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INSECT PROTEIN PRODUCTION – POSSIBILITIES IN FINLAND

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ABSTRACT

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This thesis gathers information from articles relating to insect farming techniques and possibilities in Europe, giving an idea how insect farming could become a more sustainable form of producing protein than currently used livestock. Comparison between traditional livestock animals is made in the fields of nutritional contents, water, energy and land usage, CO_2eq emissions and feed conversion rates.

This study is done as a literature review taking relevant information from various magazines, articles, books and other sources to formulate a review of the current situation in Europe and Finland.

The research data suggest that insects, mostly mealworm and house cricket are just as or more efficient in every category than traditional livestock. This data supports the idea that implementing insect farming as a part of existing agriculture frameworks, or replacing some traditional livestock farms with insect farms, would mean less land-usage and especially a lot less emissions to the atmosphere.

Finland has every possibility to adapting this relatively new field of farming if legislative problems are tackled. Making changes to current legislation or passing insects through tedious novel food regulations would provide willing farmers with a framework to start businesses in the field and thus promote entomophagy in the country.

CONTENTS

GLOSSARY or ABBREVIATIONS AND TERMS (choose one or other)

TAMK	Tampere University of Applied Sciences
GHG	Greenhouse gas
GWP	Global warming potential
CO2eq	Carbon Dioxide equivalent
Entomophagy	The practice of eating insects
FAO	Food and agriculture organization of united nations
EC	European Commission
EFSA	European food and safety authority
LCA	Life cycle assessment
BSE	bovine spongiform encephalopathy (mad cow disease)

1 INTRODUCTION

Insect protein has been consumed in many forms in all continents for millennia. In many countries of the world the different insects are highly utilized as an extra source of protein for families and in many as an alternative source of nutrition when more commonly used staples are scarce (FAO, 2014). What insects may lack in appeal to people not accustomed to eating them, they makes up with efficient transformation of resources into high quality protein.

With the growing population on Earth comes a dire need for more efficient practices of food production, the kind of production that does not hinder future generations' ability to thrive. Meaning the sort of operations that are not resource intensive, do not create excessive amounts of GHG's and do not require vast areas of land to be utilized.

The rearing of insects meets all these challenges head on: it is more efficient in transforming feed to protein than poultry, cattle, pigs and other traditional farm animals, the farm land it needs is far less and the GHG emissions are far below the common farm animals' (FAO, 2014). However, where insect protein seemingly is exactly the kind of food staple needed to cover the increasing food demand, it meets a seemingly unsurmountable amount of obstacles, from legislative difficulties to sociological issues.

European legislation is hindering the growth of this industry. There are some special permits given to a few select companies, one of them is ediblebugfarm in Netherlands. The situation in Finland is very similar; only some individuals and universities are studying the possibilities of insect based protein as a legitimate opportunity to tackle global food issues as well as provide income. This thesis aims to give a better understanding of these said obstacles and aims to propose ways and means of producing insect protein for human consumption in Finland.

The main focus of the thesis is on mealworms and how they compare to traditional livestock animals in feed conversion, nutritional content, land and energy usage and GWP. Where information on mealworms is scarce house crickets are used as an example of insect species.

2 Entomophagy – the practice of eating insects

Throughout humanity’s history insects have been eaten in every continent. In Africa, Latin America and Asia the practice is rather common and especially so in rural areas where as in Northern America it is mainly done by the native inhabitants and in Europe it has withered out of practice in the last 100 years or so. In Europe the practice has never been very common but there are recipes from the early 1900’s of Maybug soup that has been used in Germany (Maikäffersuppe, Manoi, 2009) proving that the practice is not totally foreign to the area. Mealworm and cricket burgers are seen in various events even in Finland at times because of their relatively mild taste, which can be greatly influenced by different cooking techniques.

Picture 1 A maybug (Rasbak)

In the western world the attitudes towards entomophagy are often negative. Many view insects only as pests and the mere idea of eating them can make one. Even with such negative bias towards entomophagy there is references to eating insects even in the bible: “Even these of them ye may eat; the locust after his kind, and the bald locust after his kind, and the beetle after his kind, and the grasshopper after his kind” (Leviticus XI:

22)”. Entomophagy is in many parts a forgotten part of history in the western world and it has not been until reports in the 19th century from tropical countries that Europe became familiar with the concept again (FAO, 2014).

When Europeans were busy colonizing the world insects were used much more globally. But after invading various countries the Europeans brought with them their ideas of what a thriving society looks like (to them) and what is efficient farming practice and possibly in this way hindered the usage of insects as a food source for humans for centuries (FAO, 2014).

Where entomophagy is rather rare in the western world, it is an everyday occurring practice in many parts of Asia and Africa. Especially in Asia and more specifically so in China and Thailand one can easily stumble upon a street vendor selling various different insect species gathered locally and cooked in oil.

Picture 2 A street vendor in Thailand with a wide variety of insects for sale (Takoradee)

The cultivation of insects in south-eastern Asia is often the kind done in the backyard. Creating of semi-cultivated insect production for families is commonplace to creating extra income in Thailand, Laos and Cambodia.

3 The land usage, nutritional values, water usage and other metrics - comparing insects with traditional livestock

Insects for human consumption or feed for livestock are relatively cheap to produce. They contain good amounts of protein and micronutrients such as copper, iron, magnesium, manganese, phosphorous, selenium and zinc, they meet amino-acid requirements for humans, their feed conversion rate is much better and their environmental impact is much lower than that of traditional livestock species such as cattle, pork and poultry (FAO, 2014).

To better grasp the benefits that insects can provide humans understanding their exact nutritional values is extremely important. Insects are mainly protein, fat and fibre and have a varied collection of minerals, micronutrients, acids and vitamins (FAO, 2014).

Besides the nutritional data being of importance so is the amount of land needed for the rearing practice, how much greenhouse gases the practice produces, how much energy is needed and how much water is used.

3.1 Agricultural land usage

A large part of today's land used in agriculture is going directly into livestock feed, approximately 70% of all land used in agriculture (FAO, 2006). It is estimated that the meat consumption in the world will double by the 2050's due to the rising population and economic growth of developing countries and therefore meeting the protein needs of future generations is extremely hard with existing procedures. Indeed, out of all land area available for agriculture 40% is already in use, if this was to double most of the forests would need to be cut down. If the same land area used for agriculture today could produce more food with the same input it could provide humans with the means of tackling this severe food crisis that humanity is about to face.

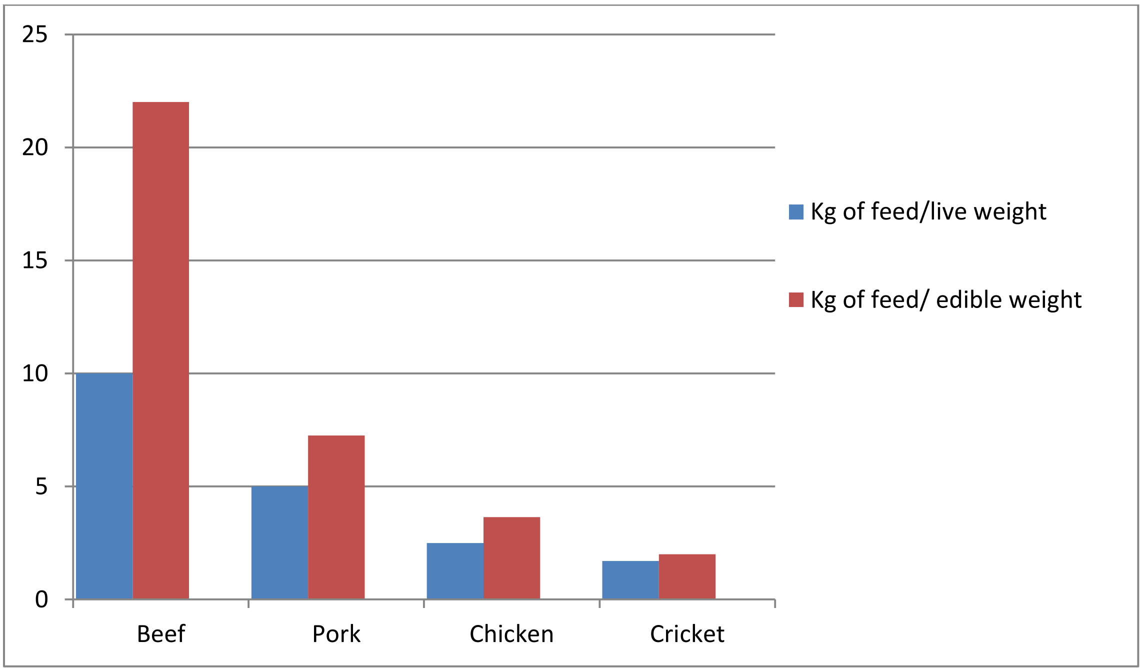
The total land area needed to produce 1kg of fresh mealworm according to a research done by Oonincx and Boer is 3.56 m^2 and for 1kg of edible protein 18m^2. This number is expected to go lower in the coming years as the systems get more automated. The production of cattle, pork and chicken, requires the following land areas for 1 kg of edible protein: 142-254m^2 for cattle, 46,2-62,8 m^2 for pork and 41,4-51,3 m^2 for chicken

(Ooninckx et al, 2012. The areas reported here also take into account the average land usage needed for the feed of the animals. Check table 3 in chapter 3.3 for better comparison.

3.2 Feed conversion rate and nutritional values

The feed conversion rate is an efficient measuring tool when weighing the options of different livestock production. A kilogram of beef requires about 10 kilograms of feed to be produced, pork requires 5 kilograms, chickens 2,5 kilograms and crickets as little as 1,7 kilograms. When combined with the fact that not every part of the animals are edible the benefits of producing crickets is even clearer. The edible bodyweight of chicken and pork is 55%, of beef 40% and of crickets 80%. Crickets are therefore twice as efficient in producing protein as chicken, 4 times more efficient than pork and 12 times more efficient than cattle. The differences are easily read from Chart 1.

Chart 1: Feed conversion rates



3.2.1 Nutritional values of mealworm larvae, cricket, pork, beef and chicken

Yellow mealworms (*Tenebrio molitor)* are a commonly utilized insect species for human consumption in Europe because of their short lifespan, high reproduction rate and availability. They have a varying protein content of 15-25% depending on environmental factors and what they are fed (Ewa Siemianowska et al. 2013, A.E Ghaly, 2009). They have high amounts of minerals when compared to traditional livestock. The actual mineral contents are seen in table 2 in chapter 3.3. When ground into a powder the amount of protein, fat and minerals is doubled (Ewa Siemianowska et al. 2013).

House Crickets (*Acheta domesticus*) have a protein content of 8-25% in fresh weight (FAO, 2014).

Both house Crickets and Mealworm larvae are well represented in B12 vitamin. Mealworms have a content of 0,47 µg per 100 grams and house crickets have a content of 5,4 µg per 100g in adults and 8,7 µg per 100 grams in nymphs (FAO, 2014). For comparison beef has a B12 vitamin content of 3,17 µg per 100 grams (Bennink et al.1982).

Many researches have been done directly on wild, hand caught, individuals which often will result in much variety in nutrients. The insects that have been subject to similar feed and conditions, such as inside a laboratory or within an insect farm will provide values much more uniform (FAO, 2014).

Beef and pork alongside with chicken are the most commonly consumed protein products in the western world. Understanding their nutritional content is beneficial when figuring out the benefits of insects for human consumption.

3.3 Comparison of traditional livestock animals and insects– tables and figures

Table 1 Protein and fat content of different livestock animals (Ewa Siemianowska et al. 2013)

Food source	% Protein	% Fat
Cattle	19	13
Pork	15,41	17,18
Chicken	17,44	8,10
House Cricket	8-22	
Mealworm	18	22

Table 2 Mineral content of different livestock animals in mg/100g (E. Siemian-owska *et al*, 2013)

	P	K	Na	Mg	Ca	Zn	Fe	Cu	Mn
Beef	212	382	52	26	4	2,93	3,1	0,10	0,04
Pork	208	343	42	24	15	1,93	1,0	0.06	0,04
Chicken	215	334	91	26	8	1,40	0,7	0,08	0,01
Mealworm (fresh)	319	374	40,4	87,5	16,8	4,20	3,79	0,78	0,44

Table 3 Land use per kilogram of product (Oonicx et al, 2012)

	Land use per kilogram of product
Cattle	142-254m^2
Pork	46,2-62,8 m^2
Chicken	41,4-51,3 m^2
Mealworm	18m2

3.4 Water usage

Water is a commodity many people take for granted. However it is estimated that clean water and access to it will be increasingly difficult to find for a large amount of people as the population grows. The food and agricultural organization of United Nations (2012) estimate that in 2025 some 1.8 billion people will live in areas of extreme water scarcity and that by then two thirds of the population will be under stress. Agriculture is the biggest user of water globally, taking care of some 70% of today's water usage (Pi-mentel, et al. 2004).

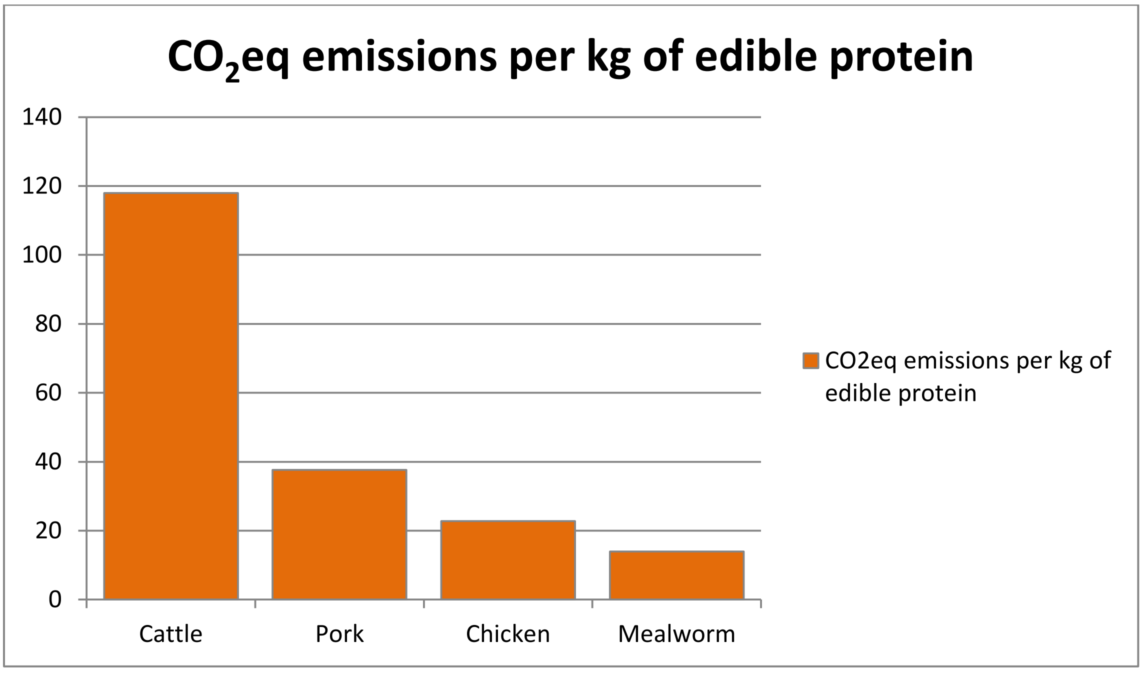
Producing of 1 kilogram of animal protein uses 5 to 20 times more water than generat-ing 1 kilogram of grain protein (Chapagain and Hoekstra, 2003). Chapagain and Hoeks-tra estimate that 1 kg of beef requires 22,000 liters of water, 1 kg of pork 3,500 and 1 kg of chicken 2,300. Unfortunately the water volume required for a similar production of edible insects is not available. It is safe to assume thought, that the production would need less water during the whole production cycle as mealworms/crickets are both more drought resistant and the amount of feed they need is lower (FAO,2014).

3.5 GHG emissions and GWP

Another important aspect of getting our plates greener is the greenhouse gases emitted during the whole production cycle. GHG emissions are a commonly used metric for understanding the pollution a certain product is causing and by comparing insects' ecological footprint with the most common livestock species one can see a different, yet important and often overlooked section where insects shine again. According to Steinfeld et al. 18% of all greenhouse gas emissions is due to livestock rearing.

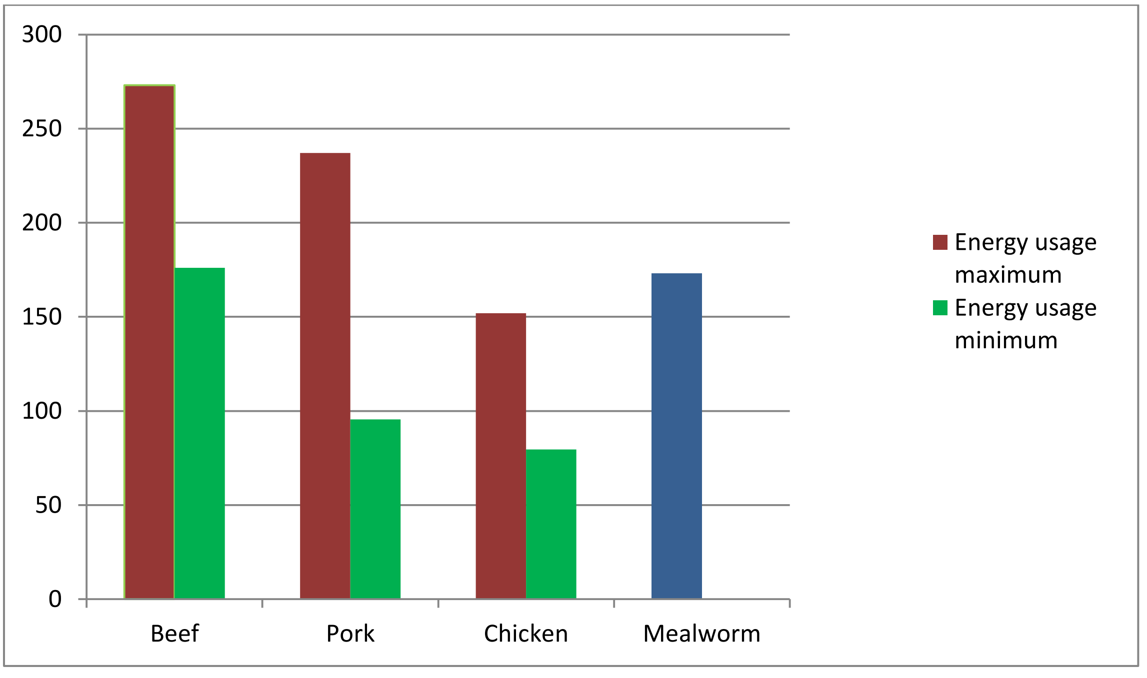
Global warming potential (GWP) is expressed here in CO_2 equivalents, which is the sum of total emitted CO_2, CH_4 and NO_2. CO_2 equivalent (CO_2eq) is a commonly used metric. CO_2eq takes carbon dioxide as the base level of having of 1, methane has a CO_2eq of 25 and Nitrous Dioxide has a CO_2eq of 289 (Oonincx et al. 2012). Mealworms do not produce any NO_2, which is the largest pollutant in livestock rearing by far (source). The total CO_2eq of mealworm production per kg of edible protein is 2.65kg. Besides the pollution the production of mealworms cause this number also takes into account the impacts of feed production and as such is an accurate number describing the total life cycle emissions of mealworms (Oonincx et al, 2012).

Chart 2: CO_2eq emissions per kg of mass gain for beef, pork, cricket and meal-worm (Oonincx et al, 2012).



3.6 Energy usage

Chart 3: Energy Usage per kilogram of edible protein in Mega Joules (Oonincx et al, 2012).



The energy usage of mealworms per kilogram of produced product is higher than chicken on average, similar to pork and lower than beef (Oonincx et al. 2012). This data takes the processing of the insects, transportation of feed, water usage, energy use and natural gas use into account. Mealworms are poikilothermic (meaning their internal temperature varies according to the ambient temperature) and therefore suitable temperatures for their growth and development need to be adjusted more. When temperatures would naturally be low mealworms require heating which in turn increases energy usage.

4 Insect farming

Insect farming closely follows the basic needs of traditional livestock rearing. The species used need a steady access to feed and water. The physical conditions of the farmed species need to meet certain criteria for optimal production rates. The farming area needs to be secluded so that no introduction of micro-organisms from the surrounding environment gets introduced. The most researched and seemingly interesting species from western perspective for human consumption are mealworms and crickets.

4.1 Minilivestock sector – a field to be developed

Traditionally livestock sector has been the farming of cattle, poultry, pigs, goats, sheep, llamas and there has been little interest in incorporating new species for rearing. However, when the world is becoming more aware with the environmental impacts of traditional rearing practices new ways to grow protein for human consumption is looked at in more and more places. Insects seemingly fit this up and coming niche: production requires less space, has high reproducing rates, can create cash flow in short periods of time, efficient conversion of energy to protein, relatively easy to produce and are relatively easy to manage (FAO, 2011b). Minilivestock refers to animals under the weight of 20kg and that have economical or nutritional benefit. Minilivestock animals can be both invertebrates and vertebrates (Hardouin, 1995).

4.2 Semi cultivation of insects

Semi cultivation of insects means cultivation in open areas out door that often require more labour and skill to increase the availability of a wanted species. Mexican Caviar (the eggs of Ayahuatl water bug) is an example of this. The impacts semi-cultivation has on the ecosystems is under study, as providing different insect species with better breeding grounds can affect other unwanted species to thrive as well. Unwanted side-effects aside semi-cultivation is often means for a low income family to produce extra income for their families and thus is a welcome practice for many who are lacking everyday needs.

Mexican Caviar is a term used to refer to the eggs of Ayahuatl, a water bug in the region. Its’ cultivation is done by piling sticks and rocks on shallow water to attract the laying of eggs in the pile. These piles are paced approximately 1 meter apart from each other and the eggs are then collected during the appropriate season.

4.3 Farming of crickets and mealworms

4.3.1 Mealworms (*Tenebrio Molitor*)

Tenebrio molitor lifecycle is 3 months during which they go through 4 stages: from eggs to larvae to pupae and then beetle. Mealworms are easy to farm, maintain and require little input because they live in their substrate rather than on it. The reproduction of mealworms is very high: one female *T. molitor* produces 160 eggs in their lifetime of 3 months (Oonicx and Boer, 2012).

Large scale farming of mealworms is rather simple. It is done in containers of various sizes, in a climate controlled rearing station. The mealworms with their substrate are held in cages until their size is optimal for collection. They are then put through a sieve which separates the insects of different sizes: small worms which go back to the rearing station, optimal sized worms which are cleaned and are ready to be used after killing, then breeder animals which are at pupae stage (cocoons) are separated into a different cage. After hatching the breeder beetles produce eggs that are separated when they start to appear and put into the rearing chamber. Whenever there are dead breeder animals in the breeder chamber they are removed (Oonincx et al. 2012). Appendix 1 shows a picture diagram of the process.

The cages used in the rearing chamber are cleaned every 2-3 months to keep the rearing station clean and prevent possible complications in the process. The feed for the worms is constantly kept at 4--6cm height. For feed mealworms can use a wide variety of material, commonly carrots and cereals. Mealworms require a temperature of over 24°C and often 28–30 °C is the temperature used. The relative humidity in which mealworms perform well is 60%.

Harvesting of mealworms is done before the larvae reach pupal stage because at that point they start losing their bodyweight (A.E. Ghaly et al. 2009). For efficient production of mealworms the larvae should be collected when they are about 100-110mg in bodyweight for maximum efficiency, this bodyweight is achieved at 8-10 weeks of age.

After deemed ready for harvesting the insects are starved for 24 hours so that they will excrete all their feces before putting them in a freezer, which finally kills them without unnecessary pain.

Picture 3 A bowl of mealworm (Pengo)

4.3.2 House Crickets (*Acheta domestica*)

Cricket farming, while not widely spread in Europe has a strong presence in Thailand. Currently some 20 000 cricket farms exist in the nation producing up to 7 500 tons of crickets annually in 2011 (Hanboonsong et al. 2013). The house cricket, *Acheta domestica*, is easy to farm, apart from their escape attempts, and can produce from 6 to 7 generations per year. It is omnivorous and can eat a large range of organic materials. Production is feasible at temperatures higher than 20°C, the ideal temperature being 28-30°C. 2000 insects can be bred on 1 m² (Hardouin et al., 2003).

The crickets are farmed in breeding containers typically made from concrete, plastic or plywood:

The concrete pens are the most used for the farming and can produce up to 20 – 30 kg of crickets. The size of a typical pen is 1.2 x 2.4 x 0.6m. The crickets in concrete block pens are subject to possible overheating as the concrete doesn't allow air to flow and the crickets in them are very crowded. The pens are suitable for medium to large scale production. A typical cricket farm in Thailand has anywhere from 5 to 100 of these pens (Hanboonsong et al. 2013).

Picture 4 deep fried house crickets (Takeaway)

Plywood pens are typically 1.2 x 2.4 x 0.5m in size and can produce 20-30 kg of crickets. The bottom section of a plywood pen is elevated from the ground so the units are more mobile than their concrete counterparts. Because of this they are also easy to clean and do not produce as much heat. As a downside though, they deteriorate faster and are subjectable to dampness (Hanboonsong et al. 2013).

The plastic containers are made from plastic sheet and are typically 0.8 x 1.8 x 0.3m in size, producing 8-10kg of crickets. They need very little space as they can be stacked on top of each other. Typically 3 or 4 containers are stacked in a cricket farm. The plastic can deteriorate quite fast and needs replacing often they are also subject to overheating, which leads to high mortality rate for the crickets (Hanboonsong et al. 2013).

The stridulating (rubbing their hind legs together to produce the familiar sound associated with crickets) of the male crickets works as a signal to indicate the females are ready to lay eggs. When this starts to happen, bowls of husk and sand is added to the pens for the female crickets to lay their eggs in. The egg-laying happens in a 7-14 day period. The eggs are moved to another breeding tank that works as incubation and hatching platform. After the mating period the crickets are ready to be collected, typically 40-45 days into their lifecycle.

The cost of each harvest cycle comes from the fixed costs of breeding materials, from plastic bottles, egg cartons and tape to the main cost of insect feed. About two thirds of the whole production cycle cost comes from the feed of the animals (Hanboonsong, 2013).

5 Legal issues and the legislation related to insect rearing in EU

The farming and production of insects as food or feed border many different regulatory areas from product quality to the environmental impact of insect rearing. These areas include legislation, standards and other regulatory mechanism both on international and local level.

Often the legislations in place describe the maximum limits of insect traces certain foodstuff are allowed to have. Examples including: grains, flour, nuts, fruits, spices and chocolate.
The following points are listed as barriers for establishing a business in insect farming in Europe by Food and Agriculture Organization of United Nation in their 2014 report:

- No real clarity on legislation regarding the farming and selling of insects as food items for human consumption.
- It is hard to understand the national and international information regarding processing and quality of insects and that there is little to no cooperation between producers as well as a lack of need for large quantities for insect protein in developed countries.
- Low awareness of consumers regarding insects as food which in turn means lack of demand.
- The general perception of insects as pests and unsanitary.

5.1 The main European regulations relating to insect rearing

According to FAO the following regulations are the main ones concerning the rearing of insects for human consumption.

Due to regulation EC 999/2001 the use of insects as a protein source for animal feed for animals reared for human consumption is not allowed. This regulation however does not prohibit the use of insects in pet food (EU directive 999/2001 and FAO 2014). This is closely related to bovine spongiform encephalopathy (mad cow disease, BSE), which is a disease that affects the brain and nervous system of infected animals. A large outbreak took place in UK in 1987 when cattle were fed remains of other cattle. As insects are considered as farmed animals their usage as feed is prohibited as by product of this directive aimed to prevent new outbreaks of BSE (Tara Smith, 2005).

As insects are reared for processed animal proteins (PAP) they are considered as "farmed animals" and therefore using manure and catering waste as their feed is prohibited under the EC regulation 1069/2009 (Minerva Communications UK ltd.).

5.2 Novel foods

Novel foods are categorized as foods that are considered conceivably hazardous to consumer health because of new, unknown elements they might contain. This makes them subject to pre-market controlling within the European Union and other countries. The European Novel Food Regulations (EC No.258/97) is applied to food products and ingredients that have not been used much for human consumption in the EU area. This means that food products that have been consumed safely elsewhere for millennia, be it vegetables, berries, fruit or insects are novel food products and need the proper authorization to enter the market which often is costly and time-consuming (Lähteenmäki-Uutela, 2007).

Insects are regarded as novel foods because no member state of EU has been able to confirm their usage as food before the year 1997, when Europen Novel Food Regulation was first implemented (Evira, 2016). This part of the Novel Food Regulations has been under criticism as foods that are and have been considered safe in other parts of the world for a long time will need excessive permits to enter European market. "History of knowledge" is not applied to food items that come from outside EU (Lähteenmäki-Uutela, 2007).

Thus: insects are being considered as novel food and this greatly hinders their entrance to European market.

The European Novel Food Regulation is being looked upon more loosely in some European countries than others. In Netherlands for example the production of insects is being done by a couple of businesses but to get to the production point a special permit from the European Comission is needed (Mentioned in Aamulehti, read about It elsewhere, still needs proper source).

Leia Magazine interviewed Santtu Vekkeli who gives estimates that getting insects through the troublesome novel food regulation would require an input of €15 million for the proper permits (Johanna Leppänen, 2015). This amount when reflected upon European agricultural subsidies of €50 000 million or Finnish subsidies of €2 000 million is a tiny fraction and proper interest in the field could easily allocate needed funds for the permits.

5.3 Legal situation in Finland

Currently insects are not regarded as a valid food source for humans. The production, selling, marketing and importing of insects for human consumption is prohibited until the consumption of relevant species/products has been proven to have occurred in Finland in the past or until the species in question is accepted as a new food commodity, instead of being treated as novel food (Evira, 2016).

The legal system will not, however, interfere with individuals who on their own risk decide to consume insects.

5.4 Legal situation in US

The US insect rearing business has similar legislative difficulties than European: for example animals can’t be slaughtered in the farm so a separate slaughter house for the insects is needed which, according to Hal Hodson, 2014, is totally unnecessary. Getting a permit to use insects in animal feed needs permission from U.S. Food and Drug Administration (FAO, 2014).

6 Creating a working system in Finland

The creation of an insect farm in Finland is currently pretty much impossible. Legislation both in EU and in Finland make it illegal to start producing insects for human consumption or even as feed for animals.

6.1 Existing businesses in Finland

There are two businesses in Finland currently working on insect rearing:

Entocube, a Finnish start-up that produces controlled atmosphere shipping containers that can be operated manually to produce food-grade edible insects. The system is very flexible and the temperatures and conditions can be altered to fit different insect species. There is also an option to automate the process for less manual labour.

Nordic insect economy: they are Finland's first entomology corporation. They aim to raise insects in ethical environment attending to environmental and social consequences. They offer starting solutions for insect farming for small to medium sized farms. They offer combined safety, quality, efficiency and ethical practices geared towards small and medium sized businesses using the best products available in the current market. Currently they are looking for interested parties outside of Europe to start insect rearing businesses, also providing them with consulting.

6.2 Approximate cost of functioning insect rearing system

The cost of creating an insect rearing operation that would yield 1 ton of insect protein on a monthly basis is dependent on a lot of factors. According to Kevin Bachhuber, the founder of Big Cricket Farms in the USA, the space needed for an operation of this size is roughly 500m^2. The cost of filling this area with insect rearing equipment, enough to keep sustaining the yield of 1 ton/month is roughly 150,000$ when producing mealworms. This calculation does not take into account local differences in prices and can vary greatly, but this is only an estimation on the possible costs of an insect rearing system.

7 DISCUSSION

In chapters 1-6 I have given a broad look into how insects are consumed globally, what their environmental impacts are and the current legislative problems.

7.1 A change needed

To support and encourage the industrial-scale insect farming plants' development not applicable quality and safety data needs to be accessible in a way that relevant current legislations and regulations in place can be reviewed. The existing agricultural subsidies need to be applied to also cover the farming of insects. Currently large amount of the subsidies are going towards livestock rearing. This has to change in the coming years anyway, as it is simply unsustainable to encourage the excessive farming of livestock, especially of cattle. A good start would be to allocate enough funds in to changing the novel-food situation of insects within the EU area, as briefly mentioned in chapter 5.2.

7.2 Finland as a forerunner in the field

As the whole industry surrounding insects is currently just starting to come to fruition Finland could be a forerunner in the field if necessary changes to legislation was to be made. There are examples of great success from other parts of the world where the practice is not as regulated as in Finland and Europe. The studies and statistics are showing very promising numbers for the insect farming as seen in chapter 3. and in the light of this starting a thriving business model in the field could prove to be a new Nokia-like success story. In Chapter 6.1 relevant existing businesses in Finland in the field are listed.

Examples of recent success in other continents in the field of edible insects can be seen. South-African company called Agriprotein has received funds of 11 million into starting their business (Packham, 2015). While 11 million is not a huge sum it is still a signal that financial sector is getting interested in the field. In Thailand there is currently 20,000 registered cricket and grasshopper farmers and the amount of protein they produce increases by the year as their farming practices get more advanced and more automated (Hanboonsong, 2013).

Insect farming in Europe is currently in the phase of innovation. There are possibilities but the way forward is rocky and needs pioneers in the field to fight through the obstacles. Starting to focus on this field now could be very beneficial as there is not much competition in the field. Typically in marketing early adopters and innovators are the ones who will be getting most out of a new business field.

7.2.1 Insect food stalls

Currently in Finland in many festivals during the summer there are stalls that provide the festival goers with insect burgers (mainly cricket or mealworm). To go around the legislative barriers the insect burgers are apparently not sold to be eaten, but as decorative objects that a person can choose to eat if they so wish. The Finnish law does not prevent any individual from consuming whatever they seem safe (Evira).

7.3 Attitudes

“There is a fly in my soup” a widely used phrase that effectively describes attitudes people in the western world currently have. Even the idea of having an insect in your plate makes some people repulsed enough to demand refunds for their food or simply makes them lose their appetite. Granted having something in your food that is not supposed to be there is not what one would want anyway. One way to tackle the attitudes is to introduce insect products that are aesthetically appealing and do not provoke the repulsion factor. Ground mealworm used in burgers or protein bars could be such an item and therefore better introduction of products that will look appealing to the consumer will be beneficial in creating new thought patterns on the topic. Having eaten one item of similar origin and enjoyed it will make the eater more likely to try the next one similar in content (Nordic Food Lab, 2012).

Shrimps and lobsters used to be considered as food for poor people. They have now become delicacies eaten around the world in high-class restaurants. Shrimps and lobsters are arthropods which is the phylum that insects also derive from and the fact that they have become so widely accepted speaks of the willingness to change palates when given enough time.

There is no data currently on the acceptance of eating of insects done on Finnish people. However, a study done in 2013 in Belgium by Megido et al. on local people showed promising numbers for people willing to participate in entomophagy. Roughly 200 out of 389 visitors to the insectarium where the experiment was conducted participated in a questionnaire about entomophagy. Out of these 200 respondents 46,6% had a negative attitude towards eating insects, yet 77% were willing to taste crickets and mealworms that were prepared for them. (Megido et al. 2014)

7.4 Media attention

The attention of the media has been grabbed by an increasing interest in insects as a possible food source for humans. Both Helsingin Sanomat and Aamulehti (Finnish major news papers) have featured a large article on the subject.

Helsingin Sanomat on 3th of April 2016 featured an article on their monthly attachment: eating insects would save the world – how do they taste? And Aamulehti on 21st of April featured an article: “Would you like to have a roach or a cricket?” This attention that media is giving to the subject is also educating the public in the matter in a very efficient way paving way for future as legislations start to allow the farming practice.

Not only Finnish newspapers are starting to write on the topic. Feednavigator.com writes in their article: “the process towards adaptation of insect protein in feed in the EU is already underway” about the legislative problems currently faced in the field and how the situation is progressing. CNN, American scientist and BBC write about insect farming in a very positive way. “Could insects be the wonder food of the future” says the headline of an online article for BBC and the articles from other major newspapers follow the same pattern. Insects are seen and understood as a potential way of improving the global food industry.

7.5 Some scepticism

Lucy and Parnella (2015) conducted a study where insects showed a similar feed conversion rate when fed the same type of feed than poultry. Also in their study the emissions followed closely on the same levels. This would suggest that the insect rearing might not be as good in all sectors as many other studies show, but perhaps mostly reflects on the small amount of studies done on the field. More studies in varying conditions, both in and out of laboratory are needed to get more reliable results and understanding in the subject area. Also worth noting that when looking at the data provided in chapter 3 it is always poultry that is the closest in terms of needed resources in the production from feed to protein. Therefore thinking that insects are similar to little bit more efficient in feed conversion rates than chicken is not a stretch and is supported by most researches.

8 Conclusions

Insects for human consumption have been considered as inferior food sources in Europe as discussed in chapter 2. In today's approaching food crisis however taking a look at the nutritious values of different food items and their environmental impacts it comes clear that insects hold potential for providing global population with more sustainable animal protein as seen in the charts and tables of chapter 3.

Mealworms and crickets combat traditional livestock in nutritional compositions and their environmental impacts are far lower than that of beef, chicken and cattle. When looking at the numbers in chapter 3 the most notable differences are feed conversion rates and CO_2eq amounts. In CO_2eq the difference between mealworm and cattle is roughly 200 times less emissions in the whole production cycle. The feed conversion rate of crickets is 12 times more efficient than that of cattle. This difference is huge and has implications that turning to insect rearing agriculture could lessen the amount of land needed and the burden on environment by large numbers.

The farming of both crickets and mealworms is rather simple and only requires bins for the animals, feed and separate breeding containers. When atmospheric conditions are met the production of good quality protein takes only one and a half months.

The attitudes in western world are currently a little negative towards the eating of insects. But as people are becoming more and more informed and knowledgeable about the issue they seem to be willing to participate in entomophagy as the Belgium study in 2013 by Megido et al, demonstrates. Finnish newspapers have written about entomophagy in their articles in 2016, and the various insect burger stalls seen in the summer time, are great ways to promote insects as an alternative protein source. And in removing negative attitudes and disgust factor from the population this kind of groundwork is necessary.

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APPENDICES

Appendix 1. Mealworm production system (Oonincx et al. 2012)