experts and biologists

7.1.4. The actors at the meta level

It is evident, that this was the level where the four groups showed less knowledge on who the actors could be, since they mostly identified elements or concepts but not institutions. Only group 1

and 4 identified possible actors in the meta level, mainly: the media (including social media), marketing agencies, the UCR, ITCR, MEP and the academia.

7.2. Main findings from the interviews

Important information related to the current state of the entopreneurial ecosystem in Costa Rica was gathered through the interviews. The main findings are detailed in the next section, divided per each systemic level analyzed.

7.2.1. The Micro Level

7.2.1.1. Production techniques

Out of the four existent entopreneurships rearing crickets, two (CR Come Insectos and Grillos en Costa Rica have a traditional production, while the other two have a more industrial or large-scale approach (CRIC and Gricket House), as summarized in Table 10.

Table 10. Profile of the existing cricket entrepreneurships

Company	Foundation Year	Products sold	Business approach	Target Market	Production method	Quotes
CR Come Insectos	2011	Dried whole crickets, cockroaches, other insects	Family business for auto consumption Educational Social	Local market	Traditional	-"Well, I do not call this a business. I have never seen it as a business." -"We try for it to be more educative than lucrative" -"CR Come Insectos is a family business. I will never stop it because I will always eat insects". (Local entopreneur 4, personal communications, 2020)
Gricket House	2018	Protein bars with cricket powder	BtoC	Local Market first, then international market	Currently traditional with the goal to convert it to Industrial/Large scale	"We have investigated farms worldwide, with bigger drawers and vertically controlled, so that the limit is the sky, so we have been prototyping to see how we are going to create our farm more massively" (Local entopreneur 1, personal communications, 2020)
CRIC	2018	Industrial cricket powder	BtoB	International market	Industrial/Large scale Program of Associated Farmers	- That was what we were validating, not if we could reproduce insects, anyone can produce insects, but as you do it on a large scale but with reduced costs" -"Then we decided to focus on the raw materials and not the final consumer, and do a pragmatic production with farmers, give it to farmers at a low cost". (Local entopreneur 2, personal communications, 2020)
Grillos en Costa Rica	2018	Dried whole crickets	Family business for auto consumption BtoC	Local market	Traditional	"To win clients, I have sold it at cost and even then it does not sell enough. So, I don't know if rather the future that can be given to cricket is like a

						source of self-consumption, that each one has two boxes in their house." (Local entopreneur 3, personal communications, 2020)

Out of the four entrepreneurships, only CRIC states to have a more industrial orientated approach. However, they are still in the phase of research and development and prefer not to give details about their production.

In the case of entopreneurs 1, 3 and 4 they are rearing at home, in special areas designed for it, while entopreneurs 2 have a separated area located in Siquirres. The researcher was only able to observe the insect farm of local entopreneur 4 and pictures of local entopreneurs 3. Figure 27 shows the production conditions of local entopreneur 4.

Figure 27. Insect rearing by entopreneur 4

Source: pictures taken during the interview

As can be observed, the production is not in an enclosed area and the racks used are not from stainless steel. However, the entrepreneur uses plastic containers and egg cartons to rear the crickets.

All the entopreneurs except for local entopreneurs 3 rear Acheta domesticus. In the case of local entopreneurs 3, he rears only field crickets (grillo campestre). Entopreneur 4 rears Acheta domesticus as well as field crickets. In general, although production processes are traditional, entopreneurs are following the basic steps necessary to rear crickets. However, in terms of the life cycle of A. domesticus, there seems still to be improvement opportunities, since the entopreneurs mentioned an average cycle of 8-14 weeks: "We have a production cycle of 8 weeks (…) We know that it lasts less, however we have not achieved it yet and if we know that we can last up to five weeks" (Local entopreneur 2, personal communications, 2019).

After rearing the crickets, local entopreneurs follow the required steps to sacrifice them using the 24-hours freezing technique and then apply heat to kill microorganisms. For the dehydrating step, entopreneurs 1 and 4 use normal ovens to dry the crickets. In the case of entopreneur 4, he developed his own dehydrating system using mirrors. In terms of the water disposing system, although the rearing techniques are very traditional there is adequate knowledge on the basics of rearing and the critical control points. For instance, entopreneur 3 is aware that the water disposing system must make sure that the instars do not drown by the water droplets: "When they are born you have to put water on a napkin, because they need water but they drown" (Local entopreneur 3, personal communications, 2019). In the case of entopreneur 4 she prefers to use fruits and vegetables from which crickets get the water they need.

However, it seems that the control of temperature and humidity is not a common practice among the local entopreneurs. For instance, local entopreneurs 4 comments:

> If you have an industrialized process, you control the climate, but me, I work with winter and summer[9] and have to adapt depending on that. It has a lot to do with the humidity. I do not have a thermometer, I do it by intuition. Here I lack a lot of things because it is a familiar production, but I do have a lot of needs (Local entopreneur 4, personal communication, 2019).

In the case of local entopreneurs 1, they know it is necessary to control the temperature, but they are not doing so yet: "It is something that we have to improve if we want to standardize the processes and do it in a more massive way, but we are not yet clear how we are going to do it." (local entopreneurs 1, personal communication, 2019).

According to the results of the stage 1, the feed is a critical factor for the rearing of insects and a process of research and development is needed in order to achieve the best feed. In the case of local entopreneurs 2, they developed their own formula after a process of research using waste from other

[9] There is no actual winter in Costa Rica. However, the interviewee refers to the rainy and dry season as "winter and summer".

industries: “We did a lot of tests with many things, fruits and vegetables, oats, the same, corn, something else, there were many things” (Local entopreneurs 2, personal communications, 2019). Meanwhile, local entopreneurs 1 started using organic oats as recommended by another entopreneur, who stated that “chicken concentrates may have some ingredients that may not be so good”. However, as they are open to find a concentrate which is more suitable than oatmeal. In the case of local entopreneurs 4, she feeds the crickets with maize, fruits (e.g. oranges) and vegetables (e.g. carrots), and sometimes potatoes in combination with chicken concentrate. She uses fresh products bought from local markets. She also stated that she used oats before but due to the high humidity, there was a problem of molds so that she stopped using it. Local entopreneurs 3 feed is crickets with broccoli, lettuce, oatmeal and chicken concentrate. In these two cases, standardization of the feed is not possible.

None of the entopreneurs were working with commercial feed producers to develop a standardized feed. In addition, none of them can assure that their feed is gluten free. In general, it was evident that all of the entopreneurs are far from complying with the expectations of the international market in terms of having an adequate enclosed cricket farm, with an implemented food safety and quality management system.

7.2.1.2. Output capacity and price

One of the main findings of the study is that there is an important challenge in terms of production, mainly the low output capacity. Currently, there are only three established entrepreneurships that produce crickets in a ‘more standardized” way. However, the output capacity is very low, when compared to the market needs (at least 2 tonnes of cricket powder per month). Local entopreneurs 1 mentioned that they have 30 rearing units (plastic containers) and their current maximum output capacity is 50 kg cricket powder per month but they have the goal to process “5-7,5 tonnes next year”, while Local entopreneur 2 states they have achieved a maximum production capacity of 0,5 ton in a month but not on a continuous basis.

Local entopreneur 4 has a more traditional production and estimates her production capacity to be 500 crickets/month but not continuously, which means that she could not even produce 0,5 kg of cricket powder per month. Local entopreneurs 3 has a maximum production capacity of 700 crickets per every production cycle, which is every 3 months approximately.

It is important to point out that the output capacity mentioned by the interviewees could not be verified by the researcher. Unfortunately, it was not possible to visit the cricket farms in most cases, which makes it impossible to assess if the numbers mentioned are feasible with the current production conditions. For this reason, the perception of the local experts was investigated. In this context, local entopreneur 4, who has been working with edible insects for 10 years, thinks the maximum output capacity of a single producer in Costa Rica is not bigger than 1kg of cricket powder a month:

> I don't think even a kilo a month. I just don't think so, just that I don't know if someone really has a production, but a kilo a month I don't think anyone is producing it. Not even me. To be able to produce like this, they would have to be industrialized. (Local entopreneur 4, personal communication, 2020)

Meanwhile, LTE 2 estimates the maximum capacity of a local producer with whom he has worked closely with, to be 20-30 kg fresh crickets per month, which translates into 3-4,5 kg cricket powder per month. In addition, he thinks it is possible that someone is producing already 0,5 tonnes but that most probably it is not continuous: That's 500 kg. If it is feasible. What happens is that because I know the rearing of bugs, I know that at any moment there is a gap. (LTE 2, personal communication, 2019).

In summary, two different output capacities are observed: two producers mention a production capacity of 50-500 kg of cricket powder/month (not continuously), and on the other side, two interviewees estimate it to be 1-4,5 kg/month, which is a very significant difference.

The price of cricket powder is also big constraint identified in the local market. In the case of CRIC, they have set their price at 40 USD per kg. Gricket House mentions they could sell their cricket powder for 50-70 USD per kg (they don't sell it since they use it to produce the bars). Costa Rica Come Insectos sells their crickets per unit at 250 colones (aprox. 0,4 USD dollars)[10]. In this context, local entopreneur 4 mentions that when someone buys a higher quantity, they usually feel it is too expensive. That is also the reason she avoids selling cricket powder and prefers to sell whole crickets, since at the current price levels, clients usually complain due to the low quantity compared to the high price.

Local entopreneur 3 sells his crickets in packages of 20 units at a price of 2000 colones (3.38 USD) the salty ones and 2500 (4.22) those covered with chocolate. For him, the current price is the main constraint for the widespread of cricket powder: "One day I calculated that a kilo of cricket powder costs about 400 thousand colones, I mean, it's like selling cocaine (laughs). How are you going to tell people: eat healthy! And they ask how much, and you, 400 thousand colones. I mean, never!" (Local entopreneur 3, personal communication, 2019).

If the traditional producers were to sell the powder with the same prices they sell the whole insects, the price in deed would be higher than 1000 USD per kg. Considering a price of 0,2-0,4 USD per cricket and an average of 2500 needed to produce one kilogram of powder[11], the final price would indeed be between 500 and 1000 USD per kg, as stated by local entopreneur 3.

[10] 1 USD= 591.44 colones as of 18.08.2020 (Source: Costa Rican Central Bank)
[11] According to https://www.cricketflours.com/faq/

7.2.1.3. Local producers' network

Although the edible insect industry in Costa Rica is still infant, the fact that there are already entopreneurs developing products and that already have years of experience in rearing insects, even if it is in a small-scale, is seen as an opportunity, since there is knowledge already present in the country, which could be extended. For instance, local entopreneurs 1 not only took the training course with local entopreneur 4, but then afterward was advised by the founder of Juicy Ant, who has more experience in improving output capacity, and acquired knowledge from him when starting his business: "He was the one that told me that the egg cartons need to be proportional to the quantity of crickets (…). (Local entopreneur 1, personal communications, 2019).

It is evident that this knowledge transfer is performed in an informal way:

> I just talked to him and he would give some advice and we would meet in different places to talk about the topic, like the UCR, we would seat there and he would share his experiences with me but I never went to his insect farm. (Local entopreneur 1, personal communication, 2019).

In addition, there is also an existent practice of genetically refreshment of the insect population by exchanging individuals with other producers, as stated by LTE 1. Nevertheless, it is clear that there is no formal cohesion among producers. Although they know each other and have occasional contact, for knowledge transfer or genetical refreshment, there is no real common goal in order to promote the cricket production: "I support myself individually. (…) I don't have contacts with other producers (…). I go on my own and I have never had contact with other producers because I don't know them, not because I don't want to". (Local entopreneur 3, personal communication, 2019).

It seems rather that they compete against each other, not really for clients but rather for recognition and they do not trust each other or do not believe nor support each the other entrepreneurships. This was also evident during the workshop.

7.2.1.4. Market opportunities

A challenge mentioned by the international expert is the fact that Costa Rica does not have an internal market for cricket powder, which is important in case the produced goods cannot be exported: "Costa Rica doesn't have the natural offtake, meaning that when you produce a lot, someone has to buy it. Mexico has a natural offtake, so it is very easy to sell the product. I'm not sure how big those industries are in Costa Rica" (International expert, personal communication, 2020). The expert refers not only to the option of selling cricket powder to the local food market (Mexico has a dynamic edible insect market for human consumption), but also to other industries like pet food or feed industries.

However, local entopreneurs have sensed an opportunity in the local market, since mostly young people are willing to try (and buy) their products. For instance, local entopreneurs mentions:

> Costa Rica, I would say, "is not on pampers"[12], because the idea is very widespread. So many people have passed through here, and in the Museum in Semana U there are always activities, and more than 100 people arrive and in 15 minutes there is nothing and that is everyday. (Local entopreneur 4, personal communication, 2020).

In this context, the local business expert comments that Gricket House has validated that there is a local market for entofoodproducts, since there is a local demand for their products. Moreover, although the production in Costa Rica is still very low, there are already opportunities to export to different countries, as stated by local entopreneurs 1: "We made a contact in Mexico. It is a company that sells insect powder to Chapul and has been in business for 5-6 years. Three or four months later we closed the deal, an order of 120,000 dollars" (Local entopreneur 2, personal communications, 2019). Local entopreneur 4 also has had export opportunities. She has been contacted from potential clients from Guatemala, the Canary Islands and Canada. However, she does not have permits to export, so she has to decline the offers.

In the case of Gricket House, there is an opportunity to start selling their products in Central America, specifically with UNILEVER, a multinational food company. This opportunity was presented after the entopreneurs won an idea competition in Guatemala.

7.2.2. The Meso Level

7.2.2.1. Training and research support

Throughout the interviews, it was evident that the academia has played a key role in the development of the insect rearing industry in Costa Rica. One of the institutions that was most referred to during the interviews was The Museum of Insects, which is part of the Faculty of Agronomy of the University of Costa Rica.

[12] Local expression meaning being in the first stage or just starting.

a. The Museum of Insects: All of the current entopreneurs had at least one contact with the Museum before starting their entopreneurship. In addition, The Museum of Insects of the University of Costa Rica has been promoting the consumption of edible insects during the past 10 years, especially thanks to the motivation of LTE 1, who has great passion for the topic and organizes insect food shows where people can try edible insects. Thanks to his work, the topic of edible insects has consistently been broadcasted on local media.

All of the interviewed entrepreneurs mention either the Museum of Insects or specifically, LTE 1 when asked how they started to get involved with edible insects. In the case of local entopreneurs 1 and 4, the first contact they had with edible insects was at the Museum and they later learned how to rear insects in there, thanks to LTE 1. In the case of local entopreneur 4, she took the course of Nutrition and Arthropods in the University of Costa Rica and that is how she decided to start the business.

Although the Museum of Insects has performed a great job in transferring knowledge, there are limitations to the service offered, mainly that it only opens from Monday to Friday and according to LTE1, many people cannot go there during that time because they work, leaving them the only option to attend private courses during the weekends. Local entopreneurs 1 took the private course offered by LTE 1 and then started his first cricket farm in the Museum of Insects, while local entopreneur 3 took the private course on rearing insects with LTE 1.

Another detected challenge was the fact that despite the great work the Museum of Insects performs, it is not a research center on edible insects and there is no research center focused on this topic in Costa Rica. In addition, the financial support that is granted for the activities related to the promotion of edible insects in the Museum is minimal, as stated by LTE 1: “They don't give me money here to buy books. The support they give me is that every now and then they give me money to buy feed for the insects. (…) For me it is very hard.” (LTE1, personal communication, 2019).

Indeed, it is evident that the resources for research on edible insects at the Museum are limited, since the laboratory does not have dedicated equipment and thus, the rearing is very traditional, as can be observed in Figure 28. LTE 1 is the only person in charge of the activities related to edible insects in the Museum.

Figure 28. Laboratory area at the Museum of Insects

Source: Picture taken during the interview

b. The training offer: It is evident that the training offer on production of edible insects is limited and the available options do not really fulfill the needs of the entrepreneurs when wanting to scale their processes. For instance, local entopreneur 2 explains that the course on Arthropods and Nutrition at the UCR did not include the topic of production: "In that course I learned what they were and how to use them and what their environmental and nutritional benefits were but they didn't teach us how to truly raise them" (Personal communications, 2019).

Due to this lack of training, entrepreneurs have to research and develop on their own: "Then I started doing experiments because you don't go to a course where they tell you how to cook crickets, nor is there a place where you go to see how they produce them" (Local entopreneur 4, personal communications, 2019).

In addition, some interviewers mentioned that they have had support from international experts, in the case of local entopreneurs 2, they were in contact with Arnold van Huis, from the University of Wageningen, who, according to them, providing relevant information on the topic of edible insects. Also, entopreneur 4 mentions she is contact with experts in Mexico and Brazil.

c. Technical experts: It is important to point out that the available local technical experts were formed at the University of Costa Rica and they have a key role in the knowledge transfer. For example, LTE 1 commented that LTE 2, was the one who originally taught him how to grow insects, and after taking the training on regencies for wild life with LTE 2, LTE1 was able to open his family business. However, there is clearly a lack of experts in the field of insect rearing in an industrial scale

in Costa Rica, as stated by Local Entrepreneur 1: “It is not like someone is super professional in the cultivation of insects here in Costa Rica” (personal communications, 2019).

Indeed, it is clear that LTE 1 is the person that is currently seen as the most expert on insect rearing. However, he does not have experience with industrial rearing, as argued by local entopreneur 2:

> I personally consider that the person who knows the most about insects in this country must be LTE 1, but if he knows from the biology for its properties and he has his farms, let's say about insects, it's true, but let's say what’s more valuable for a startup: A person who thinks of production, not really biology, (Local entopreneur 2, Personal communications, 2019)

Local entopreneurs 2 criticizes the fact that it is not enough to know about the biology of the insects to be able to mass produce them. It is thus clear that there is a professionalization that is lacking in the country, mainly the experts in mass producing insects. The experience of local entopreneurs 1 was similar, since after been trained by LTE1, they still needed advice to maximize their output capacity:

> He (LTE1) told us that that was the way he did it because he did not want to make them for mass consumption, but it was very much like having them like in the patio of the house, in some boxes (…) so he didn't see it on such a large scale and that's why he had not so standardized processes, so that's when he gave us contacts from others (Local entopreneur 1, personal communication, 2019)

In addition, there is no specialization on edible insects in the academic field, the UCR, UNA and Latina University have the option of studying Biology. However, none of them have the specialty in Entomology. According to LTE 2, those that finish a Bachelor degree, have the option to specialize in a certain field of biology during their Master degree, basically choosing courses and writing their thesis on a specific topic, which could be entomology.

According to Local entopreneurs 2, the biologists do not necessarily have the appropriate competencies to work in a start-up. They state that for working in a start-up environment, they would prefer to hire someone with knowledge on livestock production rather than an entomologist who focuses on biology.

According to LTE2, the few specialists in entomology available that research and teach in the University focus on fundamental research, such as genetics and natural biology of insects but nothing related to the consumption of insects.

It is important to mention that an opportunity for the development of a cricket powder hub in Costa Rica is the fact that there are already working research institutions in the fields of food engineering (CITA) and quality of animal feed (CINA), which could be key allies for the producers in developing better cricket feed, processing technologies and food products. For instance, the only research related to edible insects is being conducted by CITA.

7.2.2.2. Financial support for entrepreneurs

The majority of the interviewees agreed on the fact that it is difficult to get funding for a cricket production project in Costa Rica. It seems the business ecosystem is not prepared for financing start-ups and it is even more difficult when it comes to the topic of edible insects: "The stage of investment at this time is of angel investors, not investment funds, and in Costa Rica and Latin America there are only around ten angel investors throughout Latam and no one knows anything about insects". (Local entopreneur 2, personal communication, 2019)

All of the initial investment for the different local entopreneurs has come mainly from family and friends. Thus, the attraction of foreign investment is seen as a possible solution to allow local companies to scale up:

> For me, that would be the right way, to raise capital outside. It makes sense to produce here but looking for private capital here is almost impossible, the options that are available are counted by hand, and they usually invest in things that are highly cooked or in line with what they have previously decided to invest. So far, we have not heard from anyone interested in insects. (Local business expert, personal communication, 2019)

7.2.2.3. Support institutions for innovation and export promotion

Costa Rica has already established institutions supporting entrepreneurship and innovation, such as AUGE, PROINNOVA, and incubators such as IMPACTHUB and CARICACO. This is a great benefit for the entrepreneurs, who can get advice to grow their businesses. For instance, AUGE has worked with two teams related to edible insects: Gricketa (entrepreneurship that does not exist anymore) and Gricket House. Thanks to their support, Gricket House has been given a lot of exposure, they have been in the news, in the program DEMENTES (TV competition for entrepreneurships) and have received seed capital funds (Local business expert, personal communication, 2019).

In addition, the institutions promoting exports are great allies for the entrepreneurs willing to expand to other markets. In this case, PROCOMER was mentioned by both entopreneurs 1 and 2 as the institution that has supported them the most. In addition, CADEXCO was mentioned as a great supporter by local entopreneur 1: "CADEXCO, the chamber of exporters, extremely important to us,

the president of CADEXCO, Mrs. Laura Bonilla, literal has treated us like her children" (Local entopreneur 1, personal communications, 2019).

7.2.3. The Macro Level

7.2.3.1. The local regulations

It was first important to understand what are the regulations that apply to a production of cricket powder in Costa Rica. The information was gathered from the interviews, the workshop and the DESCUBRE report. Table 12 summarizes the main regulations that apply for the production of edible insects in the country.

Table 11.List of the regulations pertaining to production of cricket powder in Costa Rica

Regulation	Institution in charge	Requisites
Law N° 7317: Law of wild life conservation	SINAC	- Registry of farming sites - Management plan - Export permits (Art.19)
Law N° 8495 SENASA	SENASA	CVO
RTCA etiquetado nutricional alimentos preenvasados (Regulation on nutritional labelling of prepackaged food) RTCA etiquetado general alimentos preenvasados (Regulation on general labelling of prepackaged food)	MEIC	-Nutritional label
Law 5395: General Health Law (Ley General de Salud)	Ministry of Health	Sanitary Permit, Health Ministry ($100 every 5 years)
RTCA BPM for food and cosmetics	MEIC	-Good Manufacturing Practices
Local government regulation (plan regulador)	Each local government	Permiso de Uso de suelo (soil management permit)

There is no regulation specifically created for the production of edible insects in Costa Rica. According to LTE 2, the current legislation that regulates insect farms in Costa Rica, specifically the Law 7317 (SINAC) and Law 8495 (SENASA), was not created specifically considering the production of insects.

The Law 7317 is related to wild life protection. Considering that edible insects are included in term "wildlife", the regulation applies for the farming of insects. There are specific guidelines and requisites in order to legally develop this activity in the country. The administrative technical document of that is the Management Plan and the responsible organization is the SINAC which is part of the MINAE. However, local experts and entopreneurs agree that the regulation is not clear and even

SINAC is not sure on what are the requirements that apply to the farming of insects: "Yes, there is a clear legislation. The MINAE themselves do not know very well what to do because the insects are new, so those from SINAC are also unaware of the issue". (LTE 2, personal communication, 2019).

Moroever, according to LTE2, there seems to be an overlapping between SINAC and SENASA:

> In fact, SENASA enters there because it ensures that there is no animal abuse, which in the case of crickets does not apply but in the law it says so because the law of wildlife conservation applies to all wildlife, but as there are other wildlife that do pertain to SENASA, they threw it by default to the crickets as well (LTE 2, personal communication, 2019).

According to the interviewees, the fact that the regulation was not specifically created thinking of edible insects, is causing an overregulation, because there is a requirement that states that a technical expert has to be visit the farm every 15 days. However, LTE 2 considers this requirement unnecessary:

> The law of 92 said that the technical expert has to visit the establishment every 15 days, and that is a lot for insects, but the law of 92 did not consider only insects, it considered everything, even zoos and rescue centers, it is more for a zoo the Technical expert should be going hopefully every day, should be on the ground, same for a rescue center, for a frog exhibition maybe it can go every 15 days, but for a butterfly garden (which was what it started with), it is not necessary (LTE 2, personal communications, 2019).

7.2.3.2. Getting in line with the regulation

According to LTE 2, the legal requirements specifically related to farming insects are basically two: having a management plan and the visits of a technical expert. The management plan is a document of around 100 pages where the process of rearing the insects must be detailed. However, there are other requirements such as the permit for soil usage (permiso de uso de suelos) from the local government. (LTE 1, personal communication, 2019), the CVO from SENASA and the permit from the Ministry of Health (local entopreneur 2, personal communications, 2019).

In the case of the CVO, LTE 2 explained that this requirement is in the law by default but that it does not really apply to the insects and thus, it is possible to send a letter asking for a waiver, where it is explained that in the case of arthropods the SENASA is not needed "because the insects do not suffer, they do not have the ability to feel pain, so nothing else meets the legal requirement". (LTE2, personal communication, 2019).

Although the requirements are not numerous, the entrepreneurs commented that it is mainly difficult to get them due to bureaucracy and lack of knowledge on edible insects:

> The institutions in this country are dearticulated. The SINAC from MINAE ask you to have a biologist technical expert for an animal farm that supervises it every 3 months. For the CVO that is not necessary. You have to have the CVO to ask for the permit at the SINAC. You have to start with the CVO. The important thing is the CVO because that is what the Ministry of Health asks for to export. The SINAC requirement is only because someone came up with the idea, but it is not really limiting. (local entopreneur 2, personal communication, 2019).

All interviewees agree on the fact that public authorities are not aware of the opportunities related to edible insects and they do not have knowledge regarding the legal ground for their production. Even the authorities that are in charge of the permits, show lack of knowledge when entopreneurs have approached them: "One of the requisites is the CVO and you call SENASA and everybody looks at each other, like: what should we ask him? Because they have never done it before". (Local entopreneur 3, personal communication, 2019). Local entopreneur 2 commented that when she started looking for the permits, she was told she needed the CVO, but at the SENASA they said "We do not have a CVO for insects". However, due to her insistence, they worked it out and they already have the permit.

In this sense, the international expert mentions that it is key that burocrats understand why it is important to farm insects to make such a project feasible: "Because government officials usually think of insects as a plague. So, if you start talking about that they will think like: what, but we have been trying to kill them forever. That would be the biggest thing in terms of an FDI" (Galt, 2019).

Entrepreneurs also consider complying with the regulations to be one of the main constraints for them. From the regulators point of view, this is a critical challenge that needs to be solved, according to the SINAC representative present in the workshop:

> I am worried because from our registers I only have one site that is legalized. I am worried that I hear there is people that is rearing insects. My proposal is that we can have a meeting to explain people how to get in line with the regulation and also identify what we have to change in the regulation (SINAC representative, final remarks of the workshop, 2020).

In this respect, the local business expert comments that from an innovation and entrepreneurship point of view, the regulation should not be the first thing in mind when starting a business, but rather the acceptance in the market:

> It is something that has surprised us about Gricket House. One of the things investors and evaluators question the most is the issue of permits. Our mentality is that the most important thing is to validate that it is commercially viable and if people buy it and people have bought it in spite of everything, so that is the best indicator that the business makes sense (local business expert, personal communications, 2019).

7.2.3.3. Costs associated to the regulation

It seems that the existing law is aimed at a higher scale production and does not consider small entopreneurs, which makes it difficult for them to develop and thus, keeps them in the informality. For instance, when asked about how feasible it is to get in line with the SINAC regulation, LTE 1 commented: "It is easy if you have the money to pay for the professional".

In this context, LTE 2 explained that he charges 1500 USD to write the management plan, according to the tariffs of the Professional Association of Biologists. In addition to the cost of the management plan, the law requires a technical expert to visit the farm regularly. These visits have to be paid by the producer, which is seen as impossible for some of them: **"**One of the main constraints is the inspections. Imagine that you have a business that gives you more losses than revenues and still you have to pay for a technical expert". (Local entopreneur 3, personal communications, 2019). Local entopreneur 4 also mentions: **"**If you have the money, everything is ok. If I had to pay for a biologist, I could not do it." (Local entopreneur 4, personal communication, 2020)

On this topic, LTE 2 comments that the cost of technical expert is a complex issue and more work needs to be done. According to the expert, the law of 1992 said that the technical expert has to visit the establishment every 15 days, which "is a lot for insects". This is because the initial law did not consider only insects, but rather zoos and rescue centers. The minimum rate per visit is $ 150, which is already too much for the butterfly's producers. In order to minimize this problem, the technical experts have come to an (unofficial) agreement with the authorities to do quarterly visits.

According to the entrepreneurs this requirement is disproportionate considering their production volumes:

> How is it possible that I need a technical expert the same as in a chicken farm where the production volumes are high. My uncle has a chicken farm, but he takes out 70 thousand chickens every 60 days and pays a technical expert, but the cost is diluted

between all the production. (…) I would say that this legal and paperwork part is what they should try to investigate. (Local entopreneur 2, personal communications, 2019)

7.2.3.4. Availability of technical experts

Biologists are the professionals that by law, inspect the insect farms and control that they comply with the local regulation. Although in the past, many different professionals, specially forest engineers could act as technical expert, nowadays, due mainly to the work of LTE 2 and the Professional Association of Biologists, only biologists can perform this job. However, there is a challenge due to the low number of technical expert available. According to LTE 2, LTE 1 was the only professional with the expertise to write a management plan for an insect farm. However, he cannot cope with the amount of work required due to the fact that his main occupation is researcher in the UCR. As he mentions, he even has had to reject job offers because he has no time:

> They wanted to hire me, but I can no longer work because I work full time at the university, so I had to reject them. And there are not many people who have the technical and legal experience to do that. The law requires that there be a technical expert in all of this, but there are very few technical experts in insects so everyone is looking for me. It is good and it is bad. (LTE 2, personal communications, 2019)

In other words, the demand for wild life technical experts is higher than the offer of professionals in the country. According to LTE1, there are now approximately 80 approved technical experts for the inspection of insect farms, but the majority are trained to inspect only butterfly farms and not edible insect one. LTE1 realized this situation ten years ago and he decided to start training other professionals in the topic of wild life regencies, creating a course in the University called "Regencies for wild life" in 2010, as he mentions: "there is a need in the country and since there is only me, I worried about forming "this school", to start training professionals in that line." (LTE 2, personal communications, 2019).

According to the expert, the current situation of edible insects in Costa Rica is the same as the butterfly houses in the 80s: "there are no technical experts, people do not know how to breed insects, there are no trained professionals, that's why I tell you that you have to start by preparing professionals from the universities". (LTE 2, personal communications, 2019).

7.2.4. The Meta Level

7.2.4.1. Local history with insects: Butterflies gardens

One of the main opportunities of Costa Rica is that it has the necessary weather conditions (temperature and humidity) to rear insects. According to the local technical experts, the best areas to start a cricket production would be the South Caribbean or South Pacific, but specially the South Caribbean, mainly cities like Upala, San Carlos, Sarapiquí, Siquirres, Limón, where the temperature ranges between 31 and 25 C and the humidity is between 88 and 91%.

One of the benefits local entopreneur 2 mentions is that these areas are usually low-income zones, which means that creating a cricket powder production hub would bring important economic and social benefits to vulnerable populations.

Interestingly, it would not be the first time that Costa Rica develops an insect-based industry due to its great environmental conditions, geography and biodiversity. An interesting topic that came out from the interviews was the experience that Costa Rica already has with the rearing and commercialization of insects, specifically, butterflies. Costa Rica is one of the main exporters of butterflies in the world. This fact was used by the local experts as an analogy to the potential export of edible insects and the possible development of the market: "I think Costa Rica has the potential to be number one producer of edible insects. If we achieved that with butterflies, why not with edible insects". (Local entopreneur 4, personal communications, 2019)

LET 2 explained during his interview, how the business of butterflies started in Costa Rica. According to the expert, it was an Englishman (Yoris) who came to Costa Rica in the late 70s and realized there were a lot of butterflies, but no one was producing or exporting them. He started to raise them and very quickly England started to import them. The demand was so high, that Yoris created a network of producers wich grew from 1 to 150 in ten years, from exporting 100-200 pupae, to exporting 40 thousand pupae per week (LTE 2, personal communications, 2020).

In addition, the analogy of the butterfly situation was used to explain the legal and knowledge challenges related to edible insects: "The situation of butterflies with edible insects is the same, we are like the butterfly houses in the 80s, there are no technical experts, people do not know how to breed insects, there are no trained professionals" (LTE 2, personal communication, 2019).

Local entopreneur 4 also thinks that "the problem is that there is a great hole of legislation in all entities in the matter of insects, and not only with edible insects, but also with the butterfly, which is the closest thing." (personal communication, 2020).

The fact that Costa Rica has this experience is seen by the experts as a great opportunity because the country had to develop a legal infrastructure and there is expertise on the exports of wildlife. According to LTE 2, edible insect farmers can now learn from the lessons of the butterfly farmers, and avoid making the same mistakes:

I think it is very important for you, a new sector, to support yourself on the experience of a sector that has 40 years in the market. (…) you are not alone. There is a path already done. You can take the good things and apply them and identify the bad things to avoid making the same mistakes. After 40 years of butterfly farming in Costa Rica, finally until 3 years ago we are able to organize ourselves in an association of producers. If we had done this since the beginning, we could have developed faster and avoided a lot of problems" (LTE 2, final remarks of the workshop, 2020)

7.2.4.2. The international reputation of Costa Rica

During the interviews, it was evident that local and international interviewees consider the image of Costa Rica as a green, sustainably and socioeconomic stable country to be one of the greatest opportunities in relation to the development of an edible insect production hub: "The differentiation from the rest of the world seems to me is sustainability mentality. I mean, thinking and above all as Costa Ricans we think of being sustainable. We think of being sustainable in being green.". (Local entopreneur 2, personal communications, 2020).

The international expert, who has lived and worked in Costa Rica, considers that in terms of bringing in foreign direct investment is having a business climate and that Costa Rica is "fairly business friendly", it is politically stable and "fairly safe". The main opportunities if Costa Rica related to edible insects are the geography, the weather and the natural food (International expert, personal communications, 2020).

7.2.4.3. Attitudes towards edible insects

Costa Rica has no tradition of eating insects. Thus, most people have no knowledge on the benefits of edible insects and the possible consumption ways. This represents a challenge in the meta level, since it affects all the other levels, for example, implying that every time the entrepreneurs have to do an effort to explain the public (and different stakeholders) about the topic of edible insects, as explained by local entopreneur 4: "The key to the insects for people who have a taboo like in Costa Rica, where they are not consumed because it is not a tradition, is education, explaining to people and people are encouraged" (personal communications, 2020)

However, local entopreneurs have sensed a positive response from the local consumers when it comes to try edible insects: "There are people who call me and say: Gaby, I'm having a beer, why don't you send me some?" (Local entopreneur 4, personal communications, 2020). Local entopreneur 3 has also had similar experiences: "I took the insects and they ate them. It is difficult to get to the people

but once they see them, they get interested and the products have a high acceptance". (Local entopreneur 3, personal communications, 2019).

According to the entopreneurs and local experts, the key is to explain what are the benefits of eating them, and most local people are then open to try them.

7.2.4.4. The local innovation culture

The lack of a proper innovation culture in the country was criticized mainly by the local entopreneurs, as another constraint to the development of the sector. For instance, local entopreneur 1 commented that "people are a little scared of how to bring that (edible insects) here if Costa Rica has a very closed culture." (Local entopreneur 1, personal communications 2020). In the same line, local entopreneur 2 mentions that Costa Rica does not realize that it does not have an entrepreneurial ecosystem and criticizes the fact that it is considered "the number two country in all Latin America in innovation but in entrepreneurship it is almost in last position", which is caused mainly by a poor collaboration between the scientific and private sector.

Moreover, local entopreneur 4 stated that possible investors and entrepreneurs do not understand how an innovation works, since they pretend to see results in a short time without putting the required resources in place to make it happened:

> Many people have come here to invest but they have the mentality that in one year they will be exporting tonnes, like in other countries, but those are industrialized countries. You know starting a farm is easy and difficult at the same time. It is like farming beans, if you are not there, they will not grow. You have to be constant and trial and error are key (local entopreneurs 4, personal communications, 2020).

Although the organization of producers is discussed in the micro level, it was also identified as a challenge in the meta level because the participants criticize the national lack of collaborative organizations from entrepreneurs. It was mentioned that usually entrepreneurs tend to act alone, prioritizing their own objectives rather than the common ones, which in the case of an incipient sector may be counterproductive. In addition, the lack of collaboration between the private and public sector was criticized by entopreneurs and experts. For example, local entopreneur argues that the problem in Costa Rica is that "everybody wants to be a protagonist" and the academia works alone, and the private sector also. But when the public sector tries to do something they usually create an obstacle or make everything more complicated, which is the main reason why the legislation is not clear. (Local entopreneurs 4, personal communications, 2020). He also criticizes the fact that the public sector does not provide financial support to the private sector: "The INDER cannot help us, look how stupid,

because we are a private company. If we were a foundation or association, there would not be a problem" (Local entopreneurs 4, personal communications, 2020).

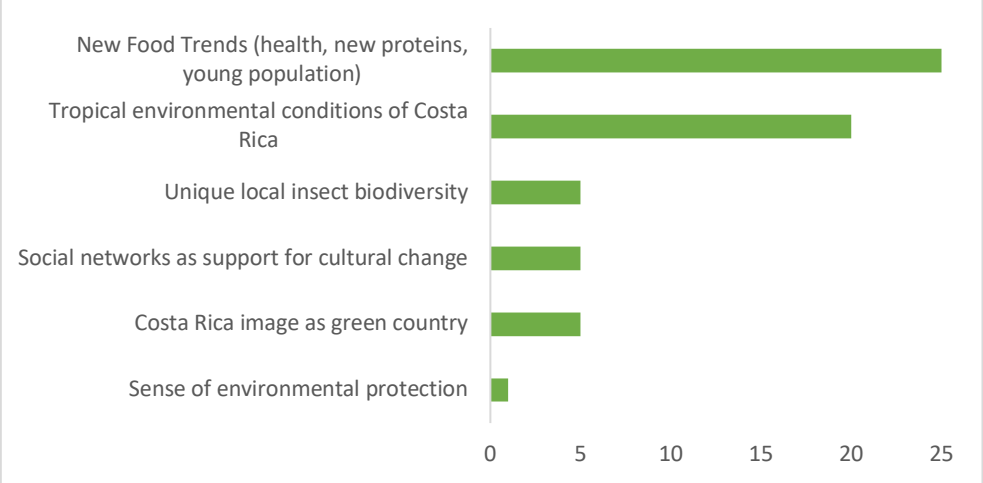
7.3. Main opportunities and challenges identified during the workshop

During the workshop, interdisciplinary teams were asked to come out with the main challenges and opportunities for producing cricket powder in Costa Rica, using the systemic competitiveness approach. Then they were asked to classify them according to their importance. Results are shown in the following sections.

The main opportunities for the meta level identified by the groups during the workshop are summarized in

Figure *29*.

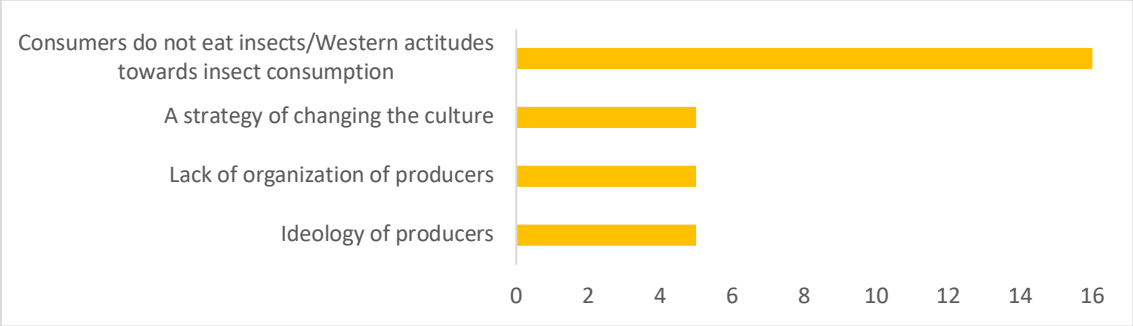
Figure 29.Main Opportunities in the Meta Level and their importance as identified in the workshop



The participants consider the new food trends in health, new proteins in the young population to be the main opportunity, as well as the tropical environmental conditions of Costa Rica. Other opportunities mentioned were the unique local insect biodiversity, social networks as support for cultural change, the Costa Rica image as a green country and the sense of environmental protection present in the country.

The main challenges for the meta level identified by the groups during the workshop are summarized in Figure 30.

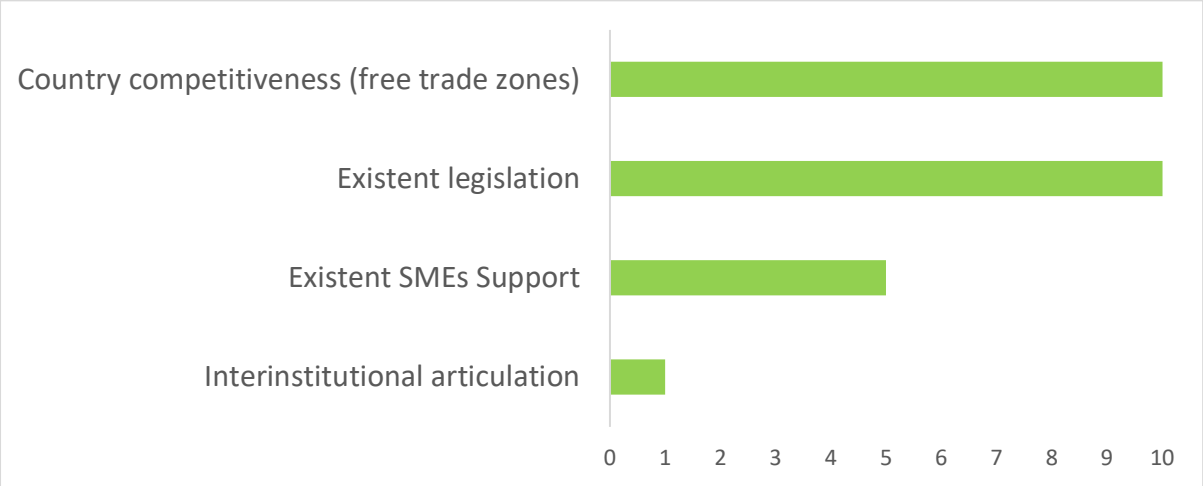
Figure 30.Main Challenges in the Meta Level and their importance as identified in the workshop



Participants of the workshop assessed the consumer acceptance to be the main challenge for the possible development of a cricket powder production hub in the country. In addition, the implementation of a strategy for cultural change, the lack of organization of producers from a cultural perspective as well as their ideology are seen as challenges for the success of the project.

The main opportunities for the macro level identified by the groups during the workshop are summarized in Figure 31.

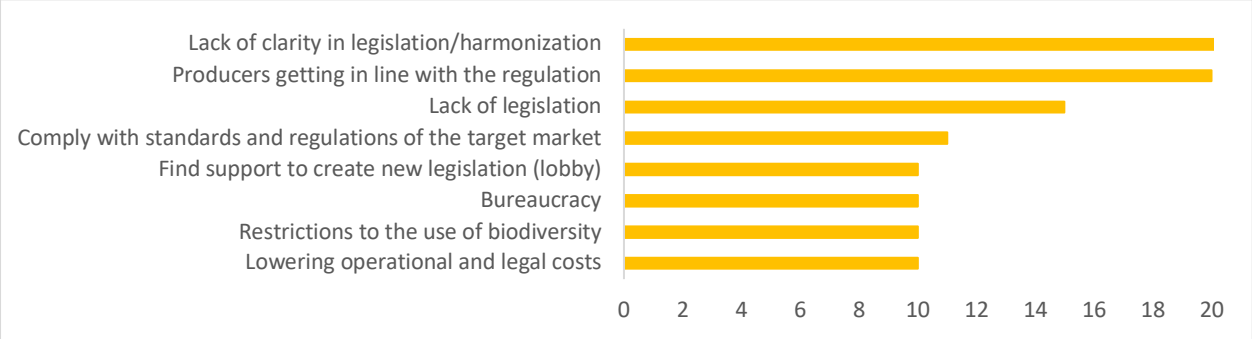
Figure 31.Main opportunities at the macro level and their relevance as identified in the workshop



The main opportunities identified for the macro level were the country's competitiveness, for example in the free trade zones, the existent legislation and the existent SMEs support. Another opportunity mentioned was the interinstitutional articulation.

The main challenges for the macro level identified by the groups during the workshop are summarized in Figure 32.

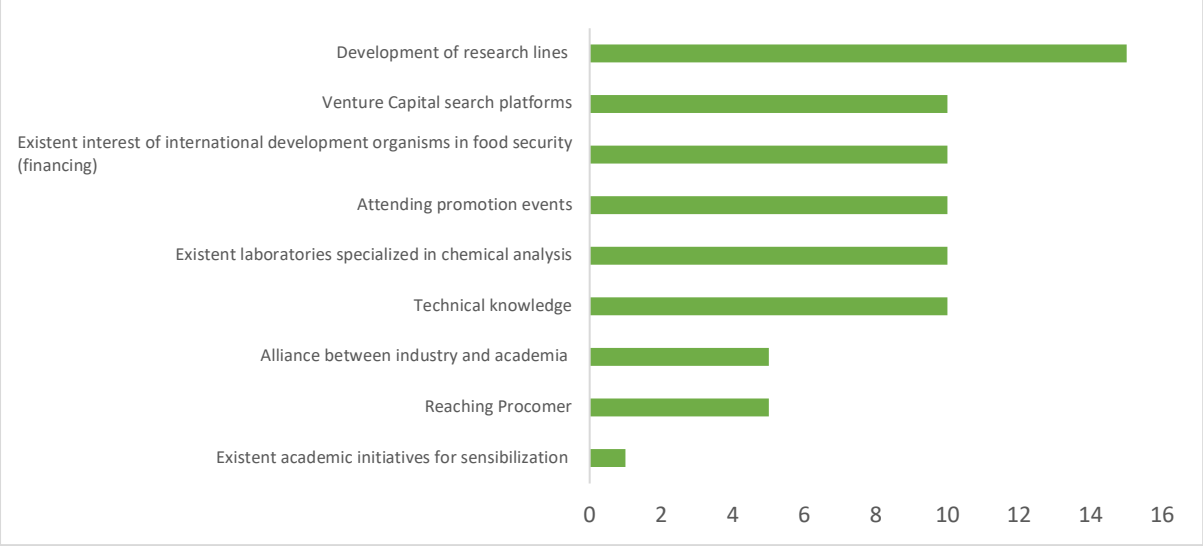
Figure 32.Main challenges at the macro level and their relevance as identified in the workshop



The main challenges identified by participants in the macro level are related to the legislation, mainly the lack of clarity and harmonization in the existent legislation, the difficulty for producers to get in line with the legislation and the lack of legislation. Also, to comply with standards and regulations of the target markets, to find the support to create new legislation, the bureaucracy, restrictions to use of biodiversity and lowering operational and legal costs.

The main opportunities for the meso level identified by the groups during the workshop are summarized in Figure 33.

Figure 33.Main opportunities at the meso level and their relevance as identified in the workshop



Here, the main opportunities identified are the development of new research lines, the existence of venture capital search platforms, the existent interest of international development organisms in food security as a financing option, attending promotion events, existent local laboratories specialized in chemical analysis and the existent technical knowledge. Other opportunities mentioned were: alliance between industry and academia, reaching PROCOMER and existent academic initiatives for sensibilization.

The main challenges for the meso level identified by the groups during the workshop are summarized in Figure 34.

Figure 34.Main challenges at the meso level and their relevance as identified in the workshop

In this case, the main challenges mentioned by participants were facilitating the contact with international buyers, the export certifications and accessible prices for chemical analysis and the lack of technical specialization and training programs. In addition, the model of interdisciplinary collaboration, more institutional and academic support needed and communication, diffusion and marketing were included in the challenges.

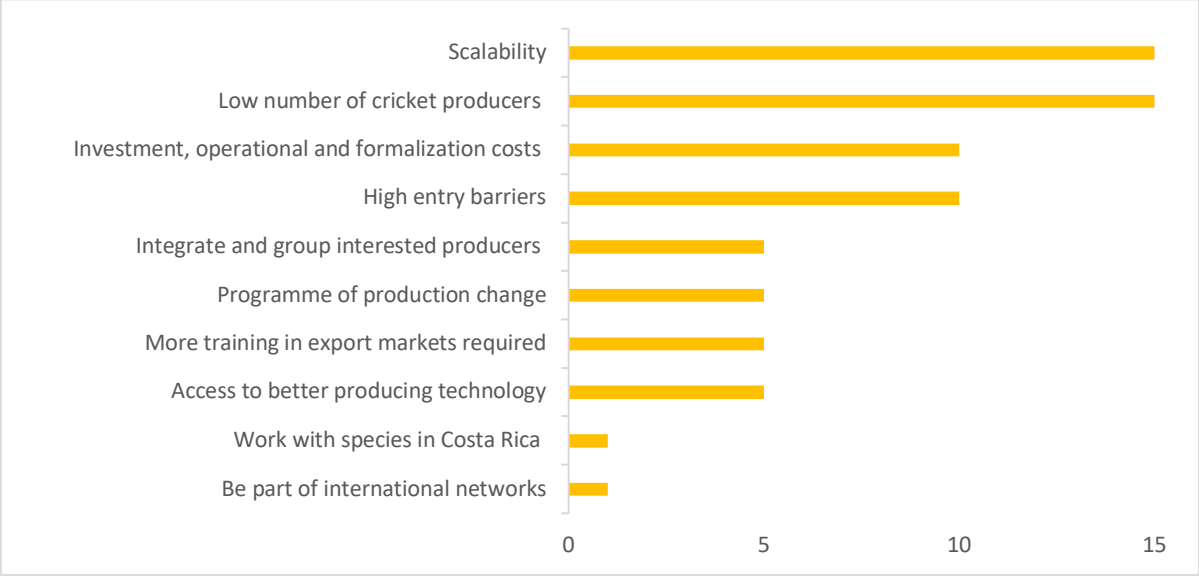
The opportunities for the micro level identified by the groups during the workshop are summarized in Figure 35.

Figure 35.Main opportunities at the micro level and their relevance as identified in the workshop

The biggest opportunity mentioned by the participants is the growing niche market for insect-based products, in the local and international scene. Then, the fact that there are already active producers willing to cooperate, the opportunity to farm local insects and the existent knowledge on insect rearing. Other opportunities mentioned were: training, creation of new companies, systematization, diversification of buyers, different entrepreneurship in SMEs, entrepreneur psychological factor and search for potential clients.

The challenges for the micro level identified by the groups during the workshop are summarized in Figure 36.

Figure 36.Main challenges at the micro level and their relevance as identified in the workshop



The main challenges mentioned by the participants are first, the scalability and the low number of cricket producers versus the high demand, as well as the investment, operational and formalization costs and high entry barriers. Other challenges identified were: integrate and group producers interested in the project, creating a program of production change, the need of more training related to export markets and access to better producing technology, working with species in Costa Rica and being part of international networks.

7.4. Is it feasible to produce cricket powder in a large scale in Costa Rica?

When asked about the feasibility of producing cricket powder at the quantities needed by the market, LTE 2 comments:

> If you tell me: I am a company, I will give you 5000 USD per month as a plant biologist,
>
> with the ideal conditions, I would commit to produce 2 tonnes per month but not in less

than 5-6 years, because that is a curve. I could not guarantee you in less than 5-6 years. I could not tell you that in one year I would produce 2 tonnes. (LTE 2, personal communications, 2019)

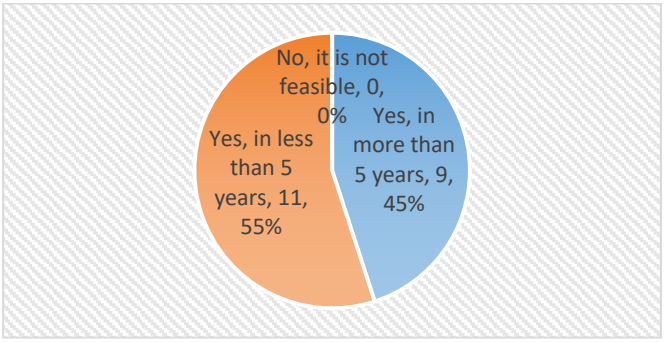
The expert also added: "Because I know how insect rearing works, I can say at any given moment, you can have a "hole" in your production. That is why you need time to play with all the variables". (LTE 2, personal communication, 2019). Local entopreneur 4 also estimates the needed time span to be 5 years. Based on these comments, the participants of the workshop were inquired about the period of time they would think, from their expertise and the learnings of the workshop, it would be needed to be able to produce at least 2 tonnes of cricket powder per month in Costa Rica.

The results of this activity are visible in Figure 37. Nine participants voted for the answer "Yes, it is feasible in more than 5 years" (blue card), while 11 participants voted "yes, it is feasible in less than 5 years" (yellow card). There were 0 votes for the answer "no, it is not feasible". Three participants were not present during the activity.

Figure 37. Results of the feasibility question activity

Figure 38 summarizes the distribution of opinions related to the feasibility question.

Figure 38. Distribution of opinions to the feasibility question



The majority (55%) of the participants think it is possible to produce more than 2 tonnes of cricket powder per month in Costa Rica in less than five years, while 45% consider it is feasible but in more than 5 years. No one voted for the option that it is not feasible.

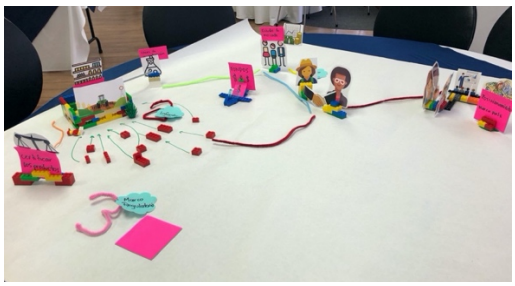
7.5. Possible implementation strategies

All participants and interviewees think it is feasible to create a cricket powder production hub in Costa Rica although there are some constraints that must be solved. That is why it was important to understand the possible strategies to implement that would allow such a production. For example, when asked about the way to go to create a cricket powder production hub in Costa Rica, the international expert mentioned that it is key to have special tax exemptions to bring investors and special programs to bring in companies. He mentioned that special economic zones are important, like the Port of Limon, where companies get tax exemptions for a period of time in exchange of building insect farms there.

The results of the workshop ideation session on possible implementation strategies, are presented in Table 12.

Table 12. Results of the ideation activity

Group	Created sketch	Included strategies
Group 1		• Creation of a Cooperative • Production in the Caribbean area • Investment through the SBD or INFOCOOP • Train employees in coordination with the academia • Perform research with the academia • Getting the proper permits is important.
Group 2		• Perform a feasibility study to analyze the financing sources. • Actors are important such as universities, research centres, other producers, international experts that can help assure the quality of the product. • Choose the production model: suppliers or centralized. • Obtain certifications. • Train personnel • Understand the legal requirements, get the permits.

		• Creation of an Association to articulate efforts is key.
Group 3		• Feasibility study to show to investors is needed. • Obtain the permits. • Start relationship with the academia, local and international. • Build a laboratory to do research. • Comply with international regulations. • Promotion and marketing. • Public digitalization is important.
Group 4		• Creation of an Association of rears similar to the coffee production, where each farmer rears and then sends to a processor. • Obtain a certification. • Regulation is important. • Training the producers. • Investment could be through MICITT, SBD. • Attract foreign angel investors. • Promote a country brand as cricket producers.

In general, the groups propose the creation of an association to articulate the efforts towards the creation of a cricket industrial hub in Costa Rica. The appropriate training of producers and personnel through links with the academia, the attraction of foreign investors, obtaining the proper permits and certifications. In addition, a feasibility study is proposed to detail the main costs of the project. The creation of a cooperative that gathers the production of small rearers was proposed by two of the groups.

7.6. Results beyond the workshop

7.6.1.1. Media coverage

The workshop was covered by the University Press Department, which created a snowball of reactions in the media. A summary article on the objectives and activities related to the workshop was published at the official website on February 5, 2020. The title of the article is "CITA-UCR supports entrepreneurs to produce and export cricket powder" and can be downloaded from the following link: https://www.ucr.ac.cr/noticias/2020/02/05/cita-ucr-apoya-a-emprendedores-para-producir-y-exportar-polvo-de-grillo.html

In addition, the pictures and main statements of the workshop were posted on the University's social media, in their Facebook and Instagram profiles (Figure 39).

Figure 39. Information posted on the Instagram profile of the University of Costa Rica

(Source: Universidad de Costa Rica, 2020a)

After the workshop, the reporter of the UCR contacted another colleague, who was interested in new topics for a show called GIROS. In this case, a TV reportage was recorded, in which LTE1 was interviewed on the process of producing cricket powder. The recording took place in the Museum of Insects of Costa Rica and was published on February 12, 2020 under the title "Learn how to prepare cricket powder"[13].

Lastly, the University of Costa Rica organized a Facebook live streaming on the topic of the opportunities of producing crickets. The activity was titled "Will insects be the protein of the future? and it was organized as an expert interview with LTE2 and Ana M. Quirós, researcher of CITA and one of the group moderators of the co-creation workshop (Figure 40). The video was viewed 53 000 times as of March 14th, 2020 (University of Costa Rica, 2020b)[14].

Figure 40. Interview with experts streamed by the University of Costa Rica

Source: Universidad de Costa Rica (2020b)

[13] Available at: http://www.repretel.com/actualidad/aprenda-preparar-polvo-de-grillo-1-177170?fbclid=IwAR23lrbW5in9sima-0u8PT7FpySjXklUDyJncrMFNiDSNgIMxW-mbbt67M4
[14] Available at: https://www.facebook.com/UniversidadCostaRica/videos/201800067818172/

As a result of this media coverages, the researcher was contacted by several individuals inquiring about business opportunities related to cricket production. Even a producer of pet food approached the researcher, as well as an official of a local public development institution. All the contacts were passed to the CITA researchers, who will be working with stakeholders to further develop the project.

7.6.1.2. Stakeholders articulation

One of the most immediate actions was the creation of a WhatsApp group of producers, in order to keep in touch and exchange information. This idea was discussed during the workshop and was taken into action by local entopreneur 4.

In addition, the SINAC representative came in contact with the researcher with the interest of gathering producers to understand their main needs and work together into getting them in compliance with the Law. Considering this was a sensitive topic to producers, the researcher informed the official that no personal information of the participants was allowed to be shared without their permission and that CITA researchers will be managing further actions on the topic. Two (online) meetings were organized between the government officials and the entopreneurs, in order to explain the current regulatory framework that applies to edible insects in Costa Rica.

7.7. Summary of main findings

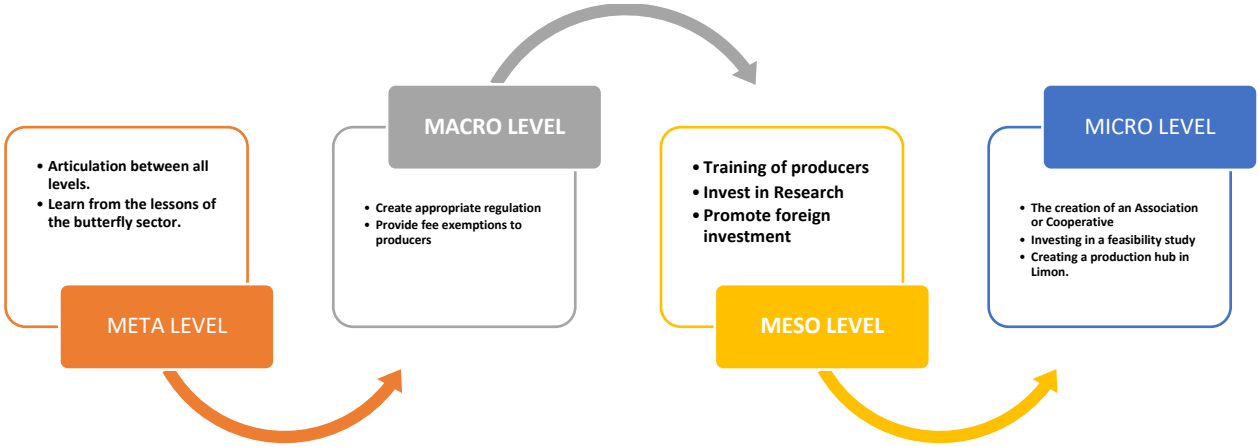
Table 13 summarizes the main opportunities and challenges related to producing cricket powder in Costa Rica as extracted from the interviews and workshop results.

Table 13. Main Opportunities and challenges identified in the different systemic levels

Systemic Level	Main Opportunities	Main Challenges
Meta	-Costa Rica has perfect weather conditions to rear insects. -The local public seems to be interested and curious about eating insects. -Costa Rica already has a history of exporting insects (butterflies). -Costa Rica has an international image as a green country.	-Lack of knowledge on consumption of insects and its benefits. -There is no articulation between the public and private sectors and the academia -Poor innovation culture -Lack of a sense of cooperation culture between producers
Macro	-Existent solid regulation related to wild life protection. -Existent SME support policy of the government	-No specific legislation for edible insects exists. -Lack of clarity in the existent regulation. -The legislation is aimed at a higher scale production and does not include small entopreneurs. -Low availability of technical experts
Meso	-The academia is playing a key role in training (UCR, The Museum of Insects). -There is technical knowledge on rearing insects. -There are existent support institutions on entrepreneurship, innovation and business promotion -Existent research institutions and laboratories	-Low financial support for entrepreneurs. -Few experts on mass production of edible insets. -Low training offer. -Low research on edible insects
Micro	-There is knowledge on rearing crickets among producers. -Producers know each other and have knowledge transfer practices. -There are existent export opportunities.	-Output capacity is too low compared to the market demand. -Producers do not comply with the production requirements. -Current prices are too high due to non-standardized production practices. -No formal cohesion among producers. -Lack of a natural offtake market

Figure 41 summarizes the main implementation strategies suggested by participants during the ideation session of the workshop.

Figure 41. Implementation strategies recommended by the workshop participants



Source: Own elaboration

Chapter 8: Discussion of Results

The results presented in Chapter 6 and Chapter 7 will be discussed in the following chapter, considering the secondary data available and the selected theoretical and conceptual framework.

8.1. Complying with market needs

The results show that there is a potential market for the Costa Rican entopreneurs to export to Mexico, North America (Canada and the USA) and Europe. Japan was also mentioned as one of the most growing markets in the field of cosmetics, which may be interesting to analyze. However, it has to be considered that there are other companies located in Asia supplying this market and it may be more difficult to compete. For example, Thailand and China are the main exporters of cricket powder, which is no surprise considering their long tradition on entomophagy and (traditional) production of edible insects. In addition, shipping costs and language barriers could make it more difficult to export to this market.

In this sense, the AFFIA representative recommends that Costa Rican should first target the US market rather than the European one due to the closeness and the complicated regulation in Europe related to edible insects (Deguerry, personal communications, 2020). In addition, the expert recommends to first understand what are the legal requirements related to the product to be exported, make sure to comply with them and then get in contact with the appropriate delegation of the chosen market in Costa Rica.

Once a target market is chosen, it is important to comply with the client's needs. In this sense, being able to provide the required quantities is one of the basic requirements of any commercial transaction. Unfortunately, this was the main constraint identified for Costa Rica since the output capacity is not big enough to comply with the current demand. According to the results, the average demand per month ranges between 0,5 and 2 tonnes per client but considering the edible insect market is still infant in the world, this demand is expected to grow. The estimated output capacity in Costa Rica is between 1-5 kg (small-scale production) to a maximum of 500 kg (large-scale production) cricket powder per month but not on a continuous basis, which means that the country could not only supply a single client with the current production capacity. Thus, upscaling is the main challenge to be addressed in order to comply with the market needs.

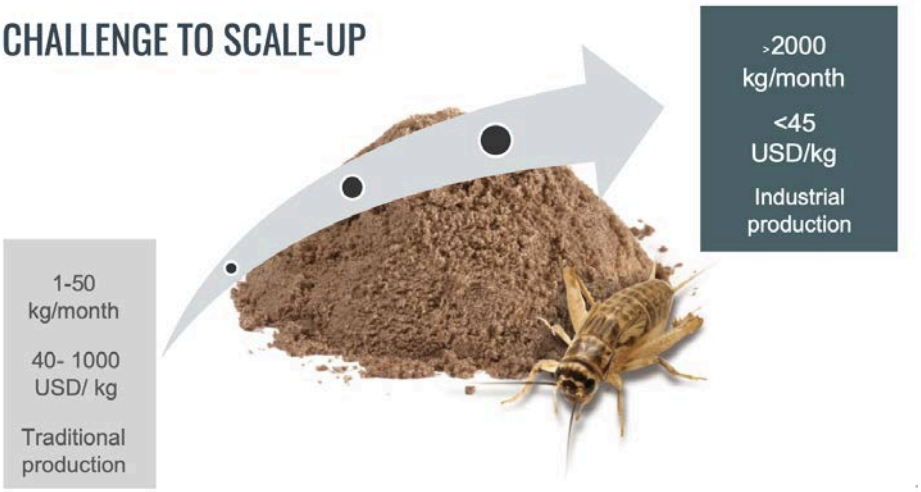
This result was expected, since the cricket production sector in Costa Rica is relatively new, as in the rest of the world. In fact, the IPIFF also considered the need to upscale as the main challenge for the European insect sector (IPIFF, 2019b).

Another important factor of selling goods is the price. In this case, results show that the current price of cricket powder is one of the biggest constraints to its widespread. Currently, the average price of 1 kg of cricket powder ranges between 50 to 60 USD. According to the interviewees, in order for

cricket powder to become a mainstream food raw material, the price should come down to a minimum of 45 USD per kg and ideally reach 20 USD per kg. In Costa Rica, two different situations were detected: traditional farmers sell whole crickets by units with an average price of 0,2 and 0,4 USD per cricket and if they were to produce cricket powder at this same price, the price of cricket powder would be 10 times higher than the current international price; while the more industrial entrepreneurships claim to have prices between 40-70 USD per kg for cricket powder which is in line with the international price but should be lowered down if they would like to be more competitive in the future. In both cases, prices are above the desired threshold. This is a general problem of the edible insect sector the production costs tend to be high when compared to traditional protein sources (Van Huis, 2020).

In this sense, in order to lower the prices, the production needs to be optimized. Thus, automation of processes must be achieved in order to have a higher output while using less labour (Dobermann *et al*, 2017; IPIFF, 2019). Without doubt, scaling the production is a key challenge that Costa Rica must be overcome not only for being able to comply with the required demand but also to reduce the price and be more competitive, as summarized in Figure 42.

Figure 42. Scaling-up challenge in Costa Rica



Source: Own elaboration

If Costa Rican entopreneurs are willing to immerse in the international market, it is important to consider the main buyers which they can offer their products to, mainly, food producers, pet food producers and the cosmetic and pharmaceutical industry. The latter being one of the most promising in terms of innovation. In this case, the fact that cricket producers targeting the food sector are also selling their products to pet food producers and the cosmetic sector is an important consideration for the Costa Rican entopreneurs, who could thus, diversify their client portfolio. According to the IPIFF (2019), pet food is a mainstream market for European insect producers, since insect products are well-suited to the

needs of pet food, due to their high digestibility and palatability. The Association reports that several European pet food companies already incorporate insects in their feed formula and this trend is expected to continue to grow in the next few years.

In addition, the results show that although natural cricket powder is the main product commercialized, defatted cricket powder and cricket oil are sub-products that can even have a higher market value due to their better applications options. Thus, it is important to understand what are the additional processing steps necessary to obtain these sub-products. The case study analyzed was only producing cricket powder, thus, it was not possible to observe these steps. However, according to Rumpold *et al*. (2017), the lipid extraction can be performed through mechanical pressing, centrifugation or an hexane or aqueous extraction.

In Costa Rica, only one company has actual plans to commercialize cricket powder. Traditional rearers sell mostly whole crickets. Thus, Cost Rica is far behind the expectations of the market in terms of functionality and should thus, develop more innovative products that allow local SMEs to immerse in the international value chain.

Requirements for the cricket powder as a raw material for the food industry are related to its quality and food safety. In this context, the protein content was referred as the most important quality aspect considered by the buyers. Thus, the protein content must be validated by a laboratory analysis. This cost must be considered by producers. In addition, avoiding a fishy odour was mentioned as a key quality indicator. In this sense, Schockley *et al*. (2018) refers to innovative techniques for obtaining a much finer grain size and less pronounce flavor and aroma profile such as spray-drying and freeze-drying.

It was evidenced that there is basic knowledge on the quality requirements of the cricket powder, mostly obtained from international business networks. In addition, due to the fact that Costa Rica has experience exporting food products there is already an ecosystem that would allow proper validation of quality requirements, such as the presence of laboratories specialized in food, chemistry and microbiology analysis, as will discussed in section 8.3.

Also, one interesting result, was the fact that clients are requiring gluten free cricket powder considering current consumer trends. In this sense, it must be considered by producers that the feed of the crickets must be gluten free (less than 20ppm) to comply with this requirement. Of course, to be able to assure this to the buyers, an adequate traceability system must be in place, meaning that all materials used during the production can be traced down from the final product. On this topic, the IPIFF Guide on Good Hygiene Practices (IPIFF, 2019a, p.18) states that:

> Insect producers must record and keep the following information in order to ensure product traceability:

1. The name and address of the substrate (e.g. feed materials, compound feed products, feed additives and premixtures) suppliers, the batch number, the quantity and delivery date of the products;

2. The name and address of the insect breeding flock providers, the main characteristics of the flock and its delivery date;

3. The nature, formulation and quantity of the products manufactured, along with their manufacturing date and batch number. Samples and records of each batch must be retained in accordance with EU food and feed hygiene Regulations;

4. Food allergens (e.g. gluten) which the substrate given to the insects may contain when the latter are intended for human consumption (and those made into semi-finished and finished products, including non-conforming products reprocessed to match treatment requirements or microbiologic criteria);

5. The name and address of the buyer(s) and of the site where the batch of semi-finished or finished products are delivered to.

None of the local entopreneurs are providing gluten free products. Thus, this is a topic that should be considered for the production system in order to be able to comply with client's requirements.

Although food safety certifications are usually a market barrier for most food products, considering that the edible insect sector is infant, this is not necessarily the case for cricket powder, where compliance with GMPs and HACCP are expected but a certification is not a limiting requirement according to the interviewees. However, knowing the sector will move towards it, both of the interviewed producers were already certified. This is an additional process and cost that must be considered by Costa Rican entopreneurs for a near future. Although local entopreneurs are far from obtaining a certification, the advantage is that there are certification companies in Costa Rica with experience in certifying food processing companies, who can train, advise and perform the required service.

8.2. Complying with Production Requirements

In terms of the farming and processing requirements it is important first to make a distinction between a traditional small-scale production and a large scale one. As stated by most of the local entopreneurs and experts, "rearing insects is very easy and anyone could do it". However, this situation

changes when it comes to a large-scale industrial production, where, output capacity must be constant and certain requirements must be fulfilled. The infant sector in Costa Rica shows two well defined distinct entopreneurs: the traditional ones and the ones with an industrial approach. It is key to analyze them from the appropriate perspective, since their context, goals and needs may be very different. Both CRIC and Gricket House seemed to be aware of the facilities requirements and have them in their future plans.

Due to the fact that only one processing facility was visited, it was important to gather secondary data concerning the main requirements for an industrial cricket farm. In this sense, the first thing that is important to keep in mind is that authors state that mass producing insects is more complex than one would expect and that the production methods vary dramatically depending on the location and resources available (Tomberlin, 2018). In this line, Mott (2018), founder and CEO of Aspire Food Group Ltd, one of the leaders in the edible insect market mentions that it is important to establish the purpose of the rearing operation, then prepare an appropriate space and obtain the starter population, before starting to rear (Mott, 2018).

Regarding the objective of the farm, Mott (2018) stated that it is important to establish since the beginning if it will be a small or industrial scale production. He defines a large production as a scale colony for commercial production, that produces a minimum of 400-1000kg/month and which farm size is 50-100 square meters or more. In this respect, Cortez *et al* (2016) report that cricket farms can produce 8-10 cycles per year and a medium-sized A. domesticus farm can have an approximate average density range of 6,000-12,000 crickets/m2.

Additional process steps are to be considered in a large-scale production, for example, taking the eggs to a special room before they hatch, or the subsequent washing of crickets, more quality control and the microbiological and moisture analysis to assure standardization. An appropriate packaging is also key for a large-scale production. Considering the freezing step, Cortez Ortiz *et al* (2016) suggest that an ideal farm for supplying the insect-based food market should have sufficient walk-in freezer space to store full pallets. The authors recommend a truckload, or 25 pallets at any given time, to maximize economies of scale involved with shipping.

Regarding the infrastructure for an industrial production, the main basic requirement is that it must be enclosed. Thus, the rearing and further processing steps must be located in a structure that has a roof and walls and where the entrance of other species is avoided. The walls must be smooth and easy to clean, as well as the floors and ceilings. These conditions comply with the requirements listed in the IPIFF Guide on Good Hygiene Practices (IPIFF, 2019a). The main areas observed in the case study are: a warehouse to store materials, the farm where crickets are reared, a washing area for containers and the post-processing area as well as a quality laboratory.

It is important to mention that the egg cartons are used to maximize the surface and thus obtain a higher cricket density. The materials should be food safe, since crickets may attempt to eat them and

due to the fact that cardboard is very fibrous and they rapidly accumulate waste, it is advisable to avoid reusing the egg cartons (Mott, 2018).

Producers stated that although water is one of the key critical factors for the survival of the crickets. It must also be considered that it may be deadly for the instars, due to their small size (Mott, 2018). Thus, special attention must be place to the water disposing system. This was a concept already known by Costa Rican entopreneurs, who were already taking care of having an appropriate disposing system.

In the case of the feed, both producers agreed that this is also one of the key success factors of cricket production, since the feed must be as standardized as possible. Thus, an intense research and development phase is needed (aprox. 1 year), usually with the help of academic institutions and commercial feed companies. In this context, Mott (2018) comments that although the industry goal is to feed crickets exclusively with waste streams, it has been reported that populations fed only with that source develop slowly or do not survive. Hence, the most used feed is currently poultry feed. Considering that feed is one of the key success factors of the rearing of crickets, the interviewees did not give details on the composition of their feed.

In this respect, Cortez *et al* (2016) state that more sustainable, cheap and efficient diets must be developed using underutilized biomass such as spent grains and yeast from brewing or ethanol operations, unused pre-consumer produce or food industry by-products, algae, and/or currently unused biomass such as various grasses (like switchgrass). The authors anticipate that the need for improved feeds and raw materials for insects will increase with increasing production levels. Additional (high) value additives may be required, as well as feed manufacturing operations, and different feed presentation forms (liquid, powders, or mash; semi-moist; pellets; extrudes; simple or complex coacervates). There are already some commercial cricket feed mixes available (such as "Cricket Chow" from the feed company Purina), but many producers prepare their own proprietary feed mixes (Cortez *et al*, 2016).

In the case of Costa Rica although there is knowledge about the nutritional requirements of the crickets, entopreneurs have established their formula on their own without the support of the academia or commercials providers that are present in the country. This is a great opportunity that can be explored in order to come up with a standardized cricket feed since there is enough technical knowledge and research institutions that could support in development of an adequate feed. For example, LTE 2 suggested a combination of organic food waste from local food manufacturers and chicken concentrate, in order to get the adequate protein amount needed by the crickets. In addition, the CINA has expertise in the research and development of animal feed, which could be applied for the case of the crickets.

Both interviewed producers agreed that environmental conditions are critical for the optimization of the crickets' lifecycle. In the visited facility, temperature was controlled at 30-32 C,

while humidity was kept between 50-60%. These values are in line with Cortez-Ortiz *et al* (2016) who report that cricket farmers use temperature ranges between 29.5 and 33°C in their rearing areas and Mott (2018) that suggest a relative humidity of 50-60%. Costa Rica environmental conditions are thus perfect to rear insects, which should be considered as a competitive advantage. However, entopreneurs have not established procedures to assure standardized conditions. Thus, if they want to improve their output capacity, having appropriate equipment to measure these variables is important, as well as standardized operational procedures to assure the necessary environmental conditions.

In addition, a quality and food safety system must in place in a cricket powder production plant, which complies with the IPIFF Guide on Good Hygiene Practices (2019). This requirement must be considered by Costa Rican entopreneurs (and investors) before starting a project, since additional costs are related to an appropriate food safety and quality management system.

Regarding the personnel, there were only two workers in charge of the farm and one more for the laboratory area, which means the production is not that labor intensive. In this case, both producers agree that due diligence and management skills are key to the personnel, since there is a lot of trial and error involved in the first years of the project. Accordingly, Mott (2018) considers that raising crickets includes a high amount of trial and error, that will last as long as the farmer works with crickets. In terms of maximizing productivity, increasing weight per cycle and decreasing cycle time are key.

In terms of the supplies and equipment needed, the main costs are related to the metallic racks, plastic containers, egg cartons, feed and the post processing steps supplies. In this case, the microwave dryer and the blender to obtain the cricket powder were the two main technological equipment identified during the visit. The microwave dryer is specific for crickets and was bought in China.

In order to comply with all these production requirements, an estimated initial investment of 1 million USD is needed, including the infrastructure, equipment, personnel, as well as the trial and error stages.

Finally, it is important to consider there are two different business models possible, one centralizes all the farming and processing steps, while the other gathers the cricket production from several producers. It is very important to analyze what the best model would be for Costa Rica.

8.3. Assessing the entopreneur ecosystem in Costa Rica

With the above discussed results, it was then important to analyze if Costa Rica would have the adequate entrepreneur ecosystem to develop a cricket powder production hub. The obtained results are discussed in the following sections, considering each systemic level from the systemic competitiveness approach. Main opportunities and challenges identified in each level are discussed.

8.3.1. The meta level

First, in the meta level, main opportunities are listed, such as the appropriate weather conditions of the country to rear insects, especially in low income areas such as the province of Limon, which not only would be the project suitable but also support the local economy. Also, although there is no tradition of entomophagy in Costa Rica, the local market has shown interest in the existing insect-based products, willing to try and buy them.

In addition, Costa Rica holds an internationally well-known image of being a sustainable country, which aligns with the purpose of an edible insect production. Most importantly, Costa Rica already has a history with the production and commercialization of butterflies, being the main world exporter of butterfly pupae to international markets such as the United Stated and Europe (Umaña, 2020). This fact is seen as one of the main opportunities to grasp due to the fact that thanks to the 40-year long history of commercializing insects, lessons have been learned in terms of creating appropriate legislation, establishing a business model and of course there is technical knowledge on rearing insects.

However, on the downside of the meta level, there is still lack of knowledge on edible insects, which can have an impact on the rest of the levels, for example making it necessary to explain to public regulators, investors and the public why the production of edible insects is important. The media, academic institutions, marketing companies and the social media were pointed out as the main actors in this level. This result goes in line with Vantomme (2018), which states that academia plays a special role in generating facts and knowledge, while the press can communicate through articles, cookbooks, TV shows, news and documentaries. The great effect of the media was observed with the publication of the workshop in the Costa Rican local media, so it is key that producers and academics are in constant collaboration with the media in order to make public awareness.

Moreover, cultural issues could affect the development of the project, like the poor sense of cooperation among producers, who rather tend to compete against each other. In addition, there is a poor innovation culture, which sometimes makes it difficult for innovators to develop start-ups, as criticized by local entopreneurs 2, stating that the professionals in biology are not open for innovation. This result goes in line with Monge-Gonzalez (2016) who state that “it can perhaps be claimed that Costa Rica lacks a culture of innovation” (p.46). The author criticizes the fact that the higher education system in Costa Rica does not currently contribute to creating a favorable environment for innovation and generally suffers from a disconnection from labor and the practical world, not stimulating critical thinking and creativity in students, and thus encouraging a passive attitude toward knowledge (Monge-Gonzalez, 2016).

Furthermore, a lack of a common strategy between the private and public sector is another challenge observed, since these actors usually seem to have different goals and rather fight against each other instead of cooperating. In this context, Vantomme (2018) considers that effective communication is

required within and among different governmental and non-governmental agencies and ministries. For instance, ministries or stakeholders from health, agriculture, food, environment, industry and trade should talk to each other.

In order to assure that the proposed project is successful, Costa Rica should learn from the lessons learned of the butterfly sector and better articulate the communication and common goals between the stakeholders in different levels. However, it has already being reported that there is a weak interaction framework between universities and research centers and the private sector. For instance, conducting joint research projects occurs sporadically. In addition, research activities at universities and research centers often lack specific market-oriented targets, and are disconnected from the needs of the productive sector (Padilla, Gaudin, and Rodriguez, 2012).

Collaboration is key for developing innovative projects like the one in question, and a success story is the strong organization of the Dutch edible insect industry, where the insect producer's association has connections with the national governments and local public representatives as well as with knowledge institutes in the Netherlands (Vantomme, 2018). Costa Rica should take this example to start creating an enabling framework for edible insect production.

8.3.2. The Macro Level

It is clear that the macro level is one of the levels were most adjustments have to be made considering a possible development of cricket powder production in Costa Rica. Here, the challenges outnumber the opportunities.

The legislation is the main constraint for a possible development of a cricket powder production hub, as stated by the participants during the workshop and the various interviewees. First, the existent legislation concerning insects was not specifically created considered edible insects, but this are included by default, causing that some requirements are not really applicable and causing confusion ans misinterpretations of the law. Luckily, this is not only the case of Costa Rica, since the same situation has been reported in the European legal framework. In fact, the IPIFF reports that the legal framework was the main factor impacting the growth of the insect sector in 2019 (IPIFF, 2019b).

Van Huis and Tomberlin (2018) criticize the fact that when the word "animals" is used in the legislation it automatically refers to the insects, but when the legislation was created, no one considered insects as food. For instance, it is evident that the EU Regulation 1099/2009 was not designed to apply to insects because all animals are required to be sacrificed in certified slaughterhouses, which for obvious reasons cannot be implemented in the case of insects.

Also, the concept of wild life may or may not apply to crickets in the Costa Rican legislation, depending on the interpretation, thus, making it unclear if it is legally possible to commercialize them or not. In addition, it is difficult for producers to get in line with the regulation. First, because the

regulation does not take into consideration small producers and the costs associated are too high for the existent one. And second, because government officials show lack of knowledge on the applicable requirements to insect production, not being able to appropriately process the paperwork. A similar situation is experienced in the European Union, where the IPIFF has reported legal gaps in the legislation (Van Huis and Tomberlin, 2018).

All in all, the fact that the regulation is the main challenge identified in the macro level, goes in line with the international state of the edible insect sector, in which it has extensively been reported that the current lack of legislation for edible insect production and commercialization is the one of the main challenges for the widespread of insects as food (Rumpold and Schlüter, 2013; Doberman *et al*, 2017, Van Huis, 2020).

The bureaucracy was also mentioned as one of the main constraints for entopreneurs. This result is no surprise, since Costa Rica's position in starting a new business is 118th out of 184 countries evaluated in the Doing Business index, which results from a relatively high number of procedures, number of days needed to complete these procedures, and the cost of starting a new business. In this context, An, Oh, and Monge-González (2015) emphasize the importance of working to deregulate the Costa Rican economy.

On a governmental perspective, there is also the challenge of the number of technical experts available. Since there are not enough for the existent butterflies' farms, and thus, would also not be enough in case more cricket farms should be inspected. Thus, it is important to work closely with the academic institutions to start training the required professionals that will be needed in the near future.

The main opportunity identified by the workshop participants is the country competitiveness through the existence of free trade zones. In this respect it is important to mention that Costa Rica has a special Free Trade Zone system regime for attracting both foreign and domestic investment, established by Act 7210. A Free Trade Zone is basically a geographical area within the country in which a group of companies can introduce goods of foreign origin without paying customs duties and taxes. Companies that may apply for such a regime are: export services companies, which must export at least 50 percent of their total sales; strategic sectors companies, which must be located outside the Greater Metropolitan Area (GAM); scientific research firms, either companies or organizations; and significant suppliers, at least 40 percent of whose sales must be made to other companies located in the free trade zone (Monge-Gonzalez, 2016).

The existence of a law protecting wildlife can be seen as an opportunity and as a constraint at the same time. One the one hand, the fact that the country protects its wildlife must be seen with good eyes, since the lack of a solid regulation to control inappropriate exploitation of wildlife is a risk stated by Ramos-Elorduy (2006) that has caused the extinction of several insect species in Mexico. However, the same law is blocking the efforts of small entrepreneurs to legalize their farms and increasing their

production, limiting the growth of the sector and the possible economic benefits related to it. Thus, it is important to identify a balance between the possible risk and the benefits.

Furthermore, the existent SME support strategy led by the government is seen as an opportunity. The government of Costa Rica has already identified the importance of SMEs in the local economy, and thus, has a strategy led by the Ministry of Commerce to strengthen them. In Costa Rica, only SMEs are potential beneficiaries of state support for investment in innovation activities. The strategy originated more than two decades ago, with the passing of the Law for the Promotion of Scientific and Technological Development (Law 7169) in 1990, which created the Ministry of Science and Technology of Costa Rica (MICITT). In 2002, a new fund was established called PROPYME (Programa de Fortalecimiento para la Innovación y Desarrollo Tecnológico de las PYMES) to promote entrepreneurship and competitiveness of Costa Rican SMEs through innovation and technological development, and to contribute to economic development. These resources are managed by CONICIT. This is definitely an opportunity for cricket powder producers, since the funds can be used for technology development, innovation and patent creation, technology transfer, human capital development and technological services development (Monge-Gonzalez, 2016).

Although there is support for SMEs, the country does not yet have programs in place to support fast growing start-up development. It seems there is still not enough knowledge in the country on how innovation in such start-ups works, which is a downside for entrepreneurs like CRIC.

As possible implementation strategies, participant propose the creation of adequate regulation for the production of edible insects. As well as promoting foreign investment by providing fee exemptions for cricket powder producers. In this respect, Monge-Gonzalez (2016) mention the importance of public policies to support the productivity growth of smaller firms with potential in Costa Rica, as a mechanism for increasing productivity in the country's economy. According to the authors, Costa Rican authorities should design and implement policies that successfully strengthen the innovation system, improve the capacity of domestic firms to absorb knowledge and technology, and remove obstacles that prevent domestic companies from growing.

In this context, the joint program DESCUBRE is a great step on that direction. This is a public-private alliance articulated by COMEX, MAG, PROCOMER, CINDE and The Development Banking System with the participation of the private sector and academia. The aim of the program is the diversification of agriculture and fishing and the attraction of investments in rural areas (DESCUBRE, 2019). The fact that edible insects were identified among the ten priorities in this program draws an excellent opportunity to develop the sector.

8.3.3. The Meso Level

Out of the four systemic levels, the meso level is the one that looks most optimistic. Here, more stakeholders could be identified. According to Meyer-Stamer (2005) support institutions at the meso

level are key for the development of innovative industries. In this context, it was evident that the academia is already playing a key role in developing an edible insect sector, especially the University of Costa Rica through the Museum of Insects, the School of Nutrition and the CITA. As the study's results show, the role of the Museum of Insects during the last 10 years has had a direct impact on the existent entopreneurships, as well as the training course provided by the School of Nutrition. Thanks mainly to knowledge transfer from the University of Costa Rica and the private individual efforts of the existent entopreneurs, there is basic knowledge on the rearing of insect, which is an important starting point for scaling up a cricket powder production.

Producing edible insects in a mass scale for food is considered a radical innovation, since it has never done before. Thus, the lack of technical knowledge specifically related to the topic is a common concern. However, since innovation is related to research and development, the fact that a country has a strong base on technical professionals and institutions, such as research centers and universities may ease the development of such an innovation.

Furthermore, although Costa Rica is a middle-income country, there are several institutions that have experience in research, specifically on food and animal nutrition, such as the National Center for Science and Food Technology (CITA) and the Center for Animal Nutrition (CINA) (both located in the University of Costa Rica), which would play a key role on supporting the private sector with research and development projects. Also, Costa Rica has already established infrastructure of laboratories on food analyses and microbiology, making it possible to comply with the quality control standards discussed in section 6.1.

This result goes in line with Vestergaard and Diaz (2007), who argue that the University of Costa Rica has the greatest research capacity in the country, consisting of a network of 64 laboratories that carry out research activities and provide scientific and technological services in the fields of molecular and cell biology, chemistry, food and materials technologies, and structural models. Accordingly, Padilla, Gaudin, and Rodriguez (2012) find that in Costa Rica there are research centers in various areas, and highlight the capacities that have been developed in agricultural technology, food, and biotechnology at the National Center for Science and Food Technology (CITA).

In addition, the fact that Costa Rica has already working institutions supporting entrepreneurs and innovation, such as AUGE, PROINNOVA, and incubators such as IMPACTHUB and CARICACO is without doubt a great benefit for the entrepreneurs, who can get advice to grow their businesses.

However, there are still challenges that need to be overcome, such as the low financial support for entopreneurs, who normally have to self-finance and thus cannot grow as fast as required. This result was expected, since according to the Enterprise Survey for Costa Rica (World Bank, 2013), many companies claim that their main obstacle related to the business environment is lack of access to funding. In addition, Monge-Gonzalez (2016) considers that the shortage of venture capital is obvious in Costa Rica, where only businesses in the information and communication technologies sector have

access to such resources. However, the creation of the Development Baking System (SBD) in 2008 was a measure to balance this situation by providing resources to promote and encourage the creation, reactivation and development of businesses, using models of seed and venture capital.

Also, although there is knowledge on the rearing of insects, there a few technical experts in the topic, and almost none specialized in mass producing crickets. As a result, the training offer on producing insects is limited. In this context, An, Oh, and Monge-González (2015) recommend developing technicians and engineers through university-industry collaboration.

Also, although the Museum of Insects has done a great job in promoting entomophagy and insect rearing there is not really a strategy to develop the sector and no funding is specifically assigned to this area, having also limited personnel. This is of course not an isolated case, Padilla, Gaudin, and Rodriguez (2012) also argue that resources for research at the universities represent a small part of the total budget in Costa Rica and that there are cases in which high-level infrastructure is available, but most research laboratories are not often adequately equipped. In general, R&D investments in Costa Rica stands at about 0.5 percent of GDP, while according to Monge-Gonzalez (2016) to this figure should be five times higher, meaning not enough resources are invested in research and development.

Participants of the study agree on the fact that more funding should be directed towards the research on edible insects, which would also allow having more specialized experts and thus, increasing the training offer for producers.

Also, considering the limited funding options in the country, it is proposed that foreign direct investment (FDI) should be attracted to invest in the project of cricket powder development. This goes in line with the country policy of the last years, in which the attraction of FDI has been a pillar for growth. The creation of CINDE at the beginning of the 1980s was a key achievement in this direction, being a private organization dedicated to attracting FDI and supporting the process of the new export-led economic model. Thus, it is key to include CINDE as an important actor for the development of the edible insect-based sector in Costa Rica.

Furthermore, the role of PROCOMER in promoting exports was acknowledged by the local entopreneurs. This public institution provides support to producers willing to export, not only through advice and training but also through international marketing strategies such as the participation in international fair trades (PROCOMER, 2019).

8.3.4. The Micro Level

On the micro level, it was evident that Costa Rica has an infant and incipient edible insect sector. But, some opportunities are present, such as existent entopreneurs with years of experience rearing insects. As well as the fact that there are informal knowledge transfer practices among them. Also, one of the main opportunities mentioned by the interviewees is that local producers have already been contacted by international buyers willing to buy insect products from them.

This must not be neglected, since this existent knowledge may be used to boost the sector. The experience of Thailand can be taken as an example. There, when cricket farming was introduced in the 90s, most farmers were small with one to ten concrete breeding containers, but with the time the business evolved to a small and medium enterprise, in which farms can have up to 150 concrete cylinders with production of 450 to 750 kilograms at each harvesting cycle (45 days). Cricket farming changed from an additional source of income to becoming the primary income source for most farmers (Hanboonsong *et al*, 2013).

Other challenges are related to the poor formal network existent between producers, who mostly see themselves as competitors and do not collaborate with each other on a common goal. This result also goes in line with the international character of the edible insect sector, which is characterized as "too secretive" as mentioned by the international expert and already reported by Van Huis & Tomberlin (2018), who state that a problem in the edible insect sector is that the methods to rear insects are often company secret, making it difficult for the new entopreneurs to get to the level of sophistication as the existing companies.

Also, the fact that there is no established offtake market yet may make the country less attractive to investors due to the fact that the produced cricket products cannot necessarily be commercialized internally, which is the case in Thailand or Mexico, where the internal demand is higher than the offer (Ramos-Elorduy, 2006).

As part of the main strategies suggested by participants, the creation of an association or cooperative of producers was proposed. This model would not only allow small producers to participate in the international market but also to have a leading institution that leads the efforts towards the development of an insect-based industry in the country. This goes in line with the suggestion of Van Huis & Tomberlin (2018), who recommend producers to organize themselves in order to tackle legislation issues.

In addition, it was suggested that a complete feasibility study must be performed before starting the project, in order to understand the main financial requirements of such a production project. In terms of the location of the project, the province of Limon was suggested to be the best region to start.

Chapter 9: Conclusions

The production of edible insect product is a novel opportunity for tropical countries. Costa Rica is a small country with a huge potential in terms of this novel business sector due to its strategic location in the tropics and near potential markets as Mexico and the United States, as well as its economic and political stability in comparison to other countries in the region. Moreover, Costa Rica has an international status as a green and sustainable country and a valuable history as the main exporter of insects in the world, thanks to a 40 year-long private strategy of exporting butterflies to Europe and Asia. In addition, Costa Rica has already 10 years of experience promoting the consumption of edible insects and in the recent years also the rearing of insects. Thus, there is a knowledge ground from the academic and private sector and also, an openness from the public related to the topic of edible insects. Hence, it is logical to think that Costa Rica can very easily start producing and exporting cricket powder to the growing international markets.

Nevertheless, there are still constraints that must be overcome in order to achieve the success of such an endeavor. First, although there are already private initiatives to start producing on a large scale, the current output capacity is not even big enough to supply the requirements of one client. Thus, more efforts must be done to scale the production capacities. In order to achieve this, it is necessary that the different stakeholders in the ecosystem commit to a common goal and take this opportunity to improve the country's productivity and competitiveness, while generating new employment options. It is necessary that the entrepreneurs, the academia, the government and the society as a whole understand the benefits of such a project and come together to make it happen. Considering the production of edible insects is a radical innovation, not only in Costa Rica, but in the world, the challenges that come with it are big and can only be turned into opportunities when there is a clear strategy defined, where all stakeholders participate from their contexts.

It is evident that the current edible insect industry in Costa Rica is incipient. However, the fact that there are already entopreneurs developing products and that there are experts that have worked on the field for 10 years is a great starting ground. Nevertheless, it is clear that there is a lot of work that must be done in the different levels in order to develop an industrial hub for cricket powder to supply the international market.

Considering all the challenges and opportunities present in the Costa Rican entopreneur ecosystem, the answer to the main research question is that Costa Rica will be able to produce cricket powder that complies with the minimum market requirements presented in a period of 5 years, if there is a strategy in place to overcome the main constraints identified in the present study.

In order to comply with the market expectations, there are important opportunities in the entopreneurial ecosystem of Costa Rica that must be exploited, as well as big constraints to be overcome. In the meta level, it is concluded that Costa Rica has the necessary environmental conditions to rear insects, holds an internationally recognized image of sustainability and, above all, the country

has expertise in producing and exporting wildlife, mainly butterflies. However, there is still a lack of knowledge related to the edible insect sector and there is no cooperation strategies between the private and public sector.

The macro level is the one that shows the main challenge, mainly the legislation. First, there is no legislation specifically designed for edible insect production. Second, the existent legislation is unclear, making it difficult for entopreneurs to legalize their productions. Also, the costs associated to the legislation are not affordable for a small-scale production, leaving small entopreneurs in the informality. However, the fact that Costa Rica has a law protecting wildlife may be seen as an opportunity to avoid incorrect exploitation of the natural resources. Also, there is a public policy to support SMEs that is beneficial for small producers.

In contrast, the meso level looks more optimistic, since there are established support institutions in research and development, innovation and business and export promotion, such as CITA, CINA, PROCOMER, AUGE and IMPACTHUB. Moreover, the role of the academia, mainly the University of Costa Rica and The Museum of Insects, has been key to develop the existent edible insect sector. However, there are low financing options, no technical experts specialized in mass producing insects and thus, a low training offer for interested entrepreneurs.

Finally, the microlevel shows that the current edible insect sector is infant and incipient and thus must be scaled up. There are export opportunities, existent knowledge on rearing insects in a small scale and some informal networks between producers. However, the main challenge is the low production capability that is too distant from the required quantities by the current market and the lack of a formal support network between existent producers.

Among the proposed implementation strategies, the formation of a producer's association is encouraged, as well as more research on edible insects, the creation of appropriate legislation, increase training offer and promoting foreign investment.

The main contribution of the present study is to fill a research gap related to the investigation of the potential of producing and exporting edible insect products in Costa Rica. In addition, the action research approach has already generated an impact in the Costa Rican entopreneurial ecosystem, making the study a key contributor to the development of the sector in Costa Rica. The comments received by the participants were very positive and hopeful towards the effects that the research will cause and is already having. The response of the media and the public was also interestingly high towards the topic. Thus, it can be expected that the research will help entrepreneurs, investors and public authorities promote the establishment of an insect-based industry in Costa Rica and also contribute to provide scientific information to the field of business and economics related to the edible insect production in Latin America and the rest of the world.

Chapter 10: Recommendations

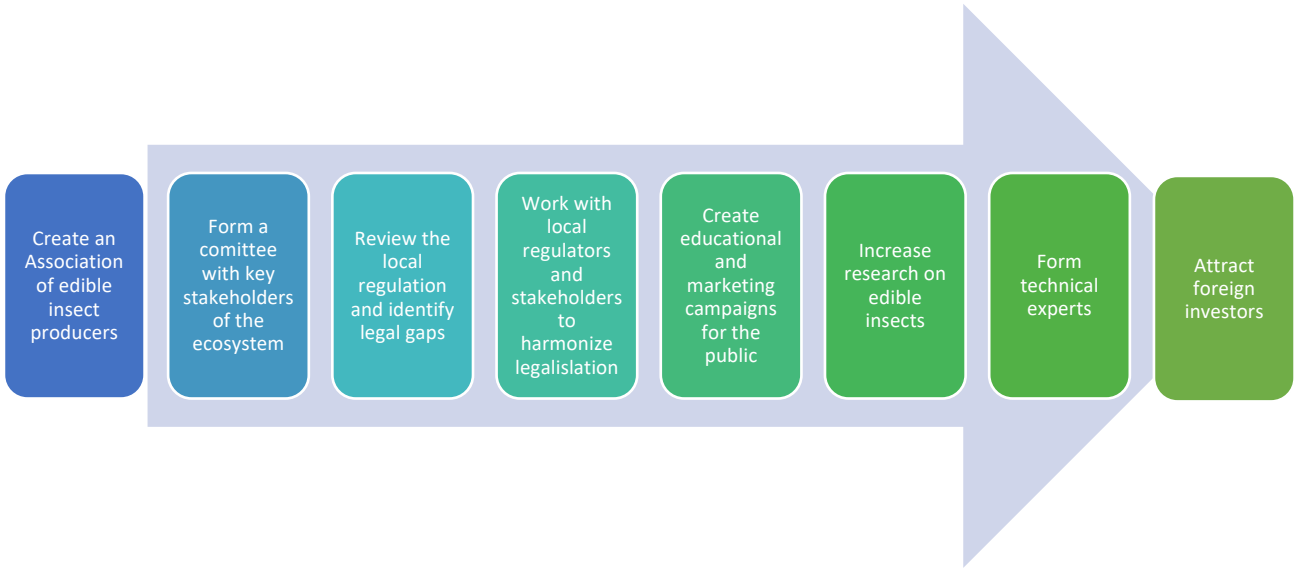
After analyzing the market needs, process requirements and feasibility of producing cricket powder in Costa Rica and discussing the main opportunities and challenges, the next sessions present recommendations from the author's perspective to achieve the goal of producing and exporting cricket powder in a large scale from Costa Rica to the world in less than 5 years.

10.1. A possible roadmap

Costa Rica has the required minimum resources to be able to produce cricket powder in an industrial scale in the near future. However, there are still constraints to be overcome such as the unclear regulation and the poor collaboration between the different sectors.

Figure 43 presents a possible action plan that could be implemented in order to make such an endeavor possible. The presented roadmap has three main areas of action, responding to the challenges that were identified in the present study: articulation of stakeholders, harmonization of regulations and education to the public

Figure 43. A possible roadmap for Costa Rica to developing an enabling environment for the industrial production of cricket powder



Source: Own elaboration

First, the creation of an association of edible insect producers is proposed. The experiences from AFFIA and IPIFF should be taken as an example in this case. As their representatives mention, the impact of working together is always much bigger than an individual working alone. This is especially important in sectors that are radically innovative. The edible insect producers must be

aligned and should have a strong representation in political arenas in order to achieve the necessary changes.

However, insect producers should not act alone, there are other key stakeholders in the ecosystem that should work together, such as academics and researchers, as well as export promoters and representatives of the gastronomy and cultural sectors. For this reason, the creation of a Committee is recommended, where knowledge is exchanged and clear action plans can be drawn on the basis of an interdisciplinary approach.

Once there is a leading organization, it is time to review the local regulation an identify the existent gaps that affect or may affect the sector and start working on the harmonization of the existent legal requirements and/or the creation of specific regulation for edible insect production. To achieve this goal, the articulation with local regulators is key since regulators must understand the multiple benefits (social, economic and nutritional) that the production of edible insects present in order to be willing to find an enabling legal ground for it.

And this is where education is so important. The Association and/or Committee should develop educational and marketing campaigns to educate the public about the benefits and implications of the production of cricket powder (and other insects). The activities that are already performed by the Museum of Insects should be extended to other institutions, such as the primary and secondary schools, for example, to teach children how (and why) edible insects are consumed. It is key to recognize that the consumption of edible insects is a tradition practiced by indigenous people, and it must be represented as an opportunity to go back to our roots (Bermudez-Serrano, 2020).

Research is one of the key elements for the creation of innovation. That is why more research should be promoted on the different areas related to edible insects: insect biology, consumption and consumer acceptance, new product development, production, economic impact, etc. The academia should be aligned with the producers in order to direct the limited resources to find answers to the main challenges that affect the sector. It is in this sense recommended to not act alone, but rather collaborate with international institutions and research centers that have been researching on edible insects in the last years, such as the Wageningen University. Moreover, it is recommended to create a Research Center on edible insects, where the necessary funding can be directed, required equipment and materials are available and research results are published on a continuous basis.

Following this line, technical experts on entomology, insect mass production, insect cooking, marketing of edible insects, etc, should be trained from the academia in order to support the efforts of the entrepreneurs. It is recommended that the Universities start offering specific courses on the topic. For example, the Faculty of Biology should have a specific course on the biology of edible insects, while the Faculty of Food Science could offer a course on production of edible insects. It is important to understand that although at the moment edible insects are not mainstream, there are several efforts

around the world to make that happen and, hence, Costa Rica should start developing experts on the topic before it is too late.

Considering that financial support in the country is limited, it is recommended to work with CINDE to attract foreign investors willing to expand their edible insect production to tropical areas. Costa Rica has the perfect setting for investors and marketing these benefits efficiently is critical to promoting the creation of an industrial hub for cricket powder (and other edible insects) in Costa Rica. It must be noted that allowing the creation of production plants will bring with it knowledge and technology and if this knowledge is adequately absorbed, it can boost the local entopreneurial ecosystem.

It is important to acknowledge that all the listed strategic activities can only work if there is a clear common goal to be achieved, in which all stakeholders are aligned and working together. For this reason, the role of the Association is critical and collaboration is key. Only if the common goal is bigger than the individual interest, it will be possible to develop such an innovative sector in Costa Rica.

10.2. For future research

The current investigation had a defined scope. However due to the fact that edible insects are a radical innovation, there are plenty of research opportunities in many fields related to the potential production of edible insect products in Costa Rica. Here are some recommendations for future research:

- Legislation: First, a detailed analysis of the local and international framework is needed to understand where the main constraints are in order to produce and export cricket powder and identify what are the needs for new legislation.
- Other species: study of the local species that can be used for human consumption. Such a study would include the identification and characterization of the insect species available in the country, as well as the posterior investigation of the best way to prepare it. In this case it would be possible to work with the School of Biology to develop such research projects.
- Economic studies: A detailed economic feasibility study, where the main costs of producing cricket powder in Costa Rica on a large scale are identified is necessary in order to have clear understanding of the necessary investment required. The requirements listed in the present study can be used as basis for the analysis.
- Innovative insect food products: The research and development of more innovative cricket and edible insect products is necessary, considering the low innovative stage of the products sold locally.
- Local consumer acceptance: An understanding of the local consumer acceptance is important to determine what is the level of acceptance towards edible insect products and compare it to other regions of the world.

- Production methods: the success of a project related to edible insect production is related to maximizing output capacity, thus the investigation of innovative production methods should be promoted.
- Main needs of producers: investigate the needs of the current entopreneurs in order to come up with adequate policies related to the promotion of SMEs on the edible insect sector.

10.3. For regulators

It is important to understand that the current legislation was not specifically created considering insects as a food for human consumption. And although requirements for insect production are mentioned in the current legislation, these must be evaluated in order to assess if the current requirement respond to the real market dynamics. Those, it is necessary to have discussions with the producers and the academia in order to identify the legal gaps related to the rearing of crickets and the processing of cricket powder.

Of special importance is to understand that regulation cannot be unidirectional, but rather has to consider the different stakeholders that are involved in the value chain of edible insects. Thus, an assessment of the main challenges of traditional producers must be performed, since due to the low technological barriers of rearing insects it is to be expected that more individuals will be willing to explore producing insects for their own consumption or as an additional income source. Hence, having legislation that demands a high investment of infrastructure or technical advice will only keep these entrepreneurs in the informal sector, not contributing to the local economy and probably representing a higher risk in terms of food safety.

It is advisable that regulators have an open mind related to the topic since radical innovations could be hindered through excess regulations at the first stages of the innovation processes.

10.4. For local entrepreneurs

Entrepreneurs should have adequate education and marketing strategies to convince the local and international consumers of the benefits of eating insects. It is important that these strategies go in line with the recommendations of experts related to the appropriate message to be communicated, since inappropriate marketing campaigns can be counterproductive. For instance, House (2016) recommends to focus efforts on early adopter who will then have a multiplier effect on their friends and family.

Even when companies want to export to other markets, it is advisable not to neglect the importance of developing a local demand for insect-based products. Thus, education to the Costa Rican society is recommended in order to increase the general knowledge and interest in entomophagy.

Also, entrepreneurs should understand that at this stage it is key that they collaborate with each other and share information and their achievements so that they can all grow to the same ground

together, avoiding the unnecessary competition but rather working as a group with the same goal in mind. For this reason, it is recommended to start an Association where producers, enthusiasts and technical experts can share knowledge and organize the required strategies to work together with the government for creating the necessary policies and regulations to support the development of the edible insect sector in Costa Rica.

It is important to understand that there are different approaches to insect production: the traditional and the industrial one. However, both of these approaches should coexist and collaborate with each other, because the traditional knowledge on rearing insects is also key to foster innovation and get more people involved in the edible insect sector.

Moreover, local entopreneurs should take advantage of the existent international networks to find advise, for example, getting in contact with the AFFIA, IPIFF and other associations related to the topic of sustainability and insect rearing.

10.5. For the academia

The academia should acknowledge its key role in the development of innovation in the edible insect sector in Costa Rica (and the region). Special focus should be placed in forming technical experts in accordance to the needs of the markets. Thus, it is vital that the academic officials understand what are the opportunities related to insect production and how they can come up with a professional profile to serve this purpose.

Once the appropriate technical experts are formed, it is important to provide training courses responding to the needs of the producers, especially in the field of mass-producing insects. To achieve this, it is recommended to bring together academics from different disciplines, such as food engineering, entomology, animal nutrition, informatics, mechanical engineering, nutrition, economic science, among others.

Innovative research projects can be promoted among students as part of their thesis or in collaboration with big companies that may be interested in the topic. These research projects could be related to innovative production techniques, automation of processes, innovative food products and marketing and education campaigns.

10.6. For investors

Costa Rica has a great potential for being a leader in the region on cricket powder production and export. But this cannot be possible without the appropriate injection of capital. Thus, it is necessary for local and international investors to support the projects of entrepreneurs by providing adequate financial support and helping to scale the production capacity.

It is important for investors to understand that the stage of the industrial edible insect sector is infant not only in Costa Rica, but in the whole world. Thus, a lot of trial and error is required and time is needed to optimize processes. Investors must consider this factor since the beginning of the project to avoid unrealistic expectations on the return of investment and properly support the entrepreneur in the early stages of project development.

References

An, G., Oh, D.S. & Monge-González, R. (2015). "Supporting Mechanisms for SMEs: Strengthening Innovative Capacity and Establishing Linkages in Global Value Chains," presentation as part of the 2014 Knowledge Sharing Program with Costa Rica. Research Gate. https://www.researchgate.net/publication/289672224_Innovation_Productivity_and_Growth_in_Costa_Rica_Challenges_and_Opportunities

AFFIA. (2019). Mission and objectives. https://affia.org/

Arteaga, A. (2017). La joven que vende galletas de chapulines y conquistó a Shark Tank. Alto Nivel. https://www.altonivel.com.mx/empresas/emprendedor/la-joven-que-vende-galletas-de-chapulines-y-conquisto-a-shark-tank/

Aspire Food Group. (2016). Aspire Food Group. https://aspirefg.com/technology.aspx

Bermudez-Serrano, I.M. (2020). Challenges and opportunities for the development of an insect-based industry in Latin America. In press. *Journal of Insects as Food and feed:* 0 (0), pp.1-20. http://doi.org/10.3920/JIFF2020.009

Belluco, S., Halloran, A. & Ricci, A. (2015). New protein sources and food legislation: the case of edible insects and EU law. Food. Sec., 7(1), pp. 739-746.

Bryman, A. (2004). Social research methods (2nd ed.). Oxford University Press.

Byrne, C. (2018). Regional and Private funds invest 15m in French insect protein firm. Feed Navigator. https://www.feednavigator.com/article/2018/02/13/regional-and-private-funds-invest-15m-in-french-insect-protein-firm

Caparros-Megido, R., Haubruge, E. & Francis, F. (2018). In: Van Huis, A. & Tomberlin, J. (Eds.). 2018. Insects as Food and Feed. Wageningen Academic Publishers

Central Intelligence Agency [CIA] (2020). The World Factbook. Costa Rica. https://www.cia.gov/library/publications/the-world-factbook/geos/cs.html

CINDE. (2020). Why Costa Rica?. http://www.cinde.org/en/why.

CITA. (2019). Quiénes somos?. http://www.cita.ucr.ac.cr/quienes-somos

COMEX. (2020). Principales productos exportados hacia el mundo. http://www.comex.go.cr/estad%C3%ADsticas-y-estudios/comercio-bienes/exportaciones/

Cooper, D. R. (2014). Business research methods / Donald R. Cooper, Florida Atlantic University, Pamela S. Schindler, Wittenberg University.—12th edition.

Cortez Ortiz, J.A., Tatum, J.T. & McGill, W.L. (2016). Insect Mass Production Technologies. In: Dossey *et al.* (Eds.) 2016. Insects as Sustainable Food Ingredients. http://dx.doi.org/10.1016/B978-0-12-802856-8.00005-3

Costa Neto, E. (2016). Special issue: los insectos comestibles – edible insects in latin america. *Journal of Insects as Food and Feed*, 2(1), pp. 2352-4588.

Costa Neto, E. & Ramos-Elorduy, J. (2006). Los insectos comestibles de brasil: etnicidad, diversidad e importancia en la alimentación. *Boletín Sociedad Entomológica Aragonesa*, 38(1), pp. 423−442.

Costa-Neto, E. M. & Dunkel, F. V. (2016). Insects as Food: History, Culture, and Modern Use around the World. In: *Insects as Sustainable Food Ingredients:* Elsevier, pp. 29–60.

De Sousa, A. Warren, H. & Rekomaa, R. (2018). Bugs Are Coming Soon to Your Dinner Table. Bloomberg. https://www.bloomberg.com/graphics/2018-insects-as-food/

DESCUBRE. n.d. Qué es Descubre?. http://www.descubre.cr/#section-descubrimientos

Di Magliano, L. (2016). Edible insects, innovative protein source for a transition in the food landscape. Master Thesis. Master Management, Economics and Consumer Studies. Wageningen University.

Dobermann, D., Swift, J. & Field, L. (2017). Opportunities and hurdles of edible insects for food and feed. Nutrition Bulletin, 42, 293–308

Dossey, A.T., Tatu, J.T. & McGill, W.L. (2016). Modern Insect Based food Industry: Current Status, Insect Processing Technology and Recommendations Moving Forward. In: Dossey *et al*. (Eds.) 2016. Insects as Sustainable Food Ingredients. http://dx.doi.org/10.1016/B978-0-12-802856-8.00005-3

Engstrom, A. (2019). Here is the list of entopreneurs around the world. Bugburger. https://www.bugburger.se/foretag/the-eating-insects-startups-here-is-the-list-of-entopreneurs-around-the-world/

Esser, K., Hillebrand, W., Messner, D. & Meyer-Stamer, J. (1996). Systemic competitiveness: new governance patterns for industrial development. https://doi.org/10.4324/9781315036465

FAO. (2018). Insects for food and feed. http://www.fao.org/edible-insects/en/

Fellows, P. (1997). Guidelines for small-scale fruit and vegetable processors. http://www.fao.org/3/w6864e/w6864e00.htm#Contents

Fellows, P. (2014). Editorial: Insects for food and feed. Food Chain. 4(2), pp. 101-102

Fernandez-Cassi, X., Supeanu, A., Vaga, M., Jansson, A., Boqvist, S. & Vagsholm, I. (2019). The house cricket (Acheta domesticus) as a novel food: A risk profile. *Journal of Insects as Food and Feed*. 5. pp.1-22. https://doi.org/10.3920/JIFF2018.0021.

FUNDES. (2019). Descubre, productos potenciales y sus cadenas de valor: Cadena de Valor Insectos. http://www.descubre.cr/wp-content/uploads/2019/11/9.-Cadena-de-Valor-Insectos.pdf

Gerstberger, I. (2018). Revised Novel Food Regulation brings new rules for insect-based food. Lexology. https://www.lexology.com/library/detail.aspx?g=4a0b1855-acd3-4632-96df-e8cb5aeb96db

Globenewswire. (2018). Global 18 Bn Edible Insects Market opportunity Analysis and Industry Forecast 2018-2023. https://globenewswire.com/news-release/2018/04/26/1487795/0/en/Global-1-18-Bn-Edible-Insects-Market-Opportunity-Analysis-And-Industry-Forecast-2018-2023.html

Goetz, J., & LeCompte, M. (1984). Ethnography and qualitative design in educational research. Academic Press.

Hammerman, E. (2016). Cooking and disgust sensitivity influence preference for attending insect-based food events. Appetite, Volume 96, pp. 319-326.

Hanboonsong, Y., Jamjanya, T. & Durst, P. (2013). Six-legged livestock: Edible insect farming, collection and marketing in Thailand. FAO. Bankgog, Thailand.

Heyrman, J., & Goedhuys, J. (2018). The Multiple Key Informant Survey: a method for the comparison of international qualitative data.

Hofstrand, D. & Holz-Clause, M. (2009a). Feasibility study outline. Iowa State University. http://www.extension.iastate.edu/agdm/wholefarm/pdf/c5-66.pdf

Hofstrand, D. & Holz-Clause, M. (2009b). What is a feasibility study? Iowa State University. ExtensionIastateEdu. http://www.extension.iastate.edu/agdm/wholefarm/pdf/c5-65.pdf.

House, J. (2016). Consumer acceptance of insect-based foods in the Netherlands: Academic and commercial implications. Appetite. 107 (1), pp. 47-58

IPIFF. (2019a). IPIFF Guide on Good Hygiene Practices. https://ipiff.org/wp-content/uploads/2019/12/IPIFF-Guide-on-Good-Hygiene-Practices.pdf

IPIFF. (2019b). The European Insect Sector Today, challenges opportunities and regulatory landscape. IPIFF vision paper on the future of the insect sector towards 2030. https://ipiff.org/wp-content/uploads/2019/12/2019IPIFF_VisionPaper_updated.pdf

Jongema, Y. (2017). List of edible insects of the world (April 1, 2017) – WUR. www.wur.nl/en/Expertise-Services/Chairgroups/Plant-Sciences/Laboratory-of-Entomology/Edible-insects/ Worldwide-species-list.htm

Kasmire, J., Korhonen, J. M. & Nikolic, I. (2012). How Radical is a Radical Innovation? An Outline for a Computational Approach. Energy Procedia, 20, 346–353. https://doi:10.1016/j.egypro.2012.03.034

Kelemu, S., Niassy,S, Torto, B., Fiaboe, K., Affognon, H., Tonnang, H., Maniania, N.K. & Ekesi, S. (2015). African edible insects for food and feed: inventory, diversity, commonalities and contribution to food security. Journal of Insects as Food and Feed, 1(2), pp.103-119

Kok, R, Lomaliza, K. & Schivahare, U.S. (1988). The design and performance of an insect/farm chemical reactor for human food production. Can. Agric. Eng. 30: 307-317

Merriam, S B. (2016). Qualitative research: A guide to design and implementation (4. ed.). San Francisco, Calif: Jossey-Bass.

Meyer-Stamer, J. (2005). Systemic Competitiveness Revisited Conclusions for Technical Assistance in Private Sector Development. Mesopartner. https://www.mesopartner.com/fileadmin/media_center/Working_papers/mp-wp14_01.pdf

Monge-Gonzalez, R. (2016). Innovation, productivity and growth in Costa Rica: Challenges and opportunities. IDB Technical Note, 920.

https://publications.iadb.org/publications/english/document/Innovation-Productivity-and-Growth-in-Costa-Rica-Challenges-and-Opportunities.pdf

Mott, G. (2018). Operational and biological considerations for the commercial production of crickets. In: Van Huis, A. & Tomberlin, J. (Eds.). 2018. Insects as Food and Feed. Wageningen Academic Publishers.

NACIA. (2019). The North American Coalition for Insect Agriculture. https://nacia.org/

Padilla, R., Y. Gaudin, & P. Rodriguez. (2012). Sistemas nacionales de innovación en Centroamérica, Serie de Estudios y Perspectivas, No. 140, CEPAL (Comisión Económica para América Latina y el Caribe). D. F., México.

Pascucci, S., Dentoni, D. & Mitsopoulos, D. (2015). The perfect storm of business venturing? The case of entomology-based venture creation. Agricultural and Food Economics, pp. 3-9.

Peltoniemi, Mirva & Vuori, Elisa. (2008). Business Ecosystem as the New Approach to Complex Adaptive Business Environments. Proceedings of EBusiness Research Forum.

Peters, T. (2017). This Giant Automated Cricket Farm Is Designed to Make Bugs A Mainstream Source Of Protein. https://www.fastcompany.com/40454212/this-automated-cricket-farm-is-designed-to-make-bugs-a-mainstream-source-of-protein.

PROCOMER. (2019). About us. https://www.procomer.com/investor/general/?lang=en

Ramos-Elorduy, J. (2005). Insects: a hopeful food source. In M.G. Paoletti, ed. Ecological implications of minilivestock, pp. 263-291. Science Pub., Enfield NH, USA.

Ramos-Elorduy, J., Pino, J. & Conconi, M. (2006). Ausencia de una reglamentación y normalización de la explotación y comercialización de insectos comestibles en méxico. Folia Entomol. Mex., 45(3), pp. 291-318.

Revuelta-Gutiérrez, R. (2012). Latin American Federation of Neurosurgical Societies (FLANC): past, present, and future. World Neurosurgery 77(2-4): 414-418

Robson, C. (20020. Real world research: A resource for users of social research methods in applied settings (3rd ed.). Wiley-Blackwell.

Rossman, E. (2018). 2019 food trends: Cricket powder, edible insect start-ups spark love for bugs. https://eu.usatoday.com/story/news/investigations/2018/12/21/2019-food-trends-cricket-powder-edible-insects-enter-us-diet/2351371002/

Rumpold, B. & Schlüter, O. (2013). Potential and challenges of insects as an innovative source for food and feed production. *Innovative Food Science and Emerging Technologies*. 17 (1), pp. 1-11 http://dx.doi.org/10.1016/j.ifset.2012.11.005

Rumpold, B. & Schlüter, O. (2014). Nutrient composition of insects and their potential application in food and feed in Europe. Food Chain. 4 (2), pp. 129-139. http://dx.doi.org/10.3362/2046-1887.2014.013

Rumpold. B.; Bussler, S., Jäger, H. & Schlüter, O. (2017). Insect processing. In: Van Huis, A and Tomberlin, J.K. (eds). Insects as food and feed: from production to consumption. Wageningen Academic Publishers, pp. 318-342

Sakali, P. C. & Skalkos, D.. (2016). Innovative agrifood supply chain network: Leading to traditional, "back to the future" foods. *International Journal of Business Science & Applied Management*, s.l., Vol. 11, Iss. 2, pp. 24-33

Salman, H. (2018). Insect Food Value Chains: Mapping and Governance Mechanisms. Dr. Jörg Meyer-Stamer Scholarship Research Paper Series – Paper No. 6

Seidler, J. (1974). On Using Informants: A Technique for Collecting Quantitative Data and Controlling Measurement Error in Organization Analysis. *American Sociological Review*, 39(6), pp. 816-831. Retrieved from http://www.jstor.org/stable/2094155

Shelomi, M. (2016). The meat of affliction: Insects and the future of food as seen in Expo 2015. *Trends in Food Science & Technology*. 56, pp. 175-179.

Schermerhorn, R. (2012). Is your agribusiness feasible? Bulletin 1066. The University of Georgia.

Shockley, M., Allen, R.N. & Gracer, D. (2018). Product development and promotion. In: Van Huis, A. & Tomberlin, J. (Eds.). 2018. Insects as Food and Feed. Wageningen Academic Publishers

Strickland, T. (2017). Meet the Entrepreneurs Driving the Edible Insect Movement. Entrepreneur. https://www.entrepreneur.com/article/288748

Tomberlin, J.K. (2018). Industrialization of insect farming. In: Van Huis, A. & Tomberlin, J. (Eds.). 2018. Insects as Food and Feed. Wageningen Academic Publishers

Umana, P. (2020). Mariposas ticas transpasan las fronteras. UCR. https://www.ucr.ac.cr/noticias/2019/03/20/mariposas-ticas-traspasan-las-fronteras.html

Universidad de Costa Rica. (2020a). Instagram Official profile. https://www.instagram.com/universidaddecostarica/?hl=en

Universidad de Costa Rica. (2020b). Facebook official profile. https://www.facebook.com/UniversidadCostaRica

Van Huis, A. (2016). Conference on 'The future of animal products in the human diet: health and environmental concerns' Boyd Orr Lecture Edible insects are the future? Proceedings of the Nutrition Society, Volume 75, pp. 294-305.

Van Huis, A. & Tomberlin, J. (2018). Insects as food and feed: from production to consumption. Wageningen Academic Publishers.

Van Huis, A., Itterbeck, J., Klunder, H., Mertens, E., Halloran, A., Muir, G. & Vantomme, P. (2013). Edible insects: future prospects for food and feed security. FAO.

Vantomme, P. (2013). Edible insects: future prospects for food and feed security. FAO Forestry Paper no. 171. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy, 187 pp. http://www.fao.org/docrep/018/i3253e/i3253e.pdf

Vestergaard, J. & C. Díaz. (2007). A strategy for innovation and sustainable development in Costa Rica. Copenhagen Business School.

Waite, R., Hanson, C., Searchinger, T. & Ranganathan, J. (2018). This is how to sustainably feed 10 billion people by 2050. World Economic Forum. https://www.weforum.org/agenda/2018/12/how-to-sustainably-feed-10-billion-people-by-2050-in-21-charts/?fbclid=IwAR2JKHAlXaOKBNGPEtclval16Ytb_-L0hvD6DG_in0bMCFA0LqobDtcmDQo

World Bank. (2013). Enterprise Survey 2010 Costa Rica. https://microdata.worldbank.org/index.php/catalog/1084/study-description

World Bank. (2018). Country profile: Costa Rica. https://databank.worldbank.org/views/reports/reportwidget.aspx?Report_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&zm=n&country=CRI

World Bank. (2020). Costa Rica Overview. https://www.worldbank.org/en/country/costarica/overview

ANNEXES

A1. Semi-structured questionnaire for potential buyers

Introductory statement:

Thank you for your participation in the research. Your opinions are very much appreciated.
As you already know, this is part of the thesis of Ileana Maricruz Bermudez, an MBA student from the SEPT Program at the University of Leipzig, Germany. The main objective of the interview is to understand your needs related to the supply of cricket powder.
I will state orientation questions to you and you can be as broad and specific as you feel it necessary. The interview will last approximately 90 minutes.

A. Understanding the business model
    1. First, I would like to understand your business model. What kind of products do you sell, who are your main customers, what is your value proposition?
B. Understanding product requirements
    2. In terms of the raw material (cricket powder), what are the main requirements you ask your current suppliers to comply with?
    3. Are there quality and food safety requirements the product has to comply with?
C. Understanding current (and future) demand and supply
    4. How many suppliers do you currently have? Who are they and where are they located?
    5. What is the weekly volume you required?
    6. How often do you purchase? Are your purchases seasonal?
    7. What is the current price you are paying for 1kg of cricket powder? Do you consider this price affordable?
D. Understanding challenges and opportunities
    8. In your opinion, what are the main constraints you face when trying to purchase cricket powder?
    9. In you were analyzing new suppliers of cricket powder, what would be the main factors you would consider?
E. Exploring possible product acceptability
    10. Would you be willing to purchase cricket powder from a new supplier in Costa Rica?

A2. Semi-structured questionnaire for producers and local entopreneurs

Introductory statement:

Thank you for your participation in the research. Your opinions are very much appreciated.
As you already know, this is part of the thesis of Ileana Maricruz Bermudez, an MBA student from the SEPT Program at the University of Leipzig, Germany. The main objective of the interview is to understand your business model and the technology you are using for rearing crickets and processing cricket powder.
I will state some orientation questions to you and you can be as broad and specific as you feel it necessary. The interview will last approximately 2 hours.

F. Understanding the business model
    11. First, I would like to understand your business model. What kind of products do you sell, who are your main customers, what is your value proposition?
G. Understanding product requirements
    12. In terms of the raw material (cricket powder), what are the main requirements your clients ask you to comply with?
    13. Are there quality and food safety requirements the product has to comply with?
H. Understanding current (and future) demand and supply
    14. How many clients do you currently have? Who are they and where are they located?
    15. What is the weekly volume you produce and sell?
    16. What is the current price for 1kg of cricket powder?
I. Raw materials requirements
    17. What are your raw materials?
    18. Who are your suppliers?
    19. How much does the raw material cost?
J. Technology requirements
    20. What technology/equipment do you use?
    21. What are the required environmental conditions (humidity, temperature)
    22. Did you develop it internally?
    23. How much was the total investment?
K. Facility requirements
    24. How big is your facility?
    25. How much was the total investment?
    26. What are the main requirements of the facility?
L. Personnel

27. How many employees do you currently have?
28. What are the main positions? What skills are required?
29. Did you train them internally?

M. Understanding challenges and opportunities

30. In your opinion, what are the main constraints you face when producing cricket powder?
31. If you had to advise someone that wants to start producing cricket powder, what would you tell them?

A3. Semi-structured questionnaire for experts

Introductory statement:

Thank you for your participation in the research. Your opinions are very much appreciated.
As you already know, this is part of the thesis of Ileana Maricruz Bermudez, an MBA student from the SEPT Program at the University of Leipzig, Germany. The main objective of the interview is to understand the technical knowledge available on the production and commercialization of edible insects.
I will state some orientation questions to you and you can be as broad and specific as you feel it necessary. The interview will last approximately 90 minutes.

1. What are the main challenges regarding the farming of crickets in Costa Rica?
2. What are the main opportunities regarding the farming of crickets in Costa Rica?
3. Do you think it is feasible to produce of cricket powder in an industrial scale in Costa Rica? In what time do you it would be feasible?
4. What elements do you think are necessary to achieve it?
5. What regulations apply to the production and commercialization in Costa Rica/the world?
6. In terms of personnel, what do you think would be required?
7. What are the main costs associated to the production of cricket powder?

A4. List of Interview partners

No.	Code	Interviewee name	Position	Company	Country	Interview date	Interview method	Language	Duration (min)
1	Potential Buyer	Anonymous	Co-Founder	Anonymous	Germany	19.09.19	Skype	Spanish	66.15
2	Producer 1	Anonymous	Co-Founder	Anonymous	Vietnam	10.10.19	In person	English	60.00
3	Producer 2	Rickard Engberg	Co-Founder	Global Bugs Asia Co, Ltd	Thailand	24.10.19	In person	English	25.40
4	Local technical expert 1	Federico Paniagua	Biologist Technician	Costa Rican Museum of Insects, University of Costa Rica	Costa Rica	13.11.19	In person	Spanish	106.20
5	Local Entopreneur 1	Andrés Guzmán Mónica Solano	Co-Founder	Gricket House	Costa Rica	21.11.19	In person	Spanish	71.53
6	Local Entopreneur 2	Daniela Arias Alejandro Ortega Carla Murillo Trejos	Co-Founder	CRIC (Costa Rican Insect Company)	Costa Rica	29.11.19	In person	Spanish	85.45
7	Local Entopreneur 3	Jose Augusto Carvajal	Founder	Grillos en Costa Rica	Costa Rica	02.12.2019	Telephone	Spanish	49.15
8	Local Business expert	David Ramírez	Program Coordinator	University Agency for Entrepreneurship Management (AUGE)	Costa Rica	02.12.19	In person	Spanish	32.40
9	Local technical expert 2	Ricardo Murillo	Head Enthomologist	Butterfly Experimental Garden, University of Costa Rica	Costa Rica	Part 1: 05.12.19 Part 2: 13.12.19	In person	Spanish	Part 1: 55.59 Part 2: 74.47
10	Local Entopreneur 4	Gabriela Soto	Founder	Costa Rica Come Insectos	Costa Rica	19.01.2020	In person	Spanish	107.38
11	International expert	Josh Galt	Founder and Consultant	Entovegan	Thailand	05.02.2020	Whatssap Call	English	48.58

A5. List of invitees to the workshop

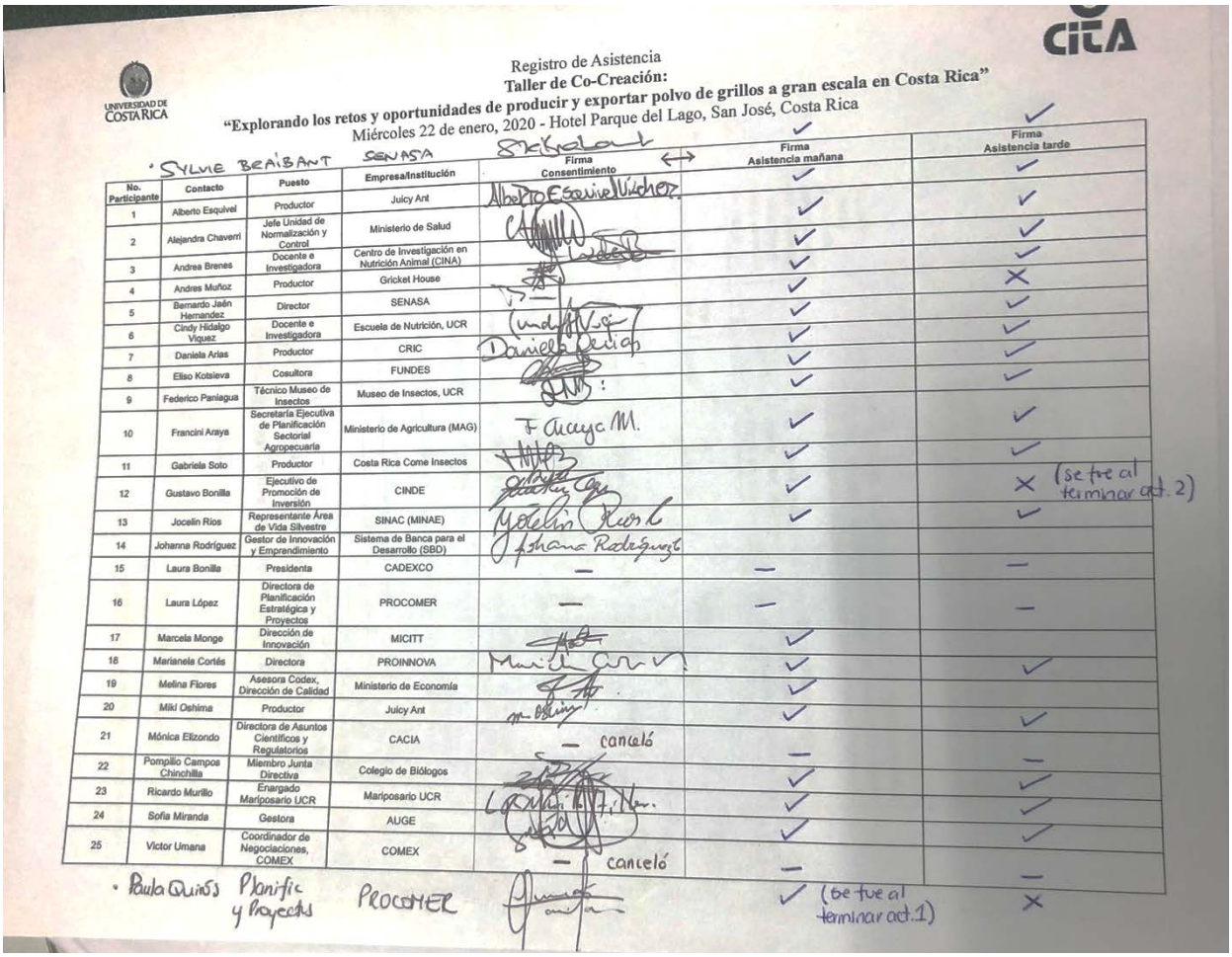
No.	Company/Institution	Contact	Position	Attended?
1	Gricket House	Andres Munoz	Co-Founder	Yes
2	CRIC	Daniela	Co-Founder	Yes
3	Costa Rica Come Insectos	Gabriela Soto	Co-Founder	Yes
4	Juicy Ant	Alberto Esquivel	Co-Founder	Yes
5	Juicy Ant	Miki Oshima	Co-Founder	Yes
6	SINAC (MINAE)	Jocelin Rios	Wild Life Coordinator	Yes
7	Colegio de Biólogos	Pompilio Campos Chinchilla	Board Member	Yes
8	SENASA	Bernardo Jaén Hernandez	Director	Yes
9	Ministry of Health	Alejandra Chaverri	Nutricionist, Department of Normalization and Control	Yes
10	Ministry of Economy	Melina Flores	Codex Adviser, Quality Department	Yes
11	Butterfly Garden, UCR	Ricardo Murillo	Head	Yes

12	Museum of Insects, UCR	Federico Paniagua	Technician	Yes
13	FUNDES	Eliso Kotsieva	Consultant	Yes
14	AUGE	Sofia Miranda	Adviser	Yes
15	PROINNOVA	Marianela Cortés	Director	Yes
16	Research Centre for Animal Nutrition (CINA)	Augusto Rojas	Director	Cancelled
17	Research Centre for Animal Nutrition (CINA)	Andrea Brenes	Researcher and Professor	Yes
18	School of Human Nutrition	Cindy Hidalgo Viquez	Researcher and Professor	Yes
19	Ministry of Science, Technology and Telecommunications (MICITT)	Marcela Monge	Director of Innovation	Yes
20	Ministry of Agriculture (MAG)	Francini Araya	Executive Secretary for Sectorial Agribusiness Planification	Yes
21	Development Banking System (SBD)	Johanna Rodriguez	Adviser for Innovation and Entrepreneurship	Yes
24	PROCOMER	Laura Lopez	Director of Planning and Projects	No show
25	COMEX	Victor Umana	General Coordinator of Negotiations	Yes
26	CINDE	Gustavo Bonilla		Yes
27	CACIA	Monica Elizondo	Directora de Asuntos Científicos y Regulatorios	Cancelled
28	CADEXCO	Laura Bonilla	President	No confirmation
			Total invitations	**28**
			Total shows	**23**
			Total cancellations/no confirmation	**3**
			No-shows	**2**

A6. List of moderation team for the workshop

No.	Name	Institution	Position
1	Maricruz Bermudez	SEPT Program, University of Leipzig	Researcher
2	Ana María Quirós	CITA	Researcher
3	Pilar Fallas	CITA	Researcher
4	Amaryllis Quirós	School of Psychology, UCR	Researcher
5	Erika Hasband	CITA	Research Assistant
6	Cristiana Gonzalez	CITA	Research Assistant

A7. Attendance list of the workshop



Registro de Asistencia

Taller de Co-Creación:

"Explorando los retos y oportunidades de producir y exportar polvo de grillos a gran escala en Costa Rica"

Miércoles 22 de enero, 2020 - Hotel Parque del Lago, San José, Costa Rica

No. Participante	Contacto	Puesto	Empresa/Institución	Firma Consentimiento	Firma Asistencia mañana	Firma Asistencia tarde
1	Alberto Esquivel	Productor	Juicy Ant		✓	✓
2	Alejandra Chaverri	Jefe Unidad de Normalización y Control	Ministerio de Salud		✓	✓
3	Andrea Brenes	Docente e Investigadora	Centro de Investigación en Nutrición Animal (CINA)		✓	✓
4	Andres Muñoz	Productor	Gricket House		✓	✓
5	Bernardo Jaén Hernandez	Director	SENASA		✓	✓
6	Cindy Hidalgo Viquez	Docente e Investigadora	Escuela de Nutrición, UCR		✓	✓
7	Daniela Arias	Productor	CRIC		✓	✓
8	Eliso Kotsieva	Cosultora	FUNDES		✓	✓
9	Federico Paniagua	Técnico Museo de Insectos	Museo de Insectos, UCR		✓	✓
10	Francini Araya	Secretaría Ejecutiva de Planificación Sectorial Agropecuaria	Ministerio de Agricultura (MAG)		✓	✓
11	Gabriela Soto	Productor	Costa Rica Come Insectos		✓	✓
12	Gustavo Bonilla	Ejecutivo de Promoción de Inversión	CINDE		✓	✗ (se fue al terminar act. 2)
13	Jocelin Rios	Representante Área de Vida Silvestre	SINAC (MINAE)		✓	✓
14	Johanna Rodríguez	Gestor de Innovación y Emprendimiento	Sistema de Banca para el Desarrollo (SBD)			
15	Laura Bonilla	Presidenta	CADEXCO	—	—	—
16	Laura López	Directora de Planificación Estratégica y Proyectos	PROCOMER	—	—	—
17	Marcela Monge	Dirección de Innovación	MICITT		✓	
18	Marianela Cortés	Directora	PROINNOVA		✓	✓
19	Melina Flores	Asesora Codex, Dirección de Calidad	Ministerio de Economía		✓	
20	Miki Oshima	Productor	Juicy Ant		✓	✓
21	Mónica Elizondo	Directora de Asuntos Científicos y Regulatorios	CACIA	— canceló	—	—
22	Pompilio Campos Chinchilla	Miembro Junta Directiva	Colegio de Biólogos		✓	✓
23	Ricardo Murillo	Enargado Mariposario UCR	Mariposario UCR		✓	✓
24	Sofía Miranda	Gestora	AUGE		✓	✓
25	Victor Umaña	Coordinador de Negociaciones, COMEX	COMEX	— canceló	—	—
• Paula Quirós		Planific y Proyectos	PROCOMER		✓ (se fue al terminar act. 1)	✗
• Sylvie Braibant			SENASA			✓

Note: Two persons that were not previously invited, showed to the workshop. The first went in representation of Laura Lopez from PROCOMER: Paula Quirós. The second, Sylvie Braibant, replaced Mr. Bernardo Jaén (SENASA) during the group work, since he only attended the morning session.

A8. Agenda of the workshop

Time	Activity Type	Activity Description	Person in charge
8.30-9.00	Registration of participants		Assistants
9.00-9.20	Welcoming and presentation of participants		Main moderator
9.20-9.40	Presentation	Opportunities and challenges of edible insects in the world	Ing. Ana María Quirós, CITA
9.40-10.00	Presentation	Edible Insect Supply Chain Opportunities (Study Descubre 150)	Eliso Kotsieva,FUNDES
15 minutes break (Coffee Break y Tasting of Edible Insects)			
10.15-10.35	Presentation	Preliminary Results of the research Analyzing the potential of producing and exporting cricket powder in Costa Rica	Ing. Maricruz Bermúdez Serrano
10.35-10.45		Introduction to the workshop, group definition and guidelines	Main moderator
10.45-11.15	Group work	Activity 1: Descriptive Stakeholders Map	Participants
11.15-12.30	Group work	Activity 2: Identification of Challenges and Opportunities	Participants
Lunch (12.30-13.20)			
13.20-14.50	Group work	Activity 3: Strategy Ideation	Participants
10 minutes break			
15.00-15.40	Group work	Activity 3: Strategy Ideation	Participants
15.40-16.00	Closing conclusions		Main moderator

A9. Preparatory document for the workshop sent to the participants

UNIVERSIDAD DE COSTA RICA

CITA

El Centro Nacional de Ciencia y Tecnología de Alimentos (CITA) se complace en invitarlo al

Taller de Co-creación:
"Explorando los retos y oportunidades para la producción y exportación de polvo de grillos en Costa Rica"

A continuación le detallamos el programa de la actividad:

Fecha y Lugar

Fecha: Miércoles 22 de enero del 2020
Horario: 8:30 am a 4:00 pm
Lugar: Hotel Parque del Lago, Paseo Colón, San José

El taller se realizará en la sala anexa del hotel:

Parqueo: sin costo adicional, según disponibilidad (utilice el parqueo principal del hotel y camine a la sala anexa).
Asistencia: sólo por invitación y con previa confirmación.

Objetivo General

Reunir a los actores claves del ecosistema emprendedor para explorar en conjunto las posibilidades de producir y exportar polvo de grillos a gran escala en Costa Rica.

Antecedentes

Este taller se enmarca dentro del proyecto B9611 *"Consumo de insectos y su aplicación en matrices alimentarias en Costa Rica: retos y oportunidades de una estrategia potencial para el fortalecimiento de la seguridad alimentaria nacional"* inscrito por el Centro Nacional de Ciencia y Tecnología de Alimentos (CITA) en la Vicerrectoría de Investigación de la Universidad de Costa Rica (http://www.cita.ucr.ac.cr/insectos).

1

UNIVERSIDAD DE COSTA RICA

CITA

La actividad es parte del Trabajo Final de Graduación *"Análisis del potencial de producción y exportación de polvo de grillos en Costa Rica"* que realiza la Ingeniera Ileana Maricruz Bermúdez Serrano, quien cursa la Maestría en Administración de Empresas con énfasis en el Desarrollo de Pequeñas y Medianas Empresas en la Universidad de Leipzig, Alemania. La investigación cuenta con financiamiento del Servicio Alemán de Intercambio Académico (DAAD).

Asimismo, se cuenta con la colaboración de la Promotora del Comercio Exterior (PROCOMER) y el Ministerio de Comercio Exterior (COMEX), como parte del programa DESCUBRE, tomando en cuenta que los insectos comestibles fueron uno de los productos identificados en el Estudio Descubre 150 (http://www.descubre.cr/).

¿Por qué un taller de co-creación?

Un taller de co-creación es una herramienta que tiene como fin reunir a personas con diferentes perspectivas, para participar conjuntamente en la creación de soluciones para la generación y realización de proyectos de innovación. Se ha demostrado que la integración de las distintas visiones y capacidades creativas de los participantes en el proceso logra que se co-construyan soluciones de un alto valor innovador y diferenciador.

Tomando en cuenta que la producción de insectos comestibles a gran escala se ha denominado como una innovación radical, se pretende con el taller reunir a los actores clave del ecosistema emprendedor de Costa Rica con el fin explorar en conjunto los retos y oportunidades de la producción y exportación de polvo de grillos y co-crear estrategias que nos permitan llevar a cabo un posible proyecto de este tipo.

Agenda

Hora	*Modalidad*	*Actividad*	*Encargado*
8.30-9.00		Recepción y registro de participantes	Organizadores
9.00-9.20		Bienvenida y presentación de asistentes	Moderadora
9.20-9.40	Ponencia	*Oportunidades y retos del sector de los insectos comestibles en el mundo*	Ing. Ana María Quirós, CITA
9.40-10.00	Ponencia	*Cadena de Valor Insectos Comestibles (Estudio Descubre 150)*	FUNDES
		Receso 15 minutos ***(Coffee Break y Degustación de insectos comestibles)***	
10.15-10.35	Ponencia	*Resultados preliminares de la investigación "Análisis del potencial de producción y exportación de polvo de grillos en Costa Rica"*	Ing. Maricruz Bermúdez Serrano
10.35-10.45		Introducción al taller, asignación de grupos, pautas	Moderadora
10.45-11.25	Trabajo grupal	Actividad 1: Mapeo de Actores Descriptivo	Participantes
11.25-12.30	Trabajo grupal	Actividad 2: Retos y oportunidades	Participantes
		Almuerzo	
13.20-14.50	Trabajo grupal	Actividad 3: Ideación de estrategias	Participantes
		Receso 10 minutos	
15.00-15.50	Trabajo grupal	Actividad 4: Mapeo de actores Prescriptivo	Participantes
15.50-16.00		Conclusiones y cierre	Moderadora

2

UNIVERSIDAD DE COSTA RICA

CITA

Lista de invitados

- Ministerio de Agricultura y Ganadería (MAG)
- Servicio Nacional de Salud Animal (SENASA)
- Ministerio de Salud
- Ministerio de Economía, Industria y Comercio (MEIC)
- Ministerio de Comercio Exterior (COMEX)
- Ministerio de Ciencia, Tecnología y Telecomunicaciones (MICITT)
- Promotora de Comercio Exterior de Costa Rica (PROCOMER)
- Agencia de Promoción de Inversión en Costa Rica (CINDE)
- Colegio de Biólogos de Costa Rica
- Agencia Universitaria para la Gestión del Emprendimiento de la Universidad de Costa Rica (AUGE)
- Unidad de Gestión y Transferencia del Conocimiento para la Innovación (PROINNOVA)
- Centro de Investigación en Nutrición Animal (CINA)
- Cámara Costarricense de la Industria Alimentaria (CACIA)
- Cámara de Exportadores de Costa Rica (CADEXCO)
- Sistema Nacional de Áreas de Conservación (SINAC)
- Museo de Insectos de la Universidad de Costa Rica
- Fundación para el Desarrollo Sostenible (FUNDES)
- Emprendedores del sector de insectos comestibles
- Expertos técnicos en entomología
- Expertos técnicos en nutrición humana

Recomendaciones

- Llevar ropa cómoda.
- Notificar al correo maricruz.bermudez@gmail.com si usted cuenta con alguna alergia alimenticia.

Organizador oficial

CITA

UNIVERSIDAD DE COSTA RICA

Con la colaboración de: DESCUBRE

3

A10. Guidance document of the workshop prepared for moderators

Elaborado por: Ing. Maricruz Bermúdez Serrano	**GUIA DE TALLER**	Fecha de elaboración: 18-01-2020 Versión 4

1. Título oficial

Taller de Co-creación:
"Explorando los retos y oportunidades para la producción y exportación de polvo de grillos en Costa Rica".

2. Fecha y lugar de la actividad

Miércoles 22 de enero 2020
Horario: 9am a 4pm
Lugar: Hotel Parque del Lago, Paseo Colón, San José, Costa Rica

El taller se realizará en la sala anexa del hotel:

Parqueo: sin costo adicional, según disponibilidad (utilice el parqueo principal del hotel y camine a la sala anexa).
Asistencia: sólo por invitación y con previa confirmación.

3. Objetivos

3.1. **Objetivo General**

Reunir a los actores claves del ecosistema emprendedor para explorar en conjunto las posibilidades de producir y exportar polvo de grillos a gran escala en Costa Rica.

3.2. **Objetivos específicos**

3.2.1. Proveer a los participantes de conocimientos básicos sobre el estado actual de la producción de insectos comestibles en el mundo y las oportunidades del mercado.
3.2.2. Mapear los actores claves en el ecosistema emprendedor, tomando en cuenta los 4 niveles del abordaje de competitividad sistémica.

3.2.3. Identificar los retos y oportunidades relacionados a producir y exportar polvo de grillos a gran escala en Costa Rica.
3.2.4. Entender si los participantes perciben el desarrollo de la industria de polvo de grillos para exportación en Costa Rica como algo posible y en cuánto tiempo.
3.2.5. Proponer posibles estrategias para desarrollar la industria de producción y exportación de polvo de grillos comestibles en Costa Rica.

4. Organizadores oficiales

Centro Nacional de Ciencia y Tecnología de Alimentos (CITA), Universidad de Costa Rica
Con la colaboración de: Programa Descubre

5. Antecedentes

Este taller se enmarca dentro del proyecto B9611 *"Consumo de insectos y su aplicación en matrices alimentarias en Costa Rica: retos y oportunidades de una estrategia potencial para el fortalecimiento de la seguridad alimentaria nacional"* inscrito por el Centro Nacional de Ciencia y Tecnología de Alimentos (CITA) en la Vicerrectoría de Investigación de la Universidad de Costa Rica (http://www.cita.ucr.ac.cr/insectos).

La actividad es parte del Trabajo Final de Graduación *"Análisis del potencial de producción y exportación de polvo de grillos en Costa Rica"* que realiza la Ingeniera Ileana Maricruz Bermúdez Serrano, quien cursa la Maestría en Administración de Empresas con énfasis en el Desarrollo de Pequeñas y Medianas Empresas en la Universidad de Leipzig, Alemania. La investigación cuenta con financiamiento del Servicio Alemán de Intercambio Académico (DAAD).

Asimismo, se cuenta con la colaboración de la Promotora del Comercio Exterior (PROCOMER) y el Ministerio de Comercio Exterior (COMEX), como parte del programa DESCUBRE, tomando en cuenta que los insectos comestibles fueron uno de los productos identificados en el Estudio Descubre 150 (http://www.descubre.cr/).

6. Requerimientos

6.1. **Recurso humano**

1 coordinadora (Maricruz Bermúdez)
1 maestra de ceremonias (Amaryllis Quirós)
2 moderadores generales (Maricruz Bermudez, Pilar Fallas)
4 facilitadores grupales (Ana María Quirós, Amaryllis Quirós/Pilar Fallas, Erika Halsband, Cristiana Gonzalez)
2 asistentes (Erika Hasbal y Cristiana Gonzalez)
1 documentador (Cristiana Gonzalez)
25 participantes

6.2. **Espacio y equipamiento**

1 sala de trabajo grupal con ventilación y luz adecuada
1 proyector (*solicitar al CITA)*
1 grabadora de video y sonido *(solicitar al CITA)*
2 grabadoras de sonido (solicitar al CITA)
2 celulares para grabar trabajo grupal
1 cámara fotográfica (solicitar al CITA)
1 computadora portátil (solicitar al CITA)

1 puntero (solicitar al CITA)
1 cronómetro
1 parlante

6.3. **Materiales**

Para el trabajo grupal:
25 Gafetes con nombres de los participantes
4 copias de entregables (ver anexos)
Post it circulares de colores (amarillo, rojo y verde)
Post it cuadrados de 5 colores
5 Rotafolios *(los da el hotel)*
2 paquetes de post its de 5 colores
4 paquete de marcadores permanentes
Hojas de trabajo
2 paquetes de Lego Serious Play
1 paquete de Lego
4 paquetes de Lana
4 paquetes de palillos de dientes
4 set de imágenes
4 Masking Tape
4 tijeras
Papel construcción

Para la degustación productos:
Productos de insectos comestibles para degustar *(lo llevan los productores)*
Productos a base de insectos disponibles en el exterior (disponibles en el CITA)
2 mesas rectangulares

Audiovisuales:
Presentación guia
Presentaciones de las ponencias
Video sobre producción de grillos a nivel industrial
Presentación con instrucciones para el taller

7. Presupuesto estimado

7.1. Sala y Alimentación: 440 000 colones
7.2. Materiales: 30 000 colones
7.3. Total: 470 000 colones

8. Agenda

Hora	*Modalidad*	*Actividad*	*Encargado*
8.30-9.00		Recepción y registro de participantes	Organizadores
9.00-9.20		Bienvenida y presentación de asistentes	Maestra de ceremonias Moderadora 1
9.20-9.40	Ponencia	*Oportunidades y retos del sector de los insectos comestibles en el mundo*	Ing. Ana María Quirós, CITA
9.40-10.00	Ponencia	*Cadena de Valor Insectos Comestibles (Estudio Descubre 150)*	FUNDES
		Receso 15 minutos	
		(Coffee Break y Degustación de insectos comestibles)	
10.15-10.35	Ponencia	*Resultados preliminares de la investigación "Análisis del potencial de producción y exportación de polvo de grillos en Costa Rica"*	Ing. Maricruz Bermúdez Serrano
10.35-10.45		Introducción al taller, asignación de grupos, pautas	Maestra de ceremonias
10.45-11.15	Trabajo grupal	Actividad 1: Mapeo de Actores Descriptivo	Participantes Moderadora 1
11.15-12.30	Trabajo grupal	Actividad 2: Retos y oportunidades	Participantes Moderadora 1
		Almuerzo (12.30-13.20)	
13.20-14.50	Trabajo grupal	Actividad 3: Ideación de estrategias	Participantes Moderadora 2
		Receso 10 minutos	
15.00-15.40	Trabajo grupal	Actividad 3: Ideación de estrategias	Participantes Moderadora 2
15.40-16.00		Conclusiones y cierre	Maestra de ceremonias Moderadora 1

9. Lista de participantes

No. Participante	Empresa/Institución	Contacto	Puesto	Confirmó asistencia?
1	Cricket House	Andres Muñoz	Productor	SI
2	CRIC	Daniela Arias	Productor	SI
3	Costa Rica Come Insectos	Gabriela Soto	Productor	SI
4	Juicy Ant	Alberto Esquivel	Productor	SI
5	Juicy Ant	Miki Oshima	Productor	SI
6	SINAC (MINAE)	Jocelin Rios	Representante Área de Vida Silvestre	SI
7	Colegio de Biólogos	Pompilio Campos Chinchilla	Miembro Junta Directiva	SI
8	SENASA	Bernardo Jaén Hernandez	Director	SI
9	Ministerio de Salud	Alejandra Chaverri	Jefe Unidad de Normalización y Control	SI
10	Ministerio de Economía	Melina Flores	Asesora Codex, Dirección de Calidad	SI
11	Mariposario UCR, Escuela de Biología	Ricardo Murillo	Enargado Mariposario UCR	SI
12	Museo de Insectos	Federico Paniagua	Técnico Museo de Insectos	SI
13	FUNDES	Elisa Kotsieva	Consultora	SI
14	AUGE	Sofia Miranda	Gestora	SI
15	PROINNOVA	Marianela Cortés	Directora	SI
16	Centro de Investigación en Nutrición Animal (CINA)	Augusto Rojas	Director	Canceló
17	Centro de Investigación en Nutrición Animal (CINA)	Andrea Brenes	Docente e Investigadora	SI
18	Escuela de Nutrición	Cindy Hidalgo Viquez	Docente e Investigadora	SI
19	MICITT	Marcela Monge	Dirección de Innovación	SI
20	Ministerio de Agricultura (MAG)	Francini Araya	Secretaría Ejecutiva de Planificación Sectorial Agropecuaria	SI

21	Sistema de Banca para el Desarrollo (SBD)	Johanna Rodríguez	Gestor de Innovación y Emprendimiento	SI
22	PROCOMER	Laura Lopez	Directora de Planificación Estratégica y Proyectos	SI
23	COMEX	Victor Umana	Coordinador de Negociaciones, COMEX	SI
24	CINDE	Gustavo Bonilla	Ejecutivo de Promoción de Inversión	SI
25	CACIA	Monica Elizondo	Directora de Asuntos Científicos y Regulatorios	SI
26	CADEXCO	Laura Bonilla	Presidenta	Sin confirmar
27	CITA	Pilar Fallas	Investigadora	SI
28	CITA	Ana María Quirós	Investigadora	SI
29	CITA	Maricruz Bermudez	Investigadora invitada	SI
30	CITA	Amaryllis Quirós	Investigadora invitada	SI
31	CITA	Erika Halsband	Asistente	SI
32	CITA	Cristiana González	Asistente	SI
			Total invitados	32
			Total confirmados	30
			Sin confirmar	1
			Cancelaciones	1

10. Grupos de trabajo

10.1. **Para las actividades 1 y 2** los participantes se dividirán en los siguientes grupos de trabajo por temática:

GRUPO	Técnico/Academia	Regulador	Innovación	Financiamiento y Exportaciones
Facilitador	**Amaryllis Quirós**	**Ana María Quirós**	**Pilar Fallas**	**Cristiana González**
Participantes	Expertos técnicos (2): Ricardo Murillo, Federico Paniagua	Jocelin Rios (SINAC)	Emprendedores (3): Andres Muñoz (GH), Daniela Arias (CRIC), Gabriela Soto (CRCI)	Laura López (PROCOMER)
	Productores de insectos (2): Miki Oshima, Alberto Esquivel	Bernardo Jaén (SENASA)	Fomento de innovación (2): Sofia Miranda (AUGE), Marianela Cortés (PROINNOVA)	Johanna Rodríguez (SBD)
	Cindy Hidalgo (Docente Nutrición)	Alejandra Chaverri (Ministerio de Salud)	Marcela Monge (MICITT)	Gustavo Bonilla (CINDE)
	Andrea Brenes (CINA)	Pompilio Campos (Colegio de Biólogos)		Francini Araya (MAG)
		Monica Elizondo (CACIA)		Eliso Kotsieva (FUNDES)
		Melina Flores (MEIC)		Victor Umaña (COMEX)
Total participantes	6	6	6	6

10.2. **Para las actividades 3 y 4** los participantes se dividirán en los siguientes grupos de trabajo interdisciplinarios.

Grupo	1	2	3	4
Facilitador	**Amaryllis Quirós**	**Ana María Quirós**	**Cristiana González**	**Erika Halsband**
Participantes	Federico Paniagua (UCR)	Alberto Esquivel (JUICY ANT)	Ricardo Murillo (UCR)	Gabriela (COSTA RICA COME INSECTOS)
	Cindy Hidalgo (Nutrición)	Mónica Elizondo (CACIA)	Andrea Brenes (CINA)	Melina Flores (MEIC)
	Pompilio Campos (Colegio de Biólogos)	Daniela (CRIC)	Jocelin Rios (SINAC)	Andrés Muñoz (GRICKET HOUSE)
	Miki Oshima (JUICY ANT)	SENASA	Alejandra Chaverri (Ministerio de Salud)	Laura Lopez (PROCOMER)
	Francini Araya (MAG)	Johanna Rodríguez	Marcela Monge (MICITT)	Sofía Miranda (AUGE)
	Marianela Cortes (PROINNOVA)	Eliso Kotsieva (FUNDES)	Victor Umana (COMEX)	Gustavo Bonilla (CINDE)
Total participantes	6	6	6	6

11. Ponencias

Duración total: 60 minutos
-Cada expositor expone el tema asignado en 20 minutos.

11.1.1. **Ponencia 1: Oportunidades y retos en la producción de insectos comestibles en el mundo**
A cargo de: Ing. Ana María Quirós, Investigadora CITA
Duración: 20 min

Objetivos:
-Dar una introducción al tema de los insectos comestibles y su importancia en la alimentación mundial
-Explicar cuál es el nivel de desarrollo de otros países en el tema
-Exponer los principales retos y oportunidades relacionados a la producción de insectos comestibles

11.1.2. **Ponencia 2: Proyecto Descubre 150, Cadena de Valor de Insectos Comestibles**
A cargo de: Representante de FUNDES
Duración: 20 min

Objetivos:
-Dar a conocer el Proyecto DESCUBRE 150 y los principales resultados relacionados a la Cadena de Valor de Insectos Comestibles
-Dar a conocer las oportunidades de mercado identificadas para la exportación de insectos comestibles en Costa Rica

3.1. **Receso**
Duración: 15 minutos

-Se invita a degustar productos a insectos comestibles hechos en Costa Rica y además se exhiben productos del exterior.

3.1.1. **Ponencia 3: Resultados Preliminares Trabajo Final de Graduación "Análisis del potencial productivo de polvo de grillos para exportación en Costa Rica"**

A cargo de: Ing. Maricruz Bermúdez, SEPT MBA Candidate
Duración: 20 min

Objetivos:
-Dar a conocer los objetivos del proyecto y la metodología
-Definir qué se entiende por "gran escala"
-Presentar los resultados preliminares de las entrevistas y el estudio de escritorio, indicando la consigna sobre la cual se va a trabajar en la segunda parte del taller
-Introducir el concepto de competitivad sistémica y presentar un mapeo preliminar de los actores del ecosistema emprendedor

12. Guión de moderación

12.1. **PRIMERA PARTE TALLER (PONENCIAS)**

Descripción de la actividad	Guión	Hora	Duración	Materiales	Encargado
	REGISTRO DE PARTICIPANTES				
Se registra a los participantes en la hoja de asistencia y se les entrega el gafete.	Buenos días! Bienvenido, cuál es su nombre? Me puede completar esta información, porfavor? Aquí, está su gafete. Pasa adelante, se puede sentar donde guste!	8.30-9.00	30 min	-Mesa de registro -Hoja de registro	Erika Halsband Cristiana González
-Los participantes se reciben en la sala. -Se da una bienvenida y un agradecimiento por venir.	Buenos días, vamos a dar inicio a la actividad, favor tomar asiento. La Ingeniera Maricruz Bermúdez, quien es la Coordinadora del Taller nos va a dar unas palabras de bienvenida.	9.00-9.02	2 min		Maestra de Ceremonias (Amaryllis)
-Se introduce el concepto de "Innovación" y "Co-Creación" -Se explica brevemente de qué se trata el taller.	Primero que todo, quisiera agradecerles por acompañarnos el día de hoy, es muy valioso para nosotros contar con su presencia en este taller, el cual esperamos que sea de mucho provecho para todos. Probablemente todos los que estamos aquí hemos escuchado el concepto de innovación, el cual se ha puesto muy de moda últimamente. Existen varias formas de definir innovación, una de las cuales es : "...". En este contexto, el caso de los insectos comestibles ha sido definido como una innovación 'radical", lo cual implica que es algo totalmente disruptivo que nunca se ha hecho antes. Y como todo lo que nunca se ha hecho antes, trae consigo muchos retos, pero también muchas oportunidades de crear, y de abordar el tema de forma totalmente autóctona y propositiva.	9.02-9.07	5 min	-Presentación de bienvenida	Moderadora 1 (Maricruz)

	Por esta razón, realizar un taller de co-creación parecía la metodología más idónea para iniciar una conversación sobre insectos comestibles en nuestro país. Y es que, qué es co-creación? Bueno, la palabra se explica sola: básicamente estamos hablando de crear en conjunto. Cada uno de nosotros tiene una formación distinta, conocimientos en temas diversos y todos pensamos diferente, y precisamente eso es lo que pretendemos aprovechar para crear soluciones más innovadoras. Por eso, el objetivo que nos propusimos lograr con este taller es Reunir a los actores claves del ecosistema emprendedor para explorar en conjunto las posibilidades de producir y exportar polvo de grillos a gran escala en Costa Rica. Cada uno de ustedes fue seleccionado debido a su experiencia y conocimientos,y la idea es que podamos mezclar todos esos conocimientos para buscar soluciones en conjunto. Para lograr este objetivo, vamos a tener un día bastante dinámico y con actividades diferentes, que espero sea de gran provecho para todos! Muchas gracias!!				
-Se explica brevemente la agenda.	(se coloca la agenda) Muchas gracias a Maricruz. Ahora, vamos a repasar la agenda del día. En la mañana contaremos con 3 ponencias con información fundamental sobre la producción de polvo de grillos. Luego, vamos a contar con una degustación de insectos para aquellos que nunca los han probado, se quiten el antojo! Posteriormente iniciaremos con el taller propiamente, vamos a realizar trabajo en grupo (actividades 1 y 2). Una vez que terminemos con estas actividades, procederemos a tener un almuerzo en esta misma sala y en la tarde estaremos realizando la actividad de generación de estrategias para finalmente concluir con un cierre. Para lograr que el taller sea exitoso, esto les solicitamos que por favor pongan en silencio sus celulares y que eviten hacer uso de ellos durante la actividad.	9.07-9.10	3 min	DP Agenda	Maestra de Ceremonias (Amaryllis)
	DINÁMICA ROMPEHIELOS				
-Rompehielo: Cada quien se presenta brevemente (nombres, institución que representa, experiencia con insectos).	Ahora vamos a hacer una pequeña dinámica para conocernos. La idea es que, en orden, cada uno vaya diciendo su nombre, en dónde trabaja y si alguna vez han comido algún alimento con insectos. Si sí, nos cuentan cuál es el más raro que se han comido y si no, nos cuentan si se animarían a hacerlo. Tenemos que hacerlo super rápido, entonces cada persona solo puede decir 3 frases!! Voy a empezar yo, *"Mi nombre es Amaryllis, soy docente de la UCR y el insecto más interesante que me he comido ha sido ....."*	9.10-9.20	10 min		Maestra de Ceremonias (Amaryllis) Participantes
	PONENCIA 1				

Presentación ponencia	Muy bien, bueno, al parecer la mayoría ya tiene bastante experiencia comiendo insectos!! Ahora, vamos a iniciar con las ponencias, cuya información será fundamental para el desarrollo de las actividades posteriores, por lo que les agradezco prestar muchísima atención. El primer tema es ***"Oportunidades y retos en la producción de insectos comestibles en el mundo"*** a cargo de Ana María Quirós, investigadora del Centro Nacional de Ciencia y Tecnología de Alimentos y parte del equipo que está liderando el Proyecto ***"Consumo de insectos y su aplicación en matrices alimentarias en Costa Rica: retos y oportunidades de una estrategia potencial para el fortalecimiento de la seguridad alimentaria nacional"***.	9.20-9.21	1 min	DP Presentación	Maestra de Ceremonias (Amaryllis)
-Ponencia 1	Ana María expone.	9.21-9.40	19 min	-Presentación con video https://www.youtube.com/watch?v=HmvZwtOOnd0 (minuto 1:05)	Ing. Ana María Quirós, CITA
Introducción ponencia 2	Muchas gracias a Ana María por su presentación. Seguidamente, tendremos la segunda ponencia a cargo de Eliso Kotsieva, quien es concultora de FUNDES. Eliso nos contará sobre el Proyecto DESCUBRE 150 y las oportunidades de exportación identificadas en el tema de los insectos comestibles.	9.40-9.41	1 min	DP Presentación	Maestra de Ceremonias (Amaryllis)
-Ponencia 2	Eliso expone.	9.41-10.00	19 min	-Presentación	Eliso Kotsieva-FUNDES
	RECESO y DEGUSTACIÓN DE INSECTOS				
-Refrigerio -Exhibición de alimentos con insectos -Degustación de alimentos con insectos	Muchas gracias a Eliso por su presentación. Ahora vamos a tomar un receso de 15 minutos, les rogamos ser puntuales para continuar a las 10.15. Como verán, contamos con una mesa de exhibición con algunos alimentos comerciales a base de insectos. Y por último, podrán encontrar una degustación de alimentos con insectos, que ojalá todos se animen a probar.	10.00-10.15	15 min	-Cartel "solo para exhibición" -Productos de exhibición -2 Mesas rectangulares -Insectos para degustación -Material publicitario productores	Maestra de ceremonias (Amaryllis) -Productores Asistentes
	PONENCIA 3				
Introducción ponencia	Les rogamos volver a sus asientos para proseguir con la última ponencia. Esta ponencia estará a cargo de la coordinadora del evento, la ingeniera Maricruz Bermúdez, quien está realizando su proyecto final de graduación sobre el potencial de exportación de polvo de grillos en Costa Rica.	10.15-10.16	1 min		Maestra de ceremonias (Amaryllis)
-Ponencia 3	Maricruz expone	10.16-10.35	19 min	-Presentación	Ing. Maricruz Bermúdez
	INTRODUCCIÓN AL TALLER				

-Se les explica a los participantes que para esta parte del taller se va a trabajar en grupos. -Se asignan los grupos. -Se presenta la consigna -Se definen las pautas y reglas para el taller	Muy bien, ahora que ya todos tenemos una base de información sobre lo que implica la producción de grillos a gran escala, vamos a iniciar el taller. Entonces, lo primero que vamos a hacer es 4 grupos de trabajo, vamos a proyectar en dónde les tocó para que por favor tomen sus pertenencias y se acomoden en la mesa respectiva (indicar cual es mesa 1,2,3 y 4): (proyectar grupos) A lo largo del taller vamos a tener una serie de mandamientos que todos tenemos que acatar, estas también se las vamos a dar para que tengan una en cada mesa (proyectar pautas). Las voy a leer en voz alta: 1. Evitaremos juzgar, todas la ideas son valiosas y no hay ideas malas. (Ejemplo: "uy, no, esa idea está pésima!") 2. Le daremos espacio a todos para participar y dar su punto de vista sin interrumpirlos. 3. Construiremos sobre las ideas de los demás: cambiaremos el "NO, no me parece" o el "NO, PERO.." por "SI, Y QUÉ TAL SI ADEMÁS...". (Ejemplo: en vez de uy, no, pero eso no se puede porque...mejor: sí, claro, y que tal si además agregamos..) 4. Daremos la mayor cantidad de ideas posibles sin salirnos del tema. Entre más ideas generemos , mejor! 5. Fomentaremos las ideas diferentes, creativas e innovadoras. (en vez de uy, no eso jamás se va a poder aquí, mejor: uy, qué idea más innovadora!) Estamos todos de acuerdo en acatar estos mandamientos durante el taller? Perfecto!! Muy bien, entonces, ahora Maricruz va a dirigir las dos primeras actividades del taller.	10.35-10.45	10 min	-Diapositiva con los grupos de trabajo -Diapositiva de la consigna -Diapositiva de los mandamientos -4 copias de la consigna -4 copias de los mandamientos	Maestra de ceremonias (Amaryllis)

12.2. SEGUNDA PARTE TALLER (TRABAJO GRUPAL)

12.2.1. ACTIVIDAD 1: MAPEO DE ACTORES Y ELEMENTOS CLAVE

Pregunta principal	**Cuáles son los actores y elementos clave del ecosistema emprendedor relacionado a la producción de polvo de grillos?**	
Moderadora	Maricruz	
Duración	30 minutos	
Hora de inicio	10.45 am	
Hora de finalización	11.15 am	
Trabajo en grupos	SI, por temática	
Metodología	-Mapeo De Actores Descriptivo	

	-Enfoque de competitividad sistémica (nivel micro, meso, macro y meta) 1. Los participantes anotan en post-its los actores y elementos claves y los pegan en el rotafolio común, ordenándolos por nivel. 2. Se ordenan los post-its según concordancias.	
Resultado esperado	Mapa de 4 niveles con actores y elementos identificados.	

Descripción de la actividad	Guión	Hora	Duración	Materiales	Encargado
-Explicación	Para lo que resta del taller vamos a tener todos una consigna como norte, ese es el objetivo final (leer consigna). Cada uno tendrá este diagrama en su mesa y deben tomarlo muy en cuenta en cada actividad que realicemos. Esta primera actividad tiene como objetivo realizar un mapeo de los actores clave y los elementos relacionados con la consigna. Es decir, vamos a identificar, aquellas instituciones, personas o elementos relacionados con la consigna y los vamos a poner en este mapa. Este mapa cuenta con 4 niveles. Son los niveles que componen nuestro ecosistema relacionado a la producción de polvo d e grillos. Recordemos que el • El nivel micro: incluye elementos microeconómicos como empresas, consumidores y mercados, y sus interrelaciones. Por ejemplo, como mi vimos previamente en las presentaciones, en este caso podemos incluir a … (se van pegando los actores) • El Nivel Meso: analiza factores que son importantes para la competitividad de las empresa, como políticas específicas e instrumentos de promoción empresarial, instituciones privadas y públicas involucradas en la promoción empresarial, así como instituciones de investigación y académicas. En este caso ya hemos identificado a … y se van pegando. • El Nivel Macro: incluye factores macroeconómicos como interés y tasa de cambio, presupuesto y política comercial, así como regulaciones. En este caso tenemos por ejemplo La ley de vida silvrestre.. (se van pegando) • El Nivel Meta: intenta responder a la pregunta de por qué los actores de una sociedad determinada logran o no crear un entorno favorable para las empresas privadas, considerando cómo interactúan los actores gubernamentales y no gubernamentales y si tienen una visión común sobre dónde la economía se dirige. Se incluye también el temas culturales y sociales. Acá podemos identificar por ejemplo… (se pegan)	10.45-10.55	10 min	-Rotafolio con mapa -Post-its con nombres de actores y elementos clave ya identificados	-Moderadora 1 -Participantes

	Ahora, cada grupo va a tomar unos minutos para analizar si en este mapa falta algún actor o elemento importante que tengamos en este momento? En caso de que identifiquen que falte un actor clave o elemento, lo van a colocar en un post it. Y luego vienen y lo colocan en este rotafolio. Todos los grupos van a analizar cada nivel. Deben discutir con sus compañeros de mesa cuáles actores faltan y en qué nivel se ubican, según la función realiza este actor y su influencia en el ecosistema. También pueden identificar algún elemento clave, por ejemplo, alguna regulación o política existente que no se ha identificado. Deben anotarlos en los post its que tienen en la mesa, solo un elemento o actor por post it. Conforme los tengan listos, un integrante del grupo se debe poner de pie y pegarlo en el nivel correspondiente. Muy importante! Deben recordar los 5 mandamientos que hablamos Dudas? Cuentan con 15 minutos a partir de ya.				
Ejecución	**Facilitadores grupales:** Ok, vamos a empezar!! Observemos primero los actores que ya incluyó Maricruz. *Les parece que falta alguna institución pública o privada en ese mapa?* *Falta algún elemento clave como alguna regulación o política pública?* Vamos anotando en los post-its todas las ideas que se les vengan a la mente! *En el nivel micro, que es el relacionado a empresas faltará algo?* *En el nivel meso, que es el de las instituciones de apoyo falta alguien?* *En el nivel macro, que es el de regulación y políticas, podríamos agregar algún elemento o actor adicional?* *Y qué tal en el meta, que es todo lo que tiene que ver con la sociedad, cultura, nuestro sistema política en general, cómo lo ven? Se les ocurre algún otro actor importante ahí?* Muy bien! Ahora, vayamos acomodándolos por nivel! Quién quiere ir a pegarlos al rotafolio?	10.55-11.10	15 min	-Post its de figuras (flor y burbuja de texto de 2 colores c/u) -Pilots -1 croquis del mapa con los 4 niveles por grupo	Facilitadores grupales
Wrap-up	**Tiempo!!** Ok, vamos a ver, aquí ya he ido juntando los que estaban repetidos.	11.10-11.15		Rotafolio	Moderadora 1

	Algunos de los actores que se identificaron fueron:… Y los elementos que no se habían incluido fueron:… Muy bien! Excelente trabajo!				

12.2.2. ACTIVIDAD 2: IDENTIFICACIÓN DE RETOS Y OPORTUNIDADES

Pregunta principal	**Cuáles son los retos y oportunidades para producir y exportar polvo de grillos en Costa Rica?**	
Moderadora	Maricruz	
Duración	75 minutos	
Hora de inicio	11.15 am	
Hora de finalización	12.30 am	
Trabajo en grupos	SI, por temática	
Metodología	-Brainstorming -Enfoque de competitividad sistémica (nivel micro, meso, macro y meta) 1. Los participantes anotan en post-its los retos y oportunidades que identifiquen en cada nivel del sistema. 2. Un miembro de cada grupo expone los reusltados principales de un nivel.	
Resultado esperado	Mapa de 4 niveles con retos y oportunidades identificados.	

Descripción de la actividad	Guión	Hora	Duración	Materiales	Encargado
-Explicación	Ahora, que ya tenemos más claros quiénes son los actores claves en el ecosistema, vamos a enlistar los retos y oportunidades que podamos identificar en cada nivel. Entonces, tomando en cuenta nuestros mandamientos, deben encontrar en grupo qué cosas podrían facilitar (oportunidades) o dificultar (retos) que la consigna sea alcanzada. Cuando los identifiquen los deben escribir en los post its cuadrados que tienen e irlos colocando en las dos columnas de sus rotafolios, tomando en cuenta en qué nivel del sistema se encuentra ese reto. Es importante que tomen en cuenta los elementos y actores que hemos identificado y preguntarse, para cada uno de ellos, cuáles son los retos y oportunidade. Por ejemplo, tenemos el elemento de la Ley de Vida Silvestre. Podríamos decir que una gran oportunidades es el hecho de	11.15-11.23	8 min	-Rotafolio con mapa en blanco dividido en 2 columnas: retos y oportunidades (1 por grupo) -Pilots -Post-its	-Moderadora 1

	que ya contamos con una ley que proteje nuestra vida silvestre contra la sobreexplotación. Ahora, si tomo ese mismo elemento y analizo cuál podría ser un reto, puedo decir que la frecuencia de visitación que establece la ley para un insectario es muy alta. Cuentan con 12 minutos para identificar las oportunidades y luego 12 para identificar los retos.				
Identificación de las oportunidades	**Facilitadores grupales:** Ok, manos a la obra! Iniciemos con las oportunidades!! *Pensemos en los recursos que tiene Costa Rica que le facilitarían producir grillos.* *Recordemos que tenemos que guiarnos con los niveles del sistema, entonces, pensemos por ejemplo, a nivel de los productores, qué condiciones de Costa Rica les facilita producir?* *En el caso del nivel meso, relacionado al apoyo institucional, con qué contamos en este momento que nos faciliten producir y exportar grillos?* *En el caso del nivel macro, podemos incluir temas relacionados a la regulación. Qué recursos tenemos ya que pueden ser considerados oportunidades?* *Por último en el nivel meta, relacionado a la sociedad, etc, qué facilitaría que logremos un proyecto como este? Por ejemplo, ustedes creen que en Costa Rica hay una cultura de innovación?*	11.23-11.35	12min	-Rotafolio con mapa en blanco dividido en 2 columnas: retos y oportunidades (1 por grupo) Post its cuadrados de 4 colores -Pilots -Stickers verdes, rojos y amarillos -Carteles con 3 respuestas	Facilitadores grupales
-Identificación de los retos	Ok, ahora pensemos en aquellas cosas que nos dificultarían producir y exportar grillos. Vamos pensandolo también por niveles: *A nivel de los productores, qué condiciones de Costa Rica les dificulta producir?* *En el caso del nivel meso, relacionado al apoyo institucional, qué nos dificultaría producir y exportar polvo de grillos?* *En el caso del nivel macro, podemos incluir temas relacionados a la regulación. Cuáles regulaciones tenemos ya que pueden ser considerados obstáculos para producir y exportar polvo de grillos?* *Por último en el nivel meta, relacionado a la sociedad, etc, qué obstaculizaría que logremos un proyecto como este? Por*	11.35-11.47	12 minutos	-Rotafolio con mapa en blanco dividido en 2 columnas: retos y oportunidades (1 por grupo) -Post its cuadrados de 4 colores -Pilots	Facilitadores grupales

	ejemplo, cuál es la actitud de las personas ante los insectos comestibles?				
- Categorización	Ok, muy bien, se acabó el tiempo. Ahora, les vamos a entregar estas stickers de 3 colores y la idea es categorizar las oportunidades y retos identificados según el peso que tienen. Entonces colocaremos el sticker rojo si creemos que es una oportunidad muy fuerte, el verde si creemos que no tiene tanto peso, y el amarillo si lo consideran un intermedio. Igualmente para los retos, colocaremos el verde, si creemos que es un reto débil, o sea fácil de superar, el rojo si es un reto muy difícil de superar y el amarillo si es un intermedio. Tienen 10 minutos para realizar esta actividad.	11.47-11.57	10 minutos	-Rotafolio con mapa en blanco dividio en 2 columnas: retos y oportunidades (1 por grupo) -Stickers verdes, rojas y amarillas	Modera-dora 1
-Presentación de resultados	Muy bien, se acabó el tiempo, regresen a sus asientos. Ahora, un miembro del grupo nos va a exponer los principales resultados de un nivel . Cada grupo tiene 5 minutos para exponer. El grupo 1 (academia) expone el nivel meso El grupo 2 ((reguladores) : nivel macro El grupo 3 (innovadores) : nivel micro El grupo 4 (fomento exportaciones): nivel meta	11.57-12.17	20 minutos		Moderadora 1 Participantes
Wrap-up	Muy bien, muchas gracias a los presentadores! Podemos ver que aunque hay retos importantes, también hay oportunidades interesantes que podemos aprovechar para lograr la consigna.	12.17-12.22	5 minutos		Moderadora 1
-Respuesta individual a la pregunta de factibilitad	Ahora, para poder salir al almuerzo, cada uno de ustedes nos tiene que responder una pregunta. Tomando en cuenta estos retos y oportunidades, cada uno debe responder esta pregunta: Es factible producir y exportar polvo de grillos a gran escala en Costa Rica? Los que crean que se puede lograr en menos de 5 años por favor colocarse aquí. Los que creen que es posible en más de 5 años por favor vienen aquí y los que creen que no es posible se pueden colocar de este lado. Vamos a tomarles una foto, que nos va servir para más tarde! (se toma foto)	12.22-12.27	5 minutos	-Carteles con 3 respuestas	Moderadora 1
Wrap-up	Muy bien! Muchas gracias a todos! Ahora, podemos pasar por aquí para almorzar.	12.27-12.30	3 minutos		Maestra de

					ceremonias

Almuerzo: 50 minutos (12.30-13.20)

12.2.3. ACTIVIDAD 3: CREACIÓN DE ESTRATEGIAS (PARTE 1)

Pregunta principal	**Cómo podemos alcanzar la consigna, aprovechando las oportunidades identificadas para superar los retos, utilizando los actores y elementos claves con los que contamos?**
Moderadora	Pilar Fallas
Duración	90 minutos
Hora de inicio	13.20
Hora de finalización	14.50
Trabajo en grupos	SI, interdisciplinarios
Metodología	-Sketching -Enfoque de competitividad sistémica (nivel micro, meso, macro y meta) 1. Los participantes idean estrategias para alcanzar la consigna, utilizando los materiales disponibles.
Resultado esperado	1 Sketch de estrategia por grupo.

Descripción de la actividad	Guión	Hora	Du-ración	Materiales	Encargado
Reasignación de grupos	Vamos a iniciar con la segunda parte del taller. Esta es la parte más dinámica y divertida! Y para que no se nos duerman después de almuerzo, vamos a hacer cambio de grupos!! Vamos a mezclar los grupos! Aquí en esta diapositiva hicimos un reacomodo de los grupos, entonces les vamos a pedir que tomen sus cosas y se sienten en la mesa correspondiente.	13.20-13.22	2 min	Dp con cambio de grupos Se trabaja sin sillas.	Maestra de ceremonias
-Explicación -	Para esta parte del taller es más que nunca necesario que sigamos los mandamientos del taller (leerlos nuevamente). Queremos que haya una actitud de juego, generadora, libre de juicios, propositiva, con vocabulario positivo... Para esta parte del taller, Pilar Fallas será la moderadora, así que le doy la palabra.	13.22-13.25	3 min	Dp co mandamientos	-Maestra de ceremonias
Activación: sombrilla loca	Vamos a calentar! Ahora, que ya estamos en los nuevos grupos, vamos a hacer una pequeña actividad de calentamiento. Aquí tengo una	13.25-13.35	10 min	-Sombrilla -Hojas y	Moderadora 2 (Pilar Fallas)

	sombrilla. Pero esta sombrilla ya pasó de moda y no satisface mis necesidades. Entonces, cada grupo tiene 5 minutos para proponer una sombrilla innovadora y luego presentarla en 1 minuto, que sea diferente a todas las sombrillas que conocemos actualmente. En sus marcas, listos, fuera!! (se monitorea el uso del lenguaje propositivo) ejecutaron estas acciones en este orden y se obtuvo Y.... Cada grupo presenta su propuesta (1 min por grupo) Muy bien, todas las propuestas están super innovadoras!! Excelente trabajo!			materiales de trabajo	
-Sketching de estrategia	Ahora, manteniendo ese mismo mood creativo, cada grupo va a generar una posible estrategia para lograr la consigna. Vamos a entender estrategia como una secuencia de acciones para lograr un objetivo. Por ejemplo, si yo quiero llegar temprano al trabajo pero también hacer ejercicio, tengo que... Ahora, ya viendo una estrategia más real, tomemos este ejemplo (ver dispositiva). Este es un país que estableció una estrategia para salir del subdesarrollo. Como podemos ver, ... (explicar diapositiva) Ahora, que ya tenemos claro qué es una estrategia, vamos a idear nuestras estrategias. Para ellos, van a elaborar un sketch (dibujo, diagrama) utilizando los materiales que tienen disponibles en sus mesas. La propuesta debe tomar en cuenta los siguientes elementos: -Zona del país donde se llevará a cabo el proyecto -Financiamiento -Actores claves -Mercados -Recursos requeridos (equipo, recurso humano, materia prima) -Cadena de Valor -Secuencia de actividades a realizar Recuerden que deben tomar en cuenta los retos y oportunidades, así como los actores identificados previamente. Además, en nuestra propuesta debemos tomar en cuenta los 5 niveles del sistema que ya hemos analizado. Lo primero que vamos a hacer es generar las acciones, usando los materiales, todas las ideas que se les venga a la mente, las pueden ir representando con los materiales. Entonces, primero, vamos a responder el QUÉ? (qué se puede hacer?) Luego, vamos a ir definiendo con más detalles cada acción, respondiendo el CÓMO? Cómo podemos llevar a cabo las acciones propuestas?	13.35-13.45	10 min	-Diapositivas con ejemplos de estrategias	Moderadora 2 (pilar)

	y para finalizar vamos a hacer la secuencia de actividades, que sería responder el CUÁNDO?. Los facilitadores grupales los van a ir guiando. Cada grupo va a tener 1 hora para idear su propuesta.				
Ideación del sketch. Parte 1: GENERACIÓN DE ACCIONES	**Facilitadores grupales:** Ok, iniciemos! Recuerden que pueden usar todos los materiales que están disponibles. Empecemos generando acciones posibles. En esta primera parte vamos a responder a la pregunta de QUÉ HAY QUE HACER? *Qué actividades les parece que se podrían implementar?* *Qué falta por hacer? Quién debería hacerlo?* *Ahora, si lo vemos por nivel, en el nivel micro, qué harían, osea, a nivel de la cadena de valor, lo que tiene que ver con proveedores, transportitas, clientes, etc?* *Ahora, a nivel meso, en cuánto a instituciones de apoyo, qué proponen?* *En el nivel macro, relacionado a regulación, incentivos, etc? Qué propondrían?* *Y en el último nivel, el meta, qué se les ocurre que se podría hacer para alcanzar la consigna?*	13.45-14.05	20 min		Facilitadores grupales
Ideación del sketch. Parte 2: DETALLAR LAS IDEAS	Ok, ahora tenemos que detallar mejor cómo llevaríamos a cabo las ideas propuestas. Entonces, vamos a responder a la pregunta de CÓMO VAMOS A HACERLO? Empecemos por ejemplo con esta propuesta "Hacer una ley sobre manejo de insectos comestibles", cómo podríamos hacer esto? Y quiénes deberían estar involucrados?	14.05-14.25	20 min		FACILITADORES GRUPALES
Ideación del sketch. Parte 2: ORDENAR LAS ACTIVIDADES	Por último, tenemos que ordenar las actividades. Entonce, vamos a responder a la pregunta de EN QUÉ ORDEN se van a realizar las acciones? Si además podemos responder en CUÁNTO TIEMPO? sería mejor. Por ejemplo en 2 años, de aquí a 5 años o más de 5 años.	14.25-14.40	15 min		FACILITADORES GRUPALES
Receso	Tiempo!! Ya todos los sketches deben estar listos! Vamos a hacer una pausa de 10 minutos y al volver cada grupo va a presentar su propuesta.	14.50-15.00	10 min		Moderadora 2
	RECESO (10 MINUTOS)				

3.1.1. ACTIVIDAD 3: CREACIÓN DE ESTRATEGIAS (PARTE 2)

Pregunta principal	**Cuáles son los principales retos de las estrategias propuestas?**
Moderadora	Pilar Fallas
Duración	40 minutos
Hora de inicio	15.00
Hora de finalización	15.40
Trabajo en grupos	SI, interdisciplinarios

Metodología	-Sketching -Enfoque de competitividad sistémica (nivel micro, meso, macro y meta) 1. Los participantes presentan sus propuestas. 2. Otro grupo identifica los principales retos de la propuesta.
Resultado esperado	1 Sketch de estrategia por grupo. 1 reto identificado por grupo.

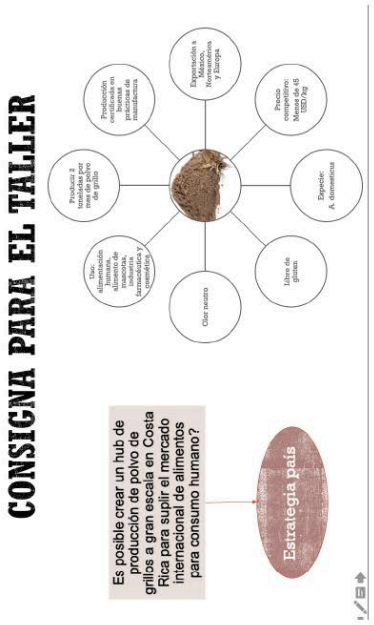
Descripción de la actividad	Guión	Hora	Duración	Materiales	Encargado
-Presentación de resultados 1	Ahora, un grupo le va a presentar su estrategia a otro grupo. Este otro grupo tiene que presentar mucha atención ya que luego deben identificar cuál es el reto más grande para lograr la estrategia propuesta. Se hace el primer set de presentaciones.	15.00-15.10	10 min		Moderadora 2
-Categorización	El grupo que escuchaba indica cuáles son los 3 principales retos que identifican en esa estrategia y porqué.	15.10-15.18	8 min		Moderadora 2
-Presentación de resultados 2	Ahora, el grupo que escuchaba debe presentar su estrategia y el otro grupo identificará el principal reto. Se presenta.	15.18-15.28	10 min		Moderadora 2
-Categorización	El grupo que escuchaba indica cuáles son los 3 principales retos que identifican en esa estrategia y porqué.	15.28-15.36	8 min		Moderadora 2
-Wrap-up	Moderadora genera conclusiones.	15.36-15.40	4 min		Moderadora 2

12.3 CONCLUSIONES Y CIERRE

Descripción de la actividad	Guión	Hora	Duración	Materiales	Encargado
-Colocar las sillas en círculo -Explicar dinámica	Para la última actividad, cada uno va a tomar su silla y vamos a formar aquí un círculo. Nos interesa conocer qué les pareció el taller, cómo se sintieron y si se sienten motivados a tomar acción de cualquier manera relacionada al tema de insectos comestibles. Entonces, para esta parte, nos gustaría que, levantando la mano, cada uno nos cuente qué se lleva del taller de hoy y a qué acciones los motiva.	15.40-15.55	15 minutos	Sillas en círculo	Maestra de ceremonias
Agradecimiento	De parte de todo el equipo organizador, quisiera agradecerles su participación. Esperamos que la actividad haya sido muy provechosa para ustedes y que este sea el inicio de muchos encuentros y actividades relacionados al tema de insectos comestibles!	15.55-16.00	5 minutos		Moderadora 1 (Maricruz)

ANEXOS

1. Consigna del Taller (entregable)



A11. Group assignments for the workshop

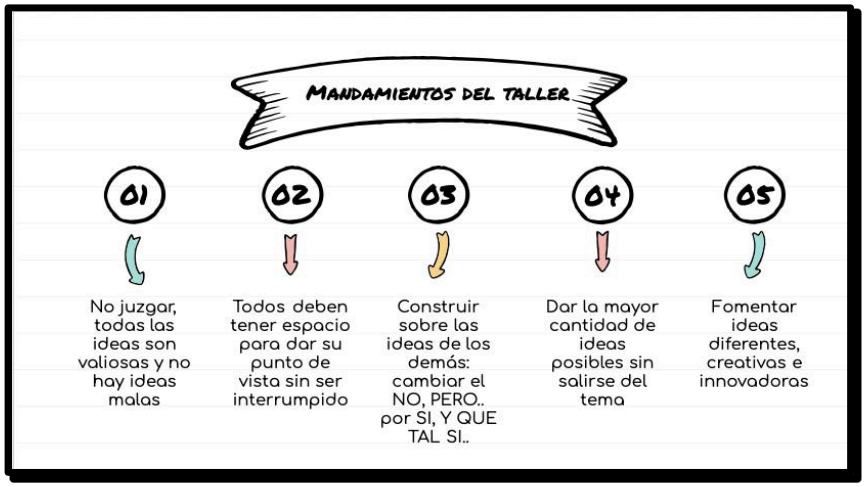
Activity 1 and 2

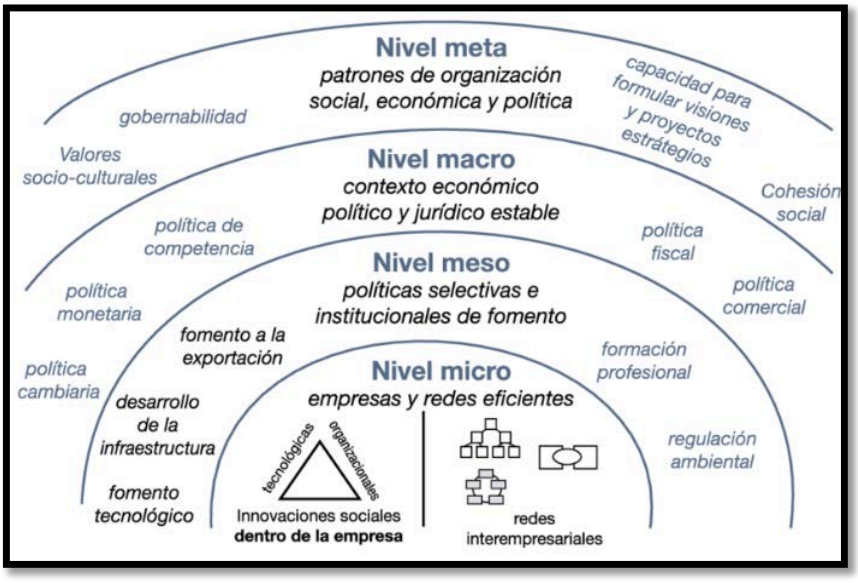
GRUPO	1.Técnico/Academia	2.Regulador	3.Innovación	4.Finaciamiento y Exportaciones
Facilitador	**Amaryllis Quirós**	**Ana María Quirós**	**Pilar Fallas**	**Cristiana González**
Participantes	Expertos técnicos (2): Ricardo Murillo, Federico Paniagua	Jocelin Rios (SINAC)	Emprendedores (3): Andres Muñoz (GH), Daniela Arias (CRIC), Gabriela Soto (CRCI)	Laura López (PROCOMER)
	Productores de insectos (2): Miki Oshima, Alberto Esquivel	Bernardo Jaén (SENASA)	Fomento de innovación (2): Sofía Miranda (AUGE), Marianela Cortés (PROINNOVA)	Johanna Rodríguez (SBD)
	Cindy Hidalgo (Docente Nutrición)	Alejandra Chaverri (Ministerio de Salud)	Marcela Monge (MICITT)	Gustavo Bonilla (CINDE)
	Andrea Brenes (CINA)	Pompilio Campos (Colegio de Biólogos)		Francini Araya (MAG)
		Melina Flores (MEIC)		Eliso Kotsieva (FUNDES)
				Victor Umaña (COMEX)
Total participantes	**6**	**6**	**6**	**6**

Activity 3

Grupo	1	2	3	4
Facilitador	**Amaryllis Quirós**	**Ana María Quirós**	**Cristiana González**	**Erika Halsband**
Participantes	Federico Paniagua (UCR)	Alberto Esquivel (JUICY ANT)	Ricardo Murillo (UCR)	Gabriela (COSTA RICA COME INSECTOS)
	Cindy Hidalgo (Nutrición)	Mónica Elizondo (CACIA)	Andrea Brenes (CINA)	Melina Flores (MEIC)
	Pompilio Campos (Colegio de Biólogos)	Daniela (CRIC)	Jocelin Rios (SINAC)	Andrés Muñoz (GRICKET HOUSE)
	Miki Oshima (JUICY ANT)	SENASA	Alejandra Chaverri (Ministerio de Salud)	Laura Lopez (PROCOMER)
	Francini Araya (MAG)	Johanna Rodríguez	Marcela Monge (MICITT)	Sofía Miranda (AUGE)
	Marianela Cortes (PROINNOVA)	Eliso Kotsieva (FUNDES)	Victor Umana (COMEX)	Gustavo Bonilla (CINDE)
Total participantes	**6**	**6**	**6**	**6**

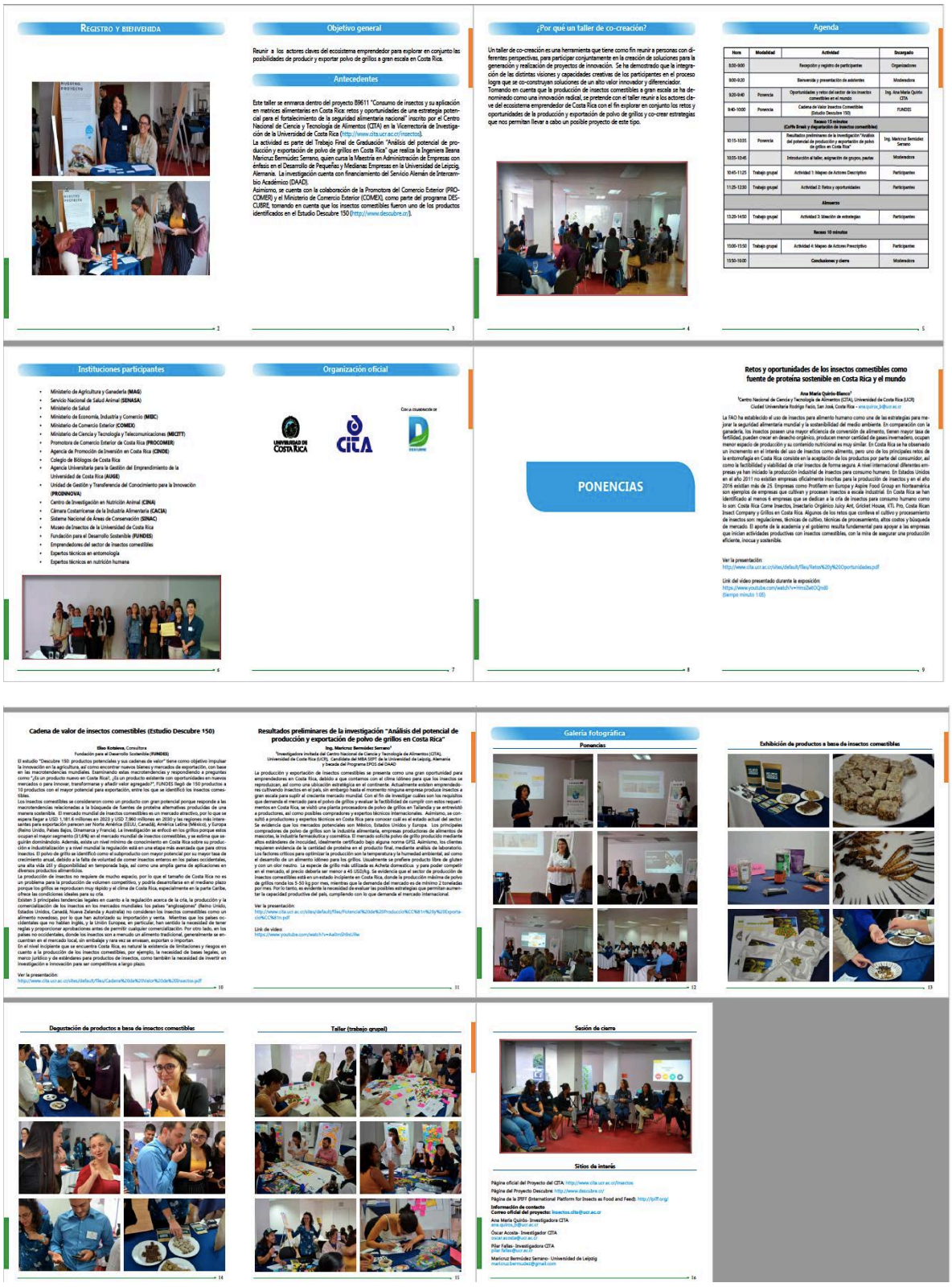
A12. Handouts given to groups during the workshop





A12. Maps of Challenges and Opportunities created by the groups during Activity 2

A13. Summary report of the workshop sent to participants



Registro y bienvenida

Objetivo general

Reunir a los actores claves del ecosistema emprendedor para explorar en conjunto las posibilidades de producir y exportar polvo de grillos a gran escala en Costa Rica.

Antecedentes

Este taller se enmarca dentro del proyecto 89611 "Consumo de insectos y su aplicación en matrices alimentarias en Costa Rica: retos y oportunidades de una estrategia potencial para el fortalecimiento de la seguridad alimentaria nacional" inscrito por el Centro Nacional de Ciencia y Tecnología de Alimentos (CITA) en la Vicerrectoría de Investigación de la Universidad de Costa Rica (http://www.cita.ucr.ac.cr/insectos).
La actividad es parte del Trabajo Final de Graduación "Análisis del potencial de producción y exportación de polvo de grillos en Costa Rica" que realiza la Ingeniera Ileana Maricruz Bermúdez Serrano, quien cursa la Maestría en Administración de Empresas con énfasis en el Desarrollo de Pequeñas y Medianas Empresas en la Universidad de Leipzig, Alemania. La investigación cuenta con financiamiento del Servicio Alemán de Intercambio Académico (DAAD).
Asimismo, se cuenta con la colaboración de la Promotora del Comercio Exterior (PROCOMER) y el Ministerio de Comercio Exterior (COMEX), como parte del programa DESCUBRE, tomando en cuenta que los insectos comestibles fueron uno de los productos identificados en el Estudio Descubre 150 (http://www.descubre.cr/).

¿Por qué un taller de co-creación?

Un taller de co-creación es una herramienta que tiene como fin reunir a personas con diferentes perspectivas, para participar conjuntamente en la creación de soluciones para la generación y realización de proyectos de innovación. Se ha demostrado que la integración de las distintas visiones y capacidades creativas de los participantes en el proceso logra que se co-construyan soluciones de un alto valor innovador y diferenciador.
Tomando en cuenta que la producción de insectos comestibles a gran escala se ha denominado como una innovación radical, se pretende con el taller reunir a los actores clave del ecosistema emprendedor de Costa Rica con el fin explorar en conjunto los retos y oportunidades de la producción y exportación de polvo de grillos y co-crear estrategias que nos permitan llevar a cabo un posible proyecto de este tipo.

Agenda

Hora	Modalidad	Actividad	Encargado
8:30-9:00		Recepción y registro de participantes	Organizadores
9:00-9:20		Bienvenida y presentación de asistentes	Moderadora
9:20-9:40	Ponencia	Oportunidades y retos del sector de los insectos comestibles en el mundo	Ing. Ana María Quirós CITA
9:40-10:00	Ponencia	Cadena de Valor Insectos Comestibles (Estudio Descubre 150)	FUNDES
		Receso 15 minutos (Coffe Break y degustación de insectos comestibles)	
10:15-10:35	Ponencia	Resultados preliminares de la investigación "Análisis del potencial de producción y exportación de polvo de grillos en Costa Rica"	Ing. Maricruz Bermúdez Serrano
10:35-10:45		Introducción al taller, asignación de grupos, pautas	Moderadora
10:45-11:25	Trabajo grupal	Actividad 1: Mapeo de Actores Descriptivo	Participantes
11:25-12:30	Trabajo grupal	Actividad 2: Retos y oportunidades	Participantes
		Almuerzo	
13:20-14:50	Trabajo grupal	Actividad 3: Ideación de estrategias	Participantes
		Receso 10 minutos	
15:00-15:50	Trabajo grupal	Actividad 4: Mapeo de Actores Prescriptivo	Participantes
15:50-16:00		Conclusiones y cierre	Moderadora

Instituciones participantes

- Ministerio de Agricultura y Ganadería (MAG)
- Servicio Nacional de Salud Animal (SENASA)
- Ministerio de Salud
- Ministerio de Economía, Industria y Comercio (MEIC)
- Ministerio de Comercio Exterior (COMEX)
- Ministerio de Ciencia y Tecnología y Telecomunicaciones (MICITT)
- Promotora de Comercio Exterior de Costa Rica (PROCOMER)
- Agencia de Promoción de Inversión en Costa Rica (CINDE)
- Colegio de Biólogos de Costa Rica
- Agencia Universitaria para la Gestión del Emprendimiento de la Universidad de Costa Rica (AUGE)
- Unidad de Gestión y Transferencia del Conocimiento para la Innovación (PROINNOVA)
- Centro de Investigación en Nutrición Animal (CINA)
- Cámara Costarricense de la Industria Alimentaria (CACIA)
- Sistema Nacional de Áreas de Conservación (SINAC)
- Museo de Insectos de la Universidad de Costa Rica
- Fundación para el Desarrollo Sostenible (FUNDES)
- Emprendedores del sector de Insectos comestibles
- Expertos técnicos en entomología
- Expertos técnicos en nutrición humana

Organización oficial

Universidad de Costa Rica · CITA · Con la colaboración de DESCUBRE

PONENCIAS

Retos y oportunidades de los insectos comestibles como fuente de proteína sostenible en Costa Rica y el mundo

Ana María Quirós-Blanco[1]
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Ciudad Universitaria Rodrigo Facio, San José, Costa Rica - ana.quiros_b@ucr.ac.cr

La FAO ha establecido el uso de insectos para alimento humano como una de las estrategias para mejorar la seguridad alimentaria mundial y la sostenibilidad del medio ambiente. En comparación con la ganadería, los insectos poseen una mayor eficiencia de conversión de alimento, tienen mayor tasa de fertilidad, pueden crecer en desecho orgánico, producen menor cantidad de gases invernadero, ocupan menor espacio de producción y su contenido nutricional es muy similar. En Costa Rica se ha observado un incremento en el interés del uso de insectos como alimento, pero uno de los principales retos de la entomofagia en Costa Rica consiste en la aceptación de los productos por parte del consumidor, así como la factibilidad y viabilidad de criar insectos de forma segura. A nivel internacional diferentes empresas ya han iniciado la producción industrial de insectos para consumo humano. En Estados Unidos en el año 2011 no existían empresas oficialmente inscritas para la producción de insectos y en el año 2016 existían más de 25. Empresas como Protifarm en Europa y Aspire Food Group en Norteamérica son ejemplos de empresas que cultivan y procesan insectos a escala industrial. En Costa Rica se han identificado al menos 6 empresas que se dedican a la cría de insectos para consumo humano como lo son: Costa Rica Come Insectos, Insectario Orgánico Juicy Ant, Cricket House, KTL Pro, Costa Rican Insect Company y Grillos en Costa Rica. Algunos de los retos que conllleva el cultivo y procesamiento de insectos son: regulaciones, técnicas de cultivo, técnicas de procesamiento, altos costos y búsqueda de mercado. El aporte de la academia y el gobierno resulta fundamental para apoyar a las empresas que inician actividades productivas con insectos comestibles, con la mira de asegurar una producción eficiente, inocua y sostenible.

Ver la presentación:
http://www.cita.ucr.ac.cr/sites/default/files/Retos%20y%20Oportunidades.pdf

Link del video presentado durante la exposición:
https://www.youtube.com/watch?v=HmsZwtOQnd0
(tiempo minuto 1:03)

Cadena de valor de insectos comestibles (Estudio Descubre 150)

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Fundación para el Desarrollo Sostenible (FUNDES)

El estudio "Descubre 150: productos potenciales y sus cadenas de valor" tiene como objetivo impulsar la innovación en la agricultura, así como encontrar nuevos bienes y mercados de exportación, con base en las macrotendencias mundiales. Examinando estas macrotendencias y respondiendo a preguntas como "¿Es un producto nuevo en Costa Rica?, ¿Es un producto existente con oportunidades en nuevos mercados o para innovar, transformarse y añadir valor agregado?", FUNDES llegó de 150 productos a 10 productos con el mayor potencial para exportación, entre los que se identificó los insectos comestibles.
Los insectos comestibles se consideraron como un producto con gran potencial porque responde a las macrotendencias relacionadas a la búsqueda de fuentes de proteína alternativas producidas de una manera sostenible. El mercado mundial de insectos comestibles es un mercado atractivo, por lo que se espera llegar a USD 1.181.6 millones en 2020 y USD 7.960 millones en 2030 y las regiones más interesantes para exportación parecen ser Norte América (EEUU, Canadá), América Latina (México), y Europa (Reino Unido, Países Bajos, Dinamarca y Francia). La investigación se enfocó en los grillos porque estos ocupan el mayor segmento (31.6%) en el mercado mundial de insectos comestibles, y se estima que seguirán dominándolo. Además, existe un nivel mínimo de conocimiento en Costa Rica sobre su producción e industrialización y a nivel mundial la regulación está en una etapa más avanzada que para otros insectos. El polvo de grillo se identificó como el subproducto con mayor potencial por su mayor tasa de crecimiento anual, debido a la falta de voluntad de comer insectos enteros en los países occidentales, una alta vida útil y disponibilidad en temporada baja, así como una amplia gama de aplicaciones en diversos productos alimenticios.
La producción de insectos no requiere de mucho espacio, por lo que el tamaño de Costa Rica no es un problema para la producción de volumen competitivo, y podría desarrollarse en el mediano plazo porque los grillos se reproducen muy rápido y el clima de Costa Rica, especialmente en la parte Caribe, ofrece las condiciones ideales para su cría.
Existen 3 principales tendencias legales en cuanto a la regulación acerca de la cría, la producción y la comercialización de los insectos en los mercados mundiales: los países "anglosajones" (Reino Unido, Estados Unidos, Canadá, Nueva Zelanda y Australia) no consideran los insectos comestibles como un alimento novedoso, por lo que han autorizado su importación y venta. Mientras que los países occidentales que no habían Inglés, y la Unión Europea, en particular, han sentido la necesidad de tener reglas y proporcionar aprobaciones antes de permitir cualquier comercialización. Por otro lado, en los países no occidentales, donde los insectos son a menudo un alimento tradicional, generalmente se encuentran en el mercado local, sin embalaje y rara vez se envasan, exportan o importan.
En el nivel incipiente que se encuentra Costa Rica, es natural la existencia de limitaciones y riesgos en cuanto a la producción de los insectos comestibles, por ejemplo, la necesidad de bases legales, un marco jurídico y de estándares para productos de insectos, como también la necesidad de invertir en investigación e innovación para ser competitivos a largo plazo.

Ver la presentación:
http://www.cita.ucr.ac.cr/sites/default/files/Cadena%20de%20Valor%20de%20Insectos.pdf

Resultados preliminares de la investigación "Análisis del potencial de producción y exportación de polvo de grillos en Costa Rica"

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La producción y exportación de insectos comestibles se presenta como una gran oportunidad para emprendedores en Costa Rica, debido a que contamos con el clima idóneo para que los insectos se reproduzcan, así como una ubicación estratégica en el continente. Actualmente existen emprendedores cultivando insectos en el país, sin embargo hasta el momento ninguna empresa produce insectos a gran escala para suplir al creciente mercado mundial. Con el fin de investigar cuáles son los requisitos que demanda el mercado para el polvo de grillos y evaluar la factibilidad de cumplir con estos requerimientos en Costa Rica, se visitó una planta procesadora de polvo de grillos en Tailandia y se entrevistó a productores, así como posibles compradores y expertos técnicos internacionales. Asimismo, se consultó a productores y expertos técnicos en Costa Rica para conocer cuál es el estado actual del sector. Se evidencia que los mercados potenciales son México, Estados Unidos y Europa. Los principales compradores de polvo de grillos son la industria alimentaria, empresas productoras de alimentos de mascotas, la industria farmacéutica y cosmética. El mercado solicita polvo de grillo producido mediante altos estándares de inocuidad, idealmente certificado bajo alguna norma GFSI. Asimismo, los clientes requieren evidencia de la cantidad de proteína en el producto final, mediante análisis de laboratorio. Los factores críticos para optimizar la producción son la temperatura y la humedad ambiental, así como el desarrollo de un alimento idóneo para los grillos. Usualmente se prefiere producto libre de gluten y con un olor neutro. La especie de grillo más utilizada es Acheta domesticus y para poder competir en el mercado, el precio debería ser menor a 4$ USD/kg. Se evidencia que el sector de producción de insectos comestibles está en un estado incipiente en Costa Rica, donde la producción máxima de polvo de grillos ronda los 5-50 kg por mes, mientras que la demanda del mercado es de mínimo 2 toneladas por mes. Por lo tanto, es evidente la necesidad de evaluar las posibles estrategias que permitan aumentar la capacidad productiva del país, cumpliendo con lo que demanda el mercado internacional.

Ver la presentación:
http://www.cita.ucr.ac.cr/sites/default/files/Potencial%20de%20Produccion%CC%81n%20y%20Exportacion%CC%81n.pdf

Link de video:
https://www.youtube.com/watch?v=Aa0m0hbUlkw

Galería Fotográfica

Ponencias

Exhibición de productos a base de insectos comestibles

Degustación de productos a base de insectos comestibles

Taller (trabajo grupal)

Sesión de cierre

Sitios de interés

Página oficial del Proyecto del CITA: http://www.cita.ucr.ac.cr/insectos
Página del Proyecto Descubre: http://www.descubre.cr/
Página de la IPIFF (International Platform for Insects as Food and Feed): http://ipiff.org/

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Declaration of Academic Honesty

I hereby declare to have written this Master's Thesis by my own, having used only the listed resources and tools. It is well known to me that a false declaration is deemed to be an offence against the examination regulations of the International SEPT Program and the Leipzig University.

Place, Date_____ Signature _____