

Identifying Opportunities to Produce and Market Snail Caviar in the Thessaloniki Region



WPI

Meet the Team

Student Team

Paul DeMarco

Timothy Bill

Lily Randle

Patrick Kroyak

Sponsor

Dr. Evangelos Vergos

Advisors

Robert Hersh

Michael Elmes





Abstract

Snail caviar is a luxury food item that has seen growing interest across Europe. The American Farm School (AFS) in Thessaloniki, Greece has begun trials to produce a snail caviar product to introduce to the Greek market. There are limited resources available regarding information on snail caviar production, and the AFS is trying to establish a protocol for this practice that can be used by future snail caviar farmers. Our team worked with the AFS to develop a preliminary design for their new snail farm, and to gauge the market for snail caviar in the Thessaloniki region through interviews. We recommended a design snail farmers could adopt for snail caviar to supplement their current snail meat production. We also made recommendations on how to introduce snail caviar to the market in Greece.

Authorship

The team worked together collaboratively throughout the project, looking for feedback and insight from our supporting team members. However, we designated specific team members to write specific sections where their specific knowledge would be best utilized. Each section and its original contributing members are outlined below. It is important to note that each member read through every section and contributed to the editing of each section of the paper.

Abstract:

All

1. Introduction:

All

2. Background

2.1 New Farmers in Greece

Tim

2.2 The Growing Interest in Snail Egg Production

Patrick

2.3 Types of Farming

Lily

2.4 Effective Farming Techniques

Lily

2.5 Egg Harvesting

Patrick and Lily

2.6 Laws Regarding the Production of Snails and their Eggs

Patrick

2.7 Snail Caviar Markets and Marketing

Paul

2.8 Snail Farming at AFS

Lily

3. Methods

3.1 Assessment of the Current Snail Farm at the American Farm School

Lily

3.2 Viability of Snail Egg Production

Tim

3.3 Identify the Market for and Consumers of Snail Caviar in Thessaloniki

Patrick and Paul

3.4 Redesigning the American Farm School's Snail Farm

Lily and Paul

4. Findings

4.1 The current snail farming facilities at the AFS are capable of producing snail caviar...

Tim and Lily

4.2 Snail farmers are hesitant to invest in snail caviar production due to their previous experiences...

Tim and Lily

4.3 Many snail farmers in the Thessaloniki region ...

Tim and Paul

4.4 The farmers formed the Snail Farmers' Cooperative of Greece ...

Paul and Patrick

4.5 Snail caviar should be sold as a seasonal product...

Lily and Tim

4.6 Snail caviar will need to be presented to the public by a respected restaurant...

Tim and Patrick

4.7 Limitations

Patrick and Lily

5. Design

SOLIDWORKS designs

Patrick

Floor Plan

Paul

Calculations

Tim

Innovations

Lily

6. Conclusion and Recommendations

ALL

Acknowledgments

We would like to thank the following people for their invaluable help on this project:

Dr. Evangelos Vergos for all of his guidance and help in setting up our interviews.

Mr. Petros Evangelou for taking the time to show us the AFS snail farm and teach us about the practices used by the AFS. Also for bringing us to various snail farms around Thessaloniki.

The Perrotis College food technology department.

All of our interviewees for taking the time out of their busy schedules to assist us in our research.

Professor Robert Hersh and Professor Michael Elmes for all of their guidance and patience during the entire course of the project.

This report represents the work of WPI undergraduate students submitted to the faculty as evidence of completion of a degree requirement. WPI routinely publishes these reports on its website without editorial or peer review. For more information about the projects program at WPI, please see <http://www.wpi.edu/academics/ugradstudies/project-learning.html>.

Table of Contents:

Introduction	1
Chapter 2: Background	2
Chapter 3: Objectives	15
Chapter 4: Findings	20
Chapter 5: Design	31
Chapter 6: Conclusion and Recommendations	42
Work Cited	45
Photo Sources	54
Appendix A	56
Appendix B	58
Appendix C	59
Appendix D	60

List of Figures and Tables

Figure 1: Graph of Greek Employment	2
Figure 2: Graph of Those Willing to Move	2
Figure 3: Outdoor Snail Farm in Northern Greece	3
Figure 4: Outdoor Snail Farm	4
Figure 5: Indoor Snail Farm	4
Figure 6: Snail Laying Eggs	6
Figure 7: Eggs Being Cleaned at Perrotis College	8
Figure 8: Marketing Process	10
Figure 9: Sushi	11
Figure 10: Snail Egg Pots	12
Figure 11: Sketch of Snail Tables	13
Figure 12: Building for Snail Farm at AFS	14
Figure 13: AFS Logo	16
Figure 14: Snail Farm Outside of Thessaloniki	17
Figure 15: Chef Interview	18
Figure 16: Outdoor Snail Farm at AFS	20
Figure 17: Thermometer and Barometer in Farm	20
Figure 18: Indoor Snail Caviar Farm	21
Figure 19: Indoor Snail Caviar Farm	21
Figure 20: Cold Pasteurizer	22
Figure 21: Snail Caviar in Brine	22
Figure 22: Snail Shell Comparison	24
Figure 23: Snail Farm After Feed	25
Figure 24: Cleaning out the Snail Habitats	30
Figure 25: Exterior View of Snail Farm	25
Figure 26: Left View of Snail Farm	32
Figure 27: Right View of Snail Farm	32
Figure 28: Floor Plan of Snail Farm	33
Figure 29: Fiberglass Batts	34
Figure 30: Spray Foam	34
Figure 31: Mineral Wool	34
Figure 32: Magnifying Lamp	36
Figure 33: Collection Room	36
Figure 34: Stereoscope	36
Figure 35: Solar Panels	37
Figure 36: Snail Eggs in Soil	38
Figure 37: Egg Carton	38
Figure 38: Sponge	38
Figure 39: Cotton Wool	38
Figure 40: Modular Snail Farm	39
Figure 41: Modular Breeding Table	41
Table 1: Indoor vs. Outdoor	5
Table 2: Design Considerations	19
Table 3: Climate Requirements	34
Table 4: Insulation Comparison	34
Table 5: Cost of Snail Farm	35
Table 6: Modular Snail Farm Cost	40

1. INTRODUCTION

The American Farm School (AFS) and its tertiary education division, Perrotis College, are investigating how to produce and market snail caviar as a way to help current snail farmers identify new marketing opportunities and diversify their revenue streams. Snail farmers are currently farming snails solely for the meat which is leading to a greater supply than demand in the Greek market (personal communication, Evangelo Vergos, March 16th, 2017).

Snail farming to produce meat has a relatively low barrier to entry given the simple materials required to build a snail farm. Additionally, these materials are available at a low cost compared to the material needs of other types of farming (USDA, 2016; Duggan, 2016). However, the market for snail meat in Greece has become saturated due to the number of farmers producing the product; farmers do not have a large enough income to support themselves (V. Vergos, personal communication, March 16th, 2017). Some farmers formed the Snail Farmer's Cooperative of Greece to compensate for this saturation and for the lack of demand for snail meat in the Greek market. Through the cooperative, snail farmers have the ability to export their products to foreign markets where the demand is higher (personal communication, Alaveras Konstantinos, April 10, 2017). Meanwhile, the market for snail caviar has steadily increased over the last decade, especially among countries in the European Union (Bronzi, 2014). Snail caviar can sell for €65 per 30 grams. Despite this high price, many news outlets and food reviewers believe snail caviar, due to its unique appeal, will increase in demand.

The American Farm School has farmed snail caviar for the past six months to identify best practices for snail caviar production and to transfer this knowledge to current snail farmers to help them increase production. Currently, the AFS is harvesting limited quantities of snail caviar and experimenting with different processing methods to decontaminate the eggs. The ultimate goal is to transfer this technology to regional snail farmers, but the AFS must first improve production methods by redesigning the environment in which its snails are raised, and second, assess market opportunities.

The goal for our project was to develop a successful method for producing and marketing snail caviar that is feasible for snail farmers to adopt. We worked with the AFS experts to optimize snail caviar farming techniques and snail caviar cleaning processes, and interviewed snail farmers in the region to understand how they might add snail caviar production to their existing farming practices. We interviewed hotel chefs to determine their interest in using snail caviar on their menus, and to identify market opportunities for snail caviar. We created a series of designs for indoor snail farms and gauged the market opportunities for snail caviar through research and thematic interview analysis.

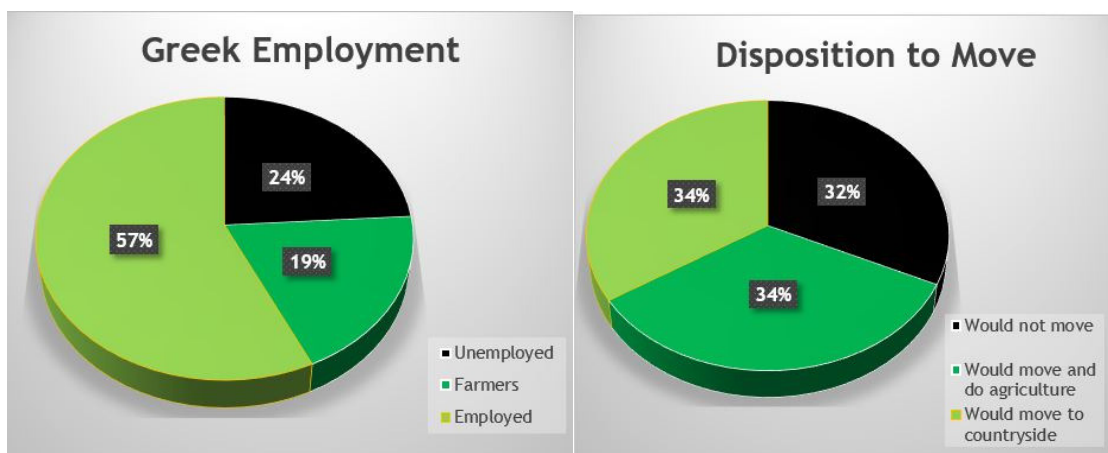
2. Background

2.1 New Farmers in Greece

Farming is an important aspect of the economy in modern Greece. Farmers currently make up 25% of the active working population in Greece, the most among EU members (Agricultural Census, 2012). In the wake of the Greek economic crisis, many urban residents lost their jobs and turned to farming to earn a living or to supplement their incomes (Moss, 2012). As of January 2017, 23.5% of the working age population are unemployed, which totals roughly 1.1 million people (Trading Economics, 2017). The movement of people back to farming has been called farmitization, a phenomenon in which new farmers commute from cities to villages to farm family land. Small scale farming is dominant in Greece because most farmland is family owned and has been passed down from generation to generation (Daudon and Vergos, 2015 p. 4).

New farmers are classified as farmers of any age who have no prior experience in agriculture or have been employed for at least 10 years in a non-agricultural occupation (Sutherland, 2015). The new farmer classification contains a higher percentage of college educated individuals than previous groups of Greek farmers (Sutherland, 2015). A study done by the Kapa Research group that surveyed people in Thessaloniki and Athens revealed that 68.2% of respondents said they were willing to move to the countryside. Additionally, of that 68.2% half stated they would be involved in agriculture. 60.1% of those willing to leave the city have college degrees and 25.4% have postgraduate degrees (Educated Young Greeks, 2012).

The European Union's (EU) goal is to keep farmers in business through the Common Agricultural Policy (CAP). The CAP assists farmers by letting them apply for a financial aid package based on their land usage. In Greece, a small scale farmer (with a plot size between 0.3 and 10 hectares) can receive a payment up to €1,250 via an application in which the farmer documents their land usage and farming practices and can be renewed yearly (European Commission, 2015). Farmers are eligible for payments if they are using their land for "the rearing of animals or growing of agricultural products" as evidenced by their application for payments (European Commission, 2015). The CAP also assists new farmers under the age of 40 by providing a supplement of an additional 25% of the basic aid payment the farmer received. This additional supplement lasts for the first five years of their operation (European Parliament, 2015).



Figures 1 & 2:: Graph of Greek employment (Unemployed, farmers, and other employed), and graph of those willing to move to farm

2.2 The Growing Interest in Snail Egg Production

Snail farming could provide a possible solution to some of the problems farmers face. From the issue of limited space, to startup costs, to effective marketing, snail farming provides prospective farmers with an attractive option. Snail farms take up little space compared to other livestock; the costs can be relatively low on startup. Snail farmers can form cooperatives to pool resources, reduce costs of processing, and increase their profit (personal communication, Alaveras Konstantinos, April 10, 2017). Snails have been farmed since Roman times, with mention of farming in the Roman historian Varro's "De Re Rustica III" (Varro, 37 BCE).

The farming of snail caviar, although known in antiquity, is not well known in contemporary Greece. However, in other parts of the world snail caviar is making a comeback. In 2011 for example, one Spanish snail farmer produced over 110 pounds of snail caviar in his first year of production, and expected an increase in demand in coming years (Alexander, 2011).

The estimated price of €80 per fifty grams of caviar is attractive to farmers already producing snails (AFP, 2015). Proponents of snail caviar laud its earthy flavors and are aiming to spread the idea of snail caviar as a food by bringing samples to chefs and food fairs (Alexander, 2011). Snail caviar is sold to both restaurants and private consumers for use as a fancy party hors d'oeuvre (Sage, 2009). Some companies have taken to selling the caviar online in an effort to better reach potential consumers (Blanc Gastronomy 2015).

Figure 3: Outdoor snail farm in Northern Greece





Figures 4 & 5: Outdoor snail farm, indoor snail farm

2.3 Snail Farming and Snail Caviar Production

Scientifically known as heliciculture, snail farming is popular around the world, especially for escargot. According to a journal published in Australia, outlining the techniques necessary to start a snail farm for the species *Helix aspersa*, most snail farmers in Europe begin by harvesting snails directly from the wild. The largest snails should be collected. The best time to find these snails is after precipitation and in areas rich with alkaline containing plants. It is important to note that the snails are under a lot of stress during this relocation, and many snails may die off in the first few days (Murphy, 2001). To begin snail farming, the first decision to be made is determining what type of snail farm is best suited for the snails, the environment, and the farmer. There are two options. The first is an outdoor snail farm, made popular in Italy and known as “the Italian Model”. The second is an indoor snail farm, known as “the French Model” as it was popularized in France (Murphy, 2001). In the table below, both models are compared.

	Outdoor	Indoor
Size	3,000-10,000sq meters of land (Beggs, 2003)	Can vary depending on space available, up to 300 snails per sq meter (Communication, Alaveras Konstantinos, April 2017)
Protection against Predators	Mesh Screening, underground fence (United States 2016)	Resistant floors and walls of the building (United States 2016)
Feed	Natural Vegetation (Beggs, 2003)	Formula feed (Murphy, 2016)
Environment Control	Build structure on an incline to limit flooding (Communication, Snail Farmer, March 2017).	Artificial system to keep humidity around 90% and temperature between 70F and 80F (Thompson, 1996)
Labor	Building the enclosure; limited daily feedings and care (Murphy, 2011)	Building of enclosure,daily cleanings, feeding and care. Snails are more reliant on the farmer (Murphy, 2011)
Benefits	Natural environment, mimics the wild (Murphy, 2011)	Snail farm operates year round
Disadvantages	Snails hibernate during winter (Murphy, 2011)	High costs and labor
Costs	Lower start-up costs and maintenance costs	Higher start-up costs and maintenance costs. Daily costs of running climate control.

Table 1



Figure 6: Snail laying eggs

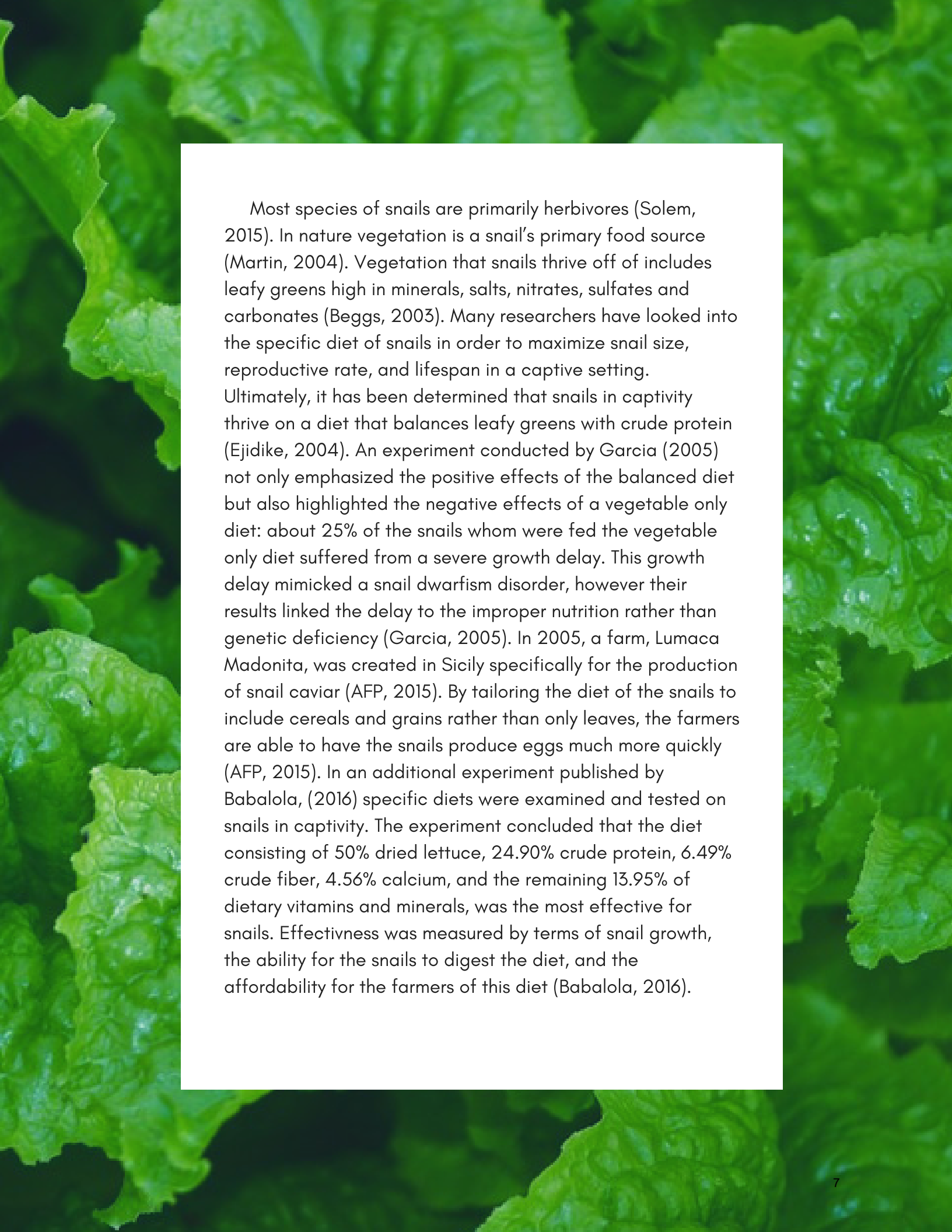
2.4 Effective farming techniques.

In captivity, snails can be specially selected for breeding. Population should be monitored as to limit overcrowding of the snails (Murphy, 2001). Special care should be taken to mix populations of captive snails with new snails from the wild to avoid complications with inbreeding depression. Inbreeding depression is the weakening of genetic material in offspring when related individuals reproduce (Chen, 1993).

The enclosures should be optimized for snail caviar laying by providing loose, damp soil without standing water. It is necessary that the soil contains 3–4% of calcium for the overall health of snails (Thompson, 1998). Additionally, the soil pH should be kept between 6.5 and 7.0 in order to be in balance with the snails biological pH (Ohta, 2011). With respect to bacteria, the soil should also be as sterile as possible (Thompson, 1996).

It is helpful to also sterilize the soil used for the habitat beforehand to limit possible sources of contamination as much as possible. This can be accomplished by steaming the soil to kill any microbes the soil may harbor (Tilley, 2011). Researchers found snails that had their environment cleaned once every two days had a higher survival rate than snails that had fewer cleanings (Marks, 1995). When cleaning the habitat, caretakers must remove waste, dead snails, and freshly laid eggs. If any of these are left in an environment for an extended period of time, they can adversely affect the herd (Marks, 1995).

The environment within the snail farm enclosure should mimic the indigenous environment of the snails. It is key for the species to be in an environment that is at least 20°C to avoid hibernation. However, if the temperature reaches above 30°C, the snail cannot function properly and its biological systems will shut down (Murphy, 2001). Light is also monitored. *Helix aspersa* can maintain a healthy circadian rhythm with levels reaching 18 hours of light and 6 hours of darkness a day (Murphy, 2001). Interestingly, a report by Ohta looked into the effects of light and reproduction. Phosphorus levels in snail gonad tissue are maximized at these light levels. When phosphorus levels are maximized, so is snail caviar production (Ohta, 2011). When it comes time to laying their eggs, snails will dig between 4 and 9 centimeters deep into the soil to make a nest (Murphy, 2001). 6



Most species of snails are primarily herbivores (Solem, 2015). In nature vegetation is a snail's primary food source (Martin, 2004). Vegetation that snails thrive off of includes leafy greens high in minerals, salts, nitrates, sulfates and carbonates (Beggs, 2003). Many researchers have looked into the specific diet of snails in order to maximize snail size, reproductive rate, and lifespan in a captive setting. Ultimately, it has been determined that snails in captivity thrive on a diet that balances leafy greens with crude protein (Ejidike, 2004). An experiment conducted by Garcia (2005) not only emphasized the positive effects of the balanced diet but also highlighted the negative effects of a vegetable only diet: about 25% of the snails whom were fed the vegetable only diet suffered from a severe growth delay. This growth delay mimicked a snail dwarfism disorder, however their results linked the delay to the improper nutrition rather than genetic deficiency (Garcia, 2005). In 2005, a farm, Lumaca Madonita, was created in Sicily specifically for the production of snail caviar (AFP, 2015). By tailoring the diet of the snails to include cereals and grains rather than only leaves, the farmers are able to have the snails produce eggs much more quickly (AFP, 2015). In an additional experiment published by Babalola, (2016) specific diets were examined and tested on snails in captivity. The experiment concluded that the diet consisting of 50% dried lettuce, 24.90% crude protein, 6.49% crude fiber, 4.56% calcium, and the remaining 13.95% of dietary vitamins and minerals, was the most effective for snails. Effectiveness was measured by terms of snail growth, the ability for the snails to digest the diet, and the affordability for the farmers of this diet (Babalola, 2016).

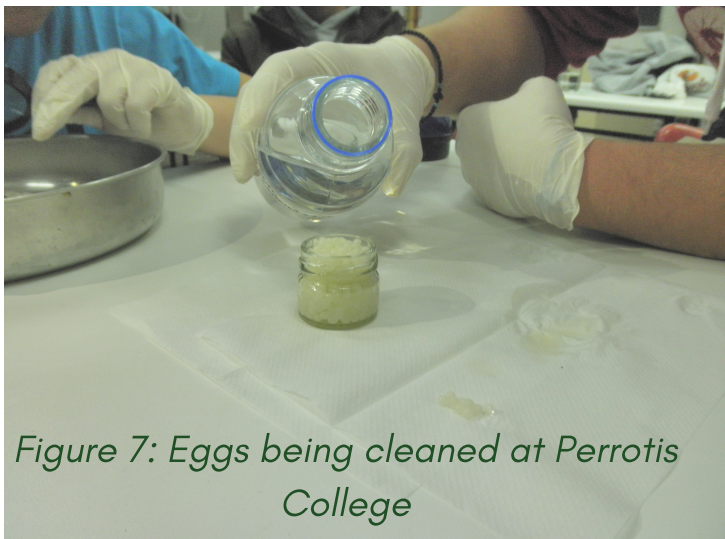


Figure 7: Eggs being cleaned at Perrotis College

2.5 Egg Harvesting

Snail caviar is extremely fragile. In order to remove the eggs successfully from the soil, harvesters must take care to ensure they do not damage the product (Murphy, 2001). Soil and vegetation should be observed for egg masses, called "clutches". Snails leave a layer of slime over holes where they lay their eggs. The slime is used by the young during hatching, however it is a good indication for eggs harvesters as to where the eggs are laid (Thompson, 1996). Eggs can be collected in different methods. The first would be to take the entire breeding box and to remove the soil gently with water. The eggs are then carefully removed and sent to processing (Murphy, 2001). Another method is to sift the soil by running it through mesh screens and using small amounts of water as needed. The mesh screens should have openings smaller than the snail caviar (Eisenburg, 1966). The average individual snail caviar is about 1-2 millimeters in size (Messari, 2014). The third method is extremely time consuming, but allows for maximum egg collection. Once the egg deposits are located in the soil, the harvester will carefully dig through the soil and remove each egg gently with tweezers (Alexander, 2011).

After harvesting eggs need to be sent to processing for preserving. Special care must be taken to ensure that the snail products remain free of harmful microbes from farm to table, such as Salmonella and E. coli (Parlapani, 2014). To begin they need to be washed in order to remove any contaminants. The eggs are then sent to a portable refrigerator, which sterilizes the eggs so they do not hatch (Alexander, 2011). Additionally, snail caviar needs to be cleaned appropriately. One method is for the eggs to be pasteurized which will provide the product with a shelf life of about 6 months. After pasteurization, snail caviar can be stored in a solution of sea salt, citric acid, potassium sorbate, and sodium benzoate. Rosemary can be added to combat the woody taste of the caviar (Messari, 2014). Pasteurization, however, has been noted to degrade the snail caviar quality (Britton, 1987). A solution arrived in 2004 when Chef Dominique Pierru, from Soisson, France, developed a new technique to preserve the snail caviar in such a way that kept qualities that patrons desired in the caviar, by preserving the natural earthy flavors of the product. Rather than pasteurize the eggs, Pierru resorted to "...simply quick-blanching the eggs in a hot bouillon and then curing them in sea salt, starch, citric acid, and rosemary." The result was a safe product that retained the texture and delicate earthy flavor, allowing chefs to add the snail caviar to their menus (Rummell, 2012).

2.6 Laws Regarding the Production of Snails and Their Eggs

A variety of laws govern snail farming for Greeks. Farming of all snail varieties in the European Union is governed by multiple pieces of legislation passed by the European Parliament, the elected, lawmaking body. The European Commission is the executive branch which passes laws regarding general food safety. These two bodies both have legislative powers to enact laws with regards to food production (European Commission, 2016; European Parliament, 2016). These laws dictate that all food products must be fit for human consumption (Regulation, 2002). All enforcement of regulations is allocated to each member state (European Commission, 2004).

The European Food Safety Authority is an organization which is independent of the legislative and executive branches of the EU government, and provides scientific analysis of risks regarding food safety as well as animal welfare. The European Food Safety Authority does not form legislation based on its findings, but attempts to display them scientifically in an impartial manner (Regulation, 2002). The responsibility of forming legislation based on this scientific analysis lies with the European Commission.

The United Kingdom published "Guidance on Producing, Harvesting and Importing Terrestrial Edible Snails for Human Consumption" in 2014, which summarizes the regulatory requirements of the European Union for farmers who wish to produce snails (UK, 2014). The guidance states that the snails must be kept in conditions that limit microbial contamination, and farmers must have procedures in place to deal with any issues that may arise; this includes breakdowns in facilities as well as contamination incidents (UK, 2014). The Hazard Analysis and Critical Control Points (HACCP) plan is a way to systematically prevent hazards in food production. Operators of a snail farm are legally required to develop a plan of action according to the HACCP guidelines (UK, 2014). It has become a standard in both the United States and the European Union, and aims to prevent physical, microbial, and biological contaminants and hazards from affecting food production (HACCP, 1997). The transportation of the snails is also subject to regulatory standards due to the threat of microbial infection. Some bacteria can double their numbers every 20 to 30 minutes, and as few as 10 E. Coli bacteria can cause sickness in humans (UK, 2014). For this reason, raw snail products must be kept wrapped, refrigerated, and kept away from cooked snail products (UK, 2014).

2.7 Snail Caviar Markets and Marketing



Figure 8: Marketing process

The AFS approach to snail caviar production is not only technically focused. Officials at the school are interested in understanding the market for snail caviar in Thessaloniki. It is an expensive product, and the AFS expects upscale hotels, restaurants and high-end delicatessens to be the primary buyers (personal contact, Evangelos Vergos, March 22, 2017).

Marketing is a set of processes for creating, communicating, and delivering value to customers and for managing customer relationships in ways that benefit the organization and its stakeholders (Keefe, 2004). Shown above in figure 2 is a diagram of how the amount of potential consumers narrows when marketing a product. The potential market is the population that has an interest in a product. After evaluating consumers with interest in the product, the population is filtered to become an available market comprised of the consumers who can afford the product. The qualified available market filters the consumer population and the new consumers the firm focuses on makes up their target market. The diagram concludes with the consumers who buy the product; this final population is considered the penetrated market (NetMBA, 2010).

The market for snail caviar can also be considered a niche market; a market that requires promoting and selling a product or service to a specialized segment of a market with the focus of satisfying a very distinct set of customer needs (Oxford Dictionary, 2017). In order to penetrate this segmented market, those that sell snail caviar will need to satisfy this distinct set of needs. When entering a niche market for specialty products, having access to high quality raw material, financial strength, and good firm reputation, are crucial factors when penetrating a market (Toften, 2009).

A great example of a product that exploited a niche market is sushi entering the fast food industry in America. "If ten years ago I would have suggested to launch global fast food that would be raw fish wrapped in black seaweed, people would've said, 'That's crazy, that's impossible'" (Feng, 2012). Contrary to belief, the establishment of this niche product in the U.S was possible, and sushi branded itself within the food industry around the nation (Feng, 2012). Firms selling sushi in the U.S. market focused on a specific segment of the population they were trying to exploit. For example, in the U.S. you can find sushi rolls such as: California rolls, Boston rolls, Texas rolls, and Philadelphia rolls. Each sushi roll offers a taste of a traditional food native to its location. For example, the Philadelphia roll contains the famous Philadelphia cream cheese (Feng, 2012).

This type of branding is an important tactic for establishing a specialty product in a niche market. One company, Beverly Hills Caviar, runs a website that sells a wide variety of caviar brands, and uses the slogan "There is a new game in town" when referring to snail caviar on their website (Beverly Hills, 2017). A catchy slogan is an example of branding and is a great strategy for catching the eye of potential consumers who might normally look past snail caviar. A similar marketing strategy to penetrate the caviar niche market is used by Aylesbury Escargots that sells its snail caviar as "Escargot Pearls" to attract the attention of potential customers (Winter, 2013).

Entrepreneurs that want to exploit the niche market of snail caviar have already begun to target their audience through a similar line of branding. Producers have begun referring to the caviar as "Aphrodite's Pearls," in reference to the Greek goddess of love and beauty (Alexander, 2011). Marketing tactics such as these allow producers to target specific groups of consumers interested in their product.

The relationship between buyer and supplier is a crucial part of the niche market for snail caviar. An article from The San Francisco Chronicle highlights how a small business owner in Northern California marketed snail caviar. The company named "EscarGrow Farms" marketed snail caviar to high-end restaurants (in San Francisco or the bay area) using direct marketing to attract and form close relationships with high-end restaurant chefs (Duggan, 2016). In one case, the company would bring a chef buckets of dirt and clusters of snail caviar to his kitchen to collect and wash the eggs together (Duggan, 2016).



Figure 9: Sushi

2.8 Snail Farming at the AFS



Figure 10: Snail egg pots

Currently the American Farm School (the AFS) and Perrotis College (the post-secondary institution at the AFS) are one of the few farmers beginning snail caviar cultivation in Greece. In 2014, the AFS began farming the snail species *Helix Aspersa Maxima* for escargot. In the fall of 2016, the AFS switched from snail meat production to snail caviar production because they were approached by snail farmers about the lack of profit in the escargot market. Our partner, Dr. Vergos, dean of professional education and extension at the AFS, began to research snail caviar, which he believed might have the potential to bring in a larger profit than snail meat alone once production capacity is secured and a market is established. Currently the production of snail caviar has been undertaken by high school students participating in an after school entrepreneurship program. There are a total of 30 students led by an the AFS graduate and their current teacher, Petros Evangelou (personal communication, Evangelos Vergos, March 16, 2017).

The current snail farm at the AFS that is devoted to snail caviar farming is an indoor facility. The snails exist in colonies of 200 snails per square meter on tables specifically designed for egg collection. The tables are made of wood or metal, and there are small pots of soil available for the snails to use for laying eggs. These pots are the only soil available in the habitat. The pots are able to be emptied daily in order to harvest the eggs that have been laid and keep the soil clean. The building where the snails live is temperature and humidity controlled. The snails are also fed a grain feed that is ground and spread on their habitat. The entire structure is built over a mesh bottom. This allows debris to easily be cleaned off and collected. The snails receive 12 hours of light and 12 hours of dark daily, and the humidity is controlled by a sprinkler system that sprays them with water for 4 minutes every day at 7:00 am. The relative humidity is monitored by a basic humidity sensor. The room is heated by a basic space heater and the temperature is monitored by room thermometers (personal communication, Petros Evangelou, April 5, 2017).

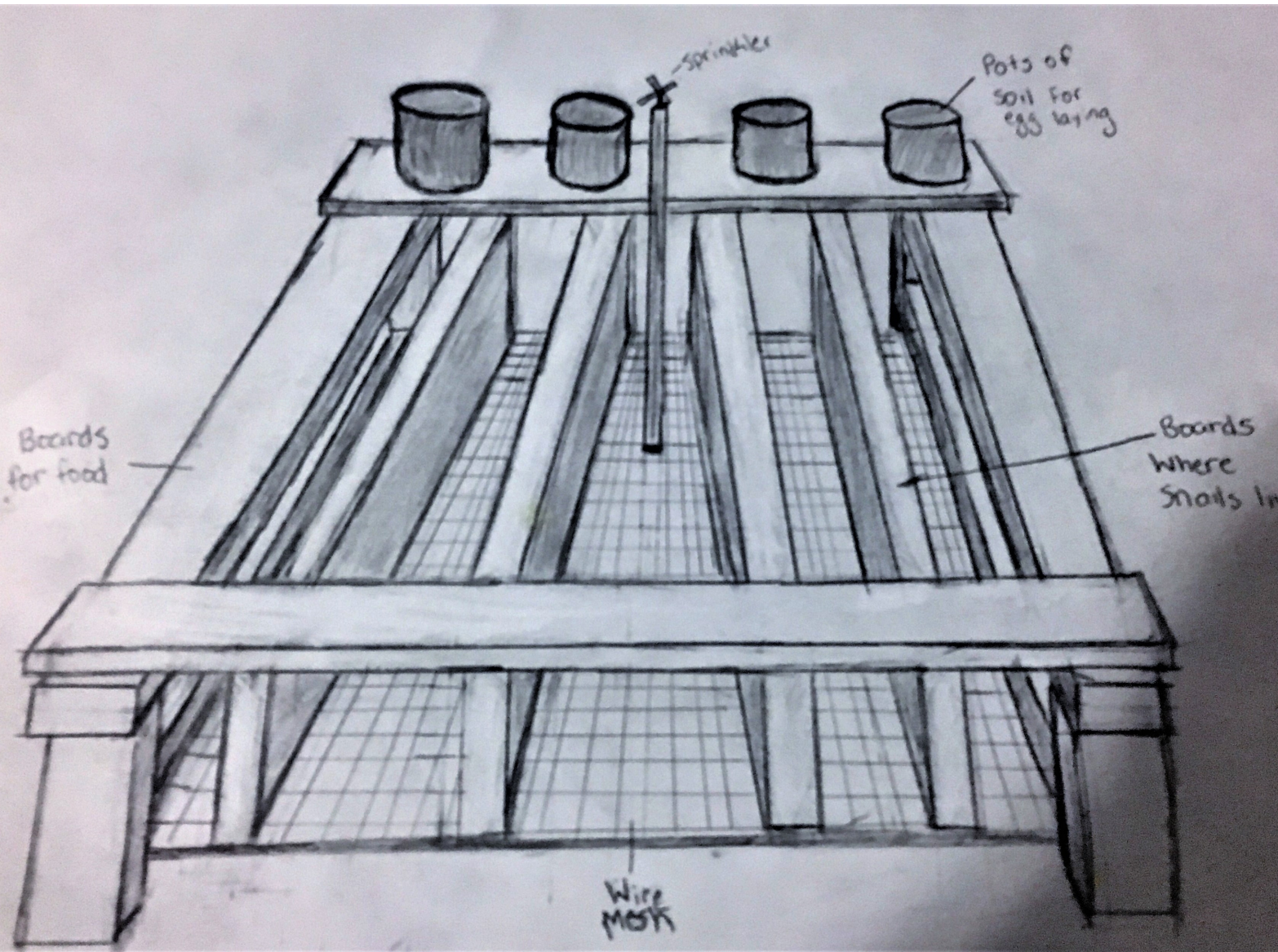


Figure 11: a sketch of the tables the snails live on. The snails live on the wooden boards that run vertically. The vertical boards that are the edge are where the food is placed. The back horizontal board contains soil pots for the snails to lay their eggs. There is wire mesh that forms the bottom of the enclosure for easy cleaning. A sprinkler is in the middle of the enclosure to maintain humidity.



Figure 12: Building to be constructed into snail farm at AFS

The snail farm building will have two separate rooms: one for snail caviar production, and one for collection. Dr. Vergos and Petros Evangelou want our team to design the snail farm as this space will provide a better, and more permanent home for the snails. The building will eventually function as a place to show farmers better ways to farm snail caviar. When designing the building, we will be considering both the ways to keep the environment controlled for the snails, and the replicability of this structure for future snail farmers.

After the snail eggs are collected, they are sent to the Perrotis College food technology department. Here, different methods are being experimented with in order to create a safer product.

The challenges faced by snail farmers, the growing interest in snail caviar, and the prospect of the AFS having a functioning snail caviar farm and product intrigued the team. We started asking ourselves what does the AFS need for their farming practices in order to improve their snail caviar production? What does Perrotis College need in order to create a safe product? How can this practice be adopted by existing farmers, and how can snail caviar be introduced to consumers in the Thessaloniki region? These questions drove our research and informed our methodology.

3. Objectives

This project identified feasible strategies to produce and market snail caviar in order to create a new revenue stream for snail farmers. To achieve this goal, the team pursued the following objectives:

1

Assess the current snail farm at The American Farm School.

2

Determine willingness and ability of current snail farmers to adopt snail caviar farming practices.

3

Gauge the potential of snail caviar as a product in Thessaloniki.

4

Design a snail farm for AFS that could be used as a future learning facility.

3.1 Assessing the Current Snail Farm at the American Farm School

Our first objective was to assess the current snail farming facilities at the AFS. The team wanted to learn what methods the school used to farm, collect, and process the eggs. This information allowed us to establish a baseline understanding of snail caviar farming practices through hands on experience to supplement our previous archival research.

To begin, the team met with Dr. Evangelos Vergos who oversees the entire snail farming project. Over the course of our project, we asked him questions regarding the school's switch from farming snail meat to caviar and covered such topics as why the switch was made, what farming methods the school tried that didn't work, and what methods the school tried that have worked.

The second step of this objective was a series of meetings with Petros Evangelou, the AFS high school teacher who runs the snail farm. The team's goal was to learn the methods used by the AFS to farm and harvest snail caviar. Mr. Evangelou brought us to the school's experimental indoor snail farm facilities, as well as the current outdoor snail farm and showed us the techniques he and the students use to farm snail caviar. During our meetings, the team asked questions regarding the cleaning methods, egg collection process, and labor required to run the snail caviar farm. The team also asked about the climate of the snail farm and the lighting intervals used by the AFS. These details were used as a baseline for developing our design for the school's new snail caviar facility.

Finally, the team met with the Perrotis College food technology department which is responsible for the processing of the eggs in order to create a consumer safe snail caviar product. This meeting was intended to gather information regarding the methods currently used by the department to sterilize the eggs for sale and their success so far. We asked the head microbiologist on the project questions about the decontamination process and whether the current method was successful or not. We used this info to structure our interviews that will be discussed in 3.2 and 3.3, as well as to form our design that will be discussed in 3.4.



**AMERICAN
FARM SCHOOL**

Thessaloniki · Greece

Figure 13: AFS logo

3.2 Determining the Feasibility of Snail Caviar Production



Our second objective was to assess the viability of snail caviar production among current snail farmers. We needed to understand what challenges snail farmers faced, and how much extra effort caviar farming entailed. We met with Petros Evangelou to gauge how much work was required in order to cultivate and harvest the caviar. We traveled with Dr. Vergos and Mr. Evangelou and conducted a group interview with three snail farmers. The interview focused on topics such as the problems farmers encountered with snail farming, improvements they would like to see with the farming process, and what kind of capital investment farmers would be willing to make in caviar farming. We also assessed the farmers' willingness to take on the added labor of harvesting snail caviar and their overall attitude towards caviar farming. The interview was semi-structured and our baseline questions can be found in Appendix B. Although the interview was with three farmers, only one was comfortable with conducting the interview in English, so he and Dr. Vergos translated for the other farmers. We recorded the interview and created a transcript of the answers the farmers gave. We used thematic analysis to identify themes of the interview that we felt were important for our project. This allowed us to identify issues which were common among the three farmers, and focus our research and suggestions to meet these issues (Chapter 2, accessed 2017).

Figure 14: Snail farm outside of Thessaloniki



Figure 15: Team with chef at the Hyatt Regency in Thessaloniki

3.3 Identify the Market for Snail Caviar

Our third goal was identifying both the consumers and the market for snail caviar in Thessaloniki. The team gathered this information by interviewing a chef in Thessaloniki, and focused on learning the motives behind why a chef would or would not be willing to incorporate snail caviar into their recipes. We targeted a high end hotel chef that already included specialty and luxury foods on his menu. Via thematic analysis, we identified the reasons chefs may add snail caviar in their cooking and what factors go into the decision. In our analysis we looked for common themes regarding interest and usability for snail caviar. The interviews were semi-structured, and our questions can be found in Appendix C.

The team also interviewed Mr. Dan Carmody, President of Eastern Market Corporation (EMC) in Detroit. EMC is a non-profit organization and one of nation's largest and longest operating public markets. Mr. Carmody provided us with information about the international marketing possibilities for snail caviar as well as strategies for market entry. The team asked questions regarding the access to distribution channels and the hygiene requirements for a producer exporting to the US. These questions can be found in Appendix D.

3.4 Redesigning the American Farm School's Snail Farm

Soon after arriving in Thessaloniki, we assessed the current operations of the snail farm at the American Farm School. Before we identified important design parameters for our snail caviar production facility redesign, we talked to Dr. Vergos and Petros Evangelou about some of the issues they faced with the outdoor and experimental indoor farm. This took the form of meetings with Petros Evangelou and Dr. Vergos to determine the needs of the facility, including tours of both the old and new farming facilities. The team used the existing issues to redesign an indoor facility that addressed the concerns of those working on the farm. The team initially researched greenhouse facilities for design inspiration, given that both environments require a warm and humid setting. This gave the group a starting point from which we could modify the design to better fit the needs of a snail farm.

SOLIDWORKS 3D modeling software and Smartdraw were used to design the new facility. The design was created to allow the space available to be accessible for working and cleaning. This was accomplished by keeping as many appliances off the floor as possible, and using tile for easy cleaning.

The team suggested a wall mounted heater and cooler to allow more accessibility for workers. We worked to create a space that would utilize the most efficient materials for climate control by calculating heat loss based on different forms of insulation and comparing these cost to running cost. Additionally, we developed potential adaptations that could cut cost and improve hygiene, such as disposable or washable mediums for the snails to lay their eggs in as a replacement to using sterilized soil. Throughout the design process, the team had to weigh the options between low cost and highest efficiency for the products being added to the design. When designing the new AFS snail farm, we had to keep snail farmers in mind so they could use our ideas for their own indoor farm. This is why the team additionally designed a farm system that was not as extensive as the AFS snail farm design that could be used by a snail farmer to supplement their current production with snail caviar.

Design Features	Design Considerations
Effective Floor Plan	Ease of access to the snails and cleaning
Type of Insulation	Cost vs. Efficiency
Climate Control devices	Efficiency & Effectiveness
Photovoltaic systems	Cost of System vs. Yearly Savings
Breeding Box Designs	Effectiveness & Replicability

Table 2

4. Findings

4.1 The current snail farming facilities at the AFS are capable of producing snail caviar, however, the Perrotis College food tech department has not yet successfully been able to decontaminate the eggs.

Petros Evangelou brought us to see the current snail farm at the AFS. We were brought to two different facilities where they farmed the snails. The first one was an outdoor farm that was used for farming snail caviar. The farm consisted of a 4 by 1 meter table constructed of metal poles. The flooring of the table was a plastic mesh to allow for debris to fall through and keeps the snails inside the structure. A plastic mesh is used because metal rusts and needs to be replaced after about a year of use. On the table were wooden boards where there were pots to hold the soil for the snails to lay their eggs in. This wood is also where the food for the snails was placed. The food is a blend of grains, greens, and vitamins and minerals essential to snails. Although it is considered an outdoor farm, the area is covered by a structure made of metal poles. There is a metal fence running around the base of the poles and plastic covering around the side. A thick nylon mesh covers the structure. The fence, plastic, and mesh are there to keep pests out of the enclosure and protect the snails.

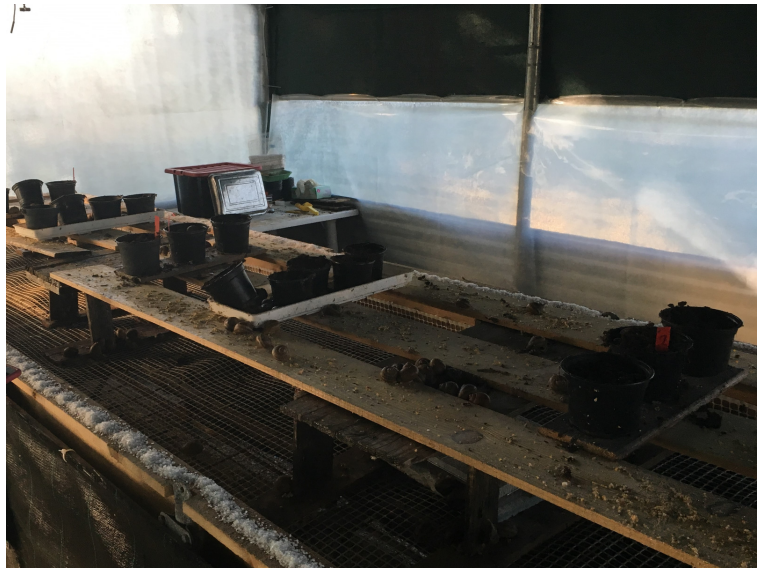


Figure 16: Outdoor Snail Caviar Farm at the AFS.



Figure 17: Thermometer and barometer in farm

The team then visited the indoor farm that had been used over the winter to harvest snail caviar. We learned the indoor farm was a prototype and it was the first time the school attempted to farm the snails for caviar. The indoor farm was used to create an artificial environment that would allow the snails to skip their dormant phase for the winter. Keeping the snails active for the winter allowed the school to continue farming them. The climate the snails were kept in was 11 hours of light and 13 hours of darkness, 90 percent humidity, and 22 degrees Celsius. In order to control humidity, the AFS used water pipes connected to misters above their prototype, these would spray in intervals throughout the day. For temperature maintenance, the indoor facility contained a small electric heater that was kept on the ground, also there was a vent built on the wall that allowed for airflow.



Figure 18 & 19: Indoor Snail Caviar Farm

The Perrotis College food technology department is responsible for decontaminating the eggs and producing a snail caviar product. The department is currently working to develop methods to create a safe and palatable product to sell. Snail caviar produced by the current methods at the AFS contain around one million enterobacteria, pathogenic microbes that infect the digestive tract, including coliforms, salmonella and shigella (personal communication, Maria Gougoli, April 26, 2017). Any egg product sold in the EU has a set limit for the number of these bacteria that can be on the product at the time of sale. All egg products should have no traces of salmonella, and the remainder of enterobacteria should fall between 10-100 cfu (colony forming units) per gram or millilitre of product (European Union, 2005). According to these standards the current snail caviar at Perrotis College has 10,000 times more microbes than the maximum amount allowed in the EU. The current methods used by Perrotis College have not developed a protocol that produces snail caviar that meets these requirements. They currently rinse the eggs from the farm with tap water. Next, the eggs are washed in a sterilized saline solution. Finally, they are stored in an airtight jar with a brine solution that contains thyme, rosemary, and oregano. These herbs contain antimicrobial properties.

In order to create a safe, final product, the food technology department needs a cold pasteurizer, a machine that sells for approximately €15,000 (personal communication, Maria Gougoli, April 26, 2017). A cold pasteurizer differs from a regular pasteurizer by using only pressure, no heat, to decontaminate a product. The heat from a regular pasteurizer breaks down the bonds and proteins in snail caviar and creates a soft, unappealing product. The cold pasteurizer uses only pressure to destroy the cells of microbes while preserving the structure of the protein in the eggs. After pasteurization, the snail caviar should be able to last for a month in the fridge. The food technology department will not be able to create a safe product until they have access to this piece of equipment (personal communication, Maria Gougoli, April 26, 2017).



Figure 20: Cold pasteurizer



Figure 21: Snail caviar in brine

4.2 Snail farmers are hesitant to invest in snail caviar production due to their previous experiences investing in snail farming and the increased production costs required.

The years 2008-2009 were identified as key years for the beginning of snail farming in Greece. Companies were formed that aimed to help aspiring farmers begin snail farming. For €25,000, these companies provided farmers information on breeding and caring for snails in addition to materials to construct a snail farm of approximately 750 square meters. The farmers we interviewed, however, did not find the information provided by these companies useful. After they invested in snail farming and began raising snails, farmers realized that not all the information they received was correct. For example, the farmers realized they needed to supplement snail feed to include proteins and vitamins, not just greens as they had been advised. Farmers also experienced a sharp increase in their snail population, but did not know that the population density should not exceed 200 snails per square meter (personal communication, Alaveras Konstantinos, April 10th, 2017). If the population density exceeds this number, the snails compete for space and food. It also reduces the reproduction rate of the snails (Jess & Marks, 1995). The farmers' plight was described in a trade paper, GR Reporter in 2013. Greek agronomist Abraham Nikolaidis wrote a story about how snail farmers received misleading and inconsistent information from these companies and the consequences were that many snail farms failed (Balezdrova, 2013). The snail farmers still have the memories of the struggles they faced during their first few years of farming, and they are being careful to not repeat these experiences.

The first years of snail farming were difficult for these farmers because they did not know the proper techniques for raising snails. Farmers didn't have information such as the proper population density, what to feed the snails, and the ideal number of harvests per year. This resulted in minimal production because the improper feed and overpopulation stunted the growth of many snails. For example, one of the snail farmers mentioned that he did not turn any profit from snail farming until his fourth year in the business. He lost his entire herd of snails his first year because he did not know that his farm design did not allow enough airflow, and the snails overheated. Another example includes specifications on when to harvest the snails; the farmers mentioned that originally they were told to harvest once per year. The farmers learned that this is not accurate, and it is actually better for the snails to have 2 or 3 smaller harvests each year. Multiple harvests a year is better for the health of the snail population. During harvesting, snails large enough to be sold are removed from the population while smaller snails are kept for future harvesting. One can tell when a snail is ready to be harvested by its shell. When the edge of the shell begins to curl outward, the snail is fully mature. The image below compares an immature and a mature snail shell.



Figure 22: The immature snail is on the left. The mature snail is on the right and can be identified by the white ring around the edge of the shell.

One harvest does not allow all of the smaller snails to reach maturity and be sold. “That is why I told you we learned the hard way” (personal communication, Alaveras Konstantinos, April 10th, 2017). All three of the farmers present at the interview expressed similar frustrations throughout all aspects of the methods involved in snail farming. “There wasn’t any knowledge about snails. Not only in Greece. After a few years we realized that there is no knowledge on the snails around the world I believe...” (personal communication, Alaveras Konstantinos, April 10th, 2017). For the Greek snail farmers, snail farming has been a learning experience. They rely on changing farming methods when something goes wrong, and learning from each other to become better farmers.

Every year snail farmers who sell raw snail meat pay the state a fee of €750.

The state puts this fee into a pool for disability insurance and for pension. If the snail farmers wish to directly sell products other than snail meat, their state fee can increase to anywhere between €3,500 and €12,000. This insurance is covered by the Agriculture Insurance Organization (OGA) in Greece, and is an obligatory insurance all farmers and agricultural workers in the EU must pay into. This provides a pension program for when they retire, or insurance if they become disabled. The OGA is a subset of the European Network of Agricultural Social Protection Systems (ENASP), an EU wide policy designed to provide a social safety net for those involved in agriculture (OGA, 2016). By adding snail caviar to their production, the contribution required from snail farmers would increase.

4.3 Many snail farmers in the Thessaloniki region are struggling to turn a profit by farming solely snail meat.

Snail farmers can sell raw snail meat to consumers for a price between €2 and €3.20 per kilogram; harvesting a yearly total of 3 tonnes of snails per 1,000 square meters between 2 harvests is considered a very good harvest for a farmer. At this rate, a farmer with a 1,000 square meter farm could hope to make a yearly revenue of €9,600 if they were able to sell their snails at the highest price (personal communication, Alaveras Konstantinos, April 10th, 2017). One farmer had a 1,000 square meter farm, and spent over €3,000 per season on food for the snails alone. Despite years of experience, he has yet to turn a profit due to operational costs of labor, food, and utilities (personal communication, Socrates, April 10th, 2017). If farmers do have a yearly net profit, they are spending multiple years' worth of these profits paying off the start-up costs. This is also a full-time job. One farmer tended to his friend's 3,000 square meter snail farm for a day, and it took him over 3 hours just to feed the snails. In addition, the snail habitat needs to be periodically cleaned, which involves going through each enclosure and removing dead snails and rotting food to prevent the spread of disease. The enclosure also needs to be inspected daily to ensure it remains secured from predators.

"You need at least 4 hours a day for 500 square meters" (personal communication, Alaveras Konstantinos, April 10th, 2017).



Figure 23: Snail farm after feed

Farmers are having difficulty making sufficient profit from selling their snail meat. The average agricultural wage is less than €3 per hour in Greece, and snail farmers in the Thessaloniki region make even less, with some farmers seeing a yearly net loss (Hill & Bradley, 2015). There is a resource available to the farmers known as the CAP, Common Agricultural Policy, subsidy program, which exists to help small scale farmers deal with start-up costs and manage expenses. The CAP subsidies are awarded on a basis of acreage, so for snail farmers, income from the subsidy would be minimal (CAP, 2016). "Until now I've never had enough money to, didn't get enough money from snails" (personal communication, Alaveras Konstantinos, April 10th, 2017).

4.4 The farmers formed the Snail Farmers' Cooperative of Greece to increase their prospective revenue, expand their market opportunities, and combat the costs accrued by snail farming.

The lack of profit from raw snail meat sales pushed the farmers to find ways to increase the value of their products. It was too expensive for many of these farmers to sell other products because of the added social contribution cost. These two main considerations led the farmers to form a snail farming cooperative. The cooperative is an organization made up of 50 snail farmers from the Thessaloniki region. The cooperative buys all the farmer's raw snail meat at €6, rather than the €3 the farmers would otherwise get by selling their meat to a processor. The cooperative then processes the snail meat, and exports the products. The profits the cooperative makes pays for the processing of the meat, and allows them to buy the raw meat at €6 rather than €3. In this way, the profits are effectively distributed to the farmers. Another consideration is the cooperative can pay more per kilogram for the raw snail meat because they have the ability to sell a variety of products, and can handle the increased cost in processing and distribution. The cooperative sells smoked snail fillets, snail fillets in brine, frozen pre-cooked snails, and Escargot a la Bourguignonne and aims to export 80% of these products to countries with higher demand for snail products such as France (Snail Farmers' Cooperative of Greece).

Many people in Greece eat snail meat that they gather from nature. The farmers interviewed operate under the belief that the domestic market for snail meat in Greece is too small; they need to export their products.

The people of Greece buy fewer snails from producers during the months when they can go into the wild and harvest snails themselves. In fact, snail harvesting is only allowed in Greece between the months of March and June, as the rate of wild harvesting was hurting the biodiversity of local habitats (Presidential Decree, 1981). Meanwhile, countries such as France and Italy are not producing enough snails to meet demand. In France over 80% of snails eaten are imported, while in Italy over 65% are imported (Touchstone Snails, 2014).

"Yes, they eat them a lot but because they are not supermarkets most of Greek people gather them from nature. ...they want to do it because they like to do it. We're going to try to change that but it's going to take a long time I believe" (personal communication, Alaveras Konstantinos, April 10th, 2017).

Before the cooperative, the snail farmers were subject to establishing themselves in the market through their own connections. When we asked Alaveras Konstantinos how he originally found customers for his products he responded,

"...with my legs and my car. From door to door" (personal communication, April 10, 2017).

Learning about the income difficulties of these farmers has helped the team to better understand the economic situation for Greek snail farmers. If snail farmers are going to adopt snail caviar farming, caviar needs to be able to provide the farmers with a larger income than farming snail meat alone. Snail farming for meat does not provide the snail farmers with a high enough income, and the switch to snail caviar farming can be a pricey investment, as the farmers must pay for the cost of creating the snail caviar farming facility. The cost estimation for the facility can be found in chapter 5, and the cost for a cold pasteurizer is approximately €15,000.

The farmers said they were looking to expand the cooperative they formed from only snail meat to other snail products such as snail caviar or collagen. However, the farmers are hesitant about switching to snail caviar because of how unknown it is in the Greek markets. Some farmers are aware of the price that snail caviar, and other products such as collagen, extracted from snail saliva, can sell for in some markets. The farmers realized this from research they conducted while trying to find a more profitable production than snail meat alone. They know that it would potentially bring in more income than snail meat alone, however, the processing methods to clean the eggs are unknown to these farmers.

None of the farmers want to begin snail caviar production until they are sure they understand the methods of production, the proper way to decontaminate the eggs, and the market where they could sell their product. The farmers are just beginning to have a yearly net income from their meat productions; by experimenting with producing caviar, they are putting what little income they are making at risk. Once the snail farmers have access to this information, they will be able to make an informed decision as to whether they will or will not be able to adopt snail caviar farming to their practice.

4.5 Snail caviar should be sold as a seasonal product in concert with the seasonality of snail meat.

In order to understand snail caviar as a product, our team had the opportunity to interview a chef from the Hyatt Regency in Thessaloniki, a 5 star hotel. In our interview with chef Altanis Apostolos, we learned that consumers will likely associate snail caviar with snail meat. Altanis noted that snail caviar would be seen as a winter product since snail meat is traditionally eaten in the winter in Greece. In the beginning of the spring and into the summer, people are searching for the fresh seafood that the Thessaloniki region is known for. Having the artificial conditions necessary to produce snail caviar in the autumn and winter months aligns with the eating habits described by Altanis.

The farmers want to keep snail meat as their primary product, so the possibility of adding snail caviar for winter production is viable to meet the demands the chef expects. Chef Altanis explained that on his menu he introduces new specialty items four times a year to enhance customer attractiveness, but pointed out that if a product is very attractive they will keep it on their menu. He would expect to introduce snail caviar in the winter, because he does not think the product would be popular in the summer months (personal communication, Altanis Apostolos, April 21st, 2017).

4.6 Snail caviar will need to be presented to the public by a respected restaurant or chef in order for consumers to trust the product.

Interviews conducted with a chef in the Thessaloniki area and the CEO of Eastern Markets in Detroit, Michigan, Mr. Dan Carmody, showed a common theme about the potential success of snail caviar as a product. Snail caviar is a niche product not well known by the average consumer. The lack of knowledge around snail caviar makes it a hard product to introduce into a market place. Mr. Carmody states,

“Until the market gets established for it. I think the initial market push should be for restaurants” (personal communication, Dan Carmody, April 26th, 2017)

Both producers and chefs believe customers would hesitate to buy snail caviar before seeing it introduced in restaurants in some form.

Alveras Konstantinos, the snail farmer whom we interviewed, said snail caviar should be sold in

“...specialized places. Mostly hotels because the foreigners, and special markets” (personal communication, Alveras Konstantinos, April 10th, 2017).

Hotels have a broader range of clientele because they are used by vacationers; hotels house travelers from around the world and they may be more inclined to be adventurous and try a new food like snail caviar. Snail caviar is a new food and customers would need to trust the source of their initial sample. This trust would stem from chefs at high-end restaurants, a demographic known for experimentation and innovation. The chefs themselves felt they had to try snail caviar before they could make the decision to place it on their menu. Chef Altanis comments,

“...if it was presented by a well-known chef, it would be easier for them” (personal communication, Altanis Apostolos, April 21st, 2017).

By first selling to high-end restaurants and exposing the public to snail caviar, the idea can be seeded for future marketing opportunities.

4.7 Limitations

Our team interviewed three snail farmers who are all part of the same cooperative, Snail Farmers' Cooperative of Greece. There are 50 snail farmers who are part of this cooperative and share similar experiences. Most of the answers to our interview questions were led by the farmer that spoke the best English, Alaveras Konstantinos, with the other farmers providing input when their experiences differed.

The team had difficulty interviewing chefs in Thessaloniki to gauge their interest in the possibility of adding snail caviar to their menu. The chef we interviewed in Thessaloniki gave us similar results to an interview we conducted while still in Worcester, with Deadhorse Hill chef, Jared Forman, as both felt they had to try snail caviar before they could give us an honest answer. The AFS caviar is not microbe free and couldn't be consumed, therefore our team was unable to offer a sample in order to get a proper opinion from them regarding this product. In addition, chefs were hesitant to talk with us and many said that they could not meet because they were too busy. This was especially the case around the time of Easter.

An additional challenge arose from cultural differences in Greece; all of our interviews needed to be facilitated by our sponsor, Dr. Vergos. In the US, we had no trouble emailing groups to ask for an interview, but we could not do the same in Greece where institutional hierarchies form more of a barrier.



Figure 24: Cleaning out the snail habitats

5. Design

Design #1: AFS Snail Farm



Figure 25: Exterior view of snail farm, SOLIDWORKS drawing

The AFS is planning to relocate their snail farm to a building originally designated as a utility shed. The building is 8m by 3.5m and will have 2 rooms. There will be a 5m by 3.5m room designated to the farming of snail caviar, and a 3m by 3.5m room for egg collection. Key construction elements are:

1. Building up the outer wall and replacing the roof.
2. Building the dividing wall between the 2 rooms.
3. Addition of a water hook up and electrical wiring to the building.
4. Installation of a large drain in the snail farm room.

The building itself will have 1 entrance/exit door that opens to the outside. The door will be located in the egg collection room. There will be a door between the rooms in the partition wall that can open both ways. The walls and floor will be tiled to make it easy to clean as well as aesthetically pleasing.

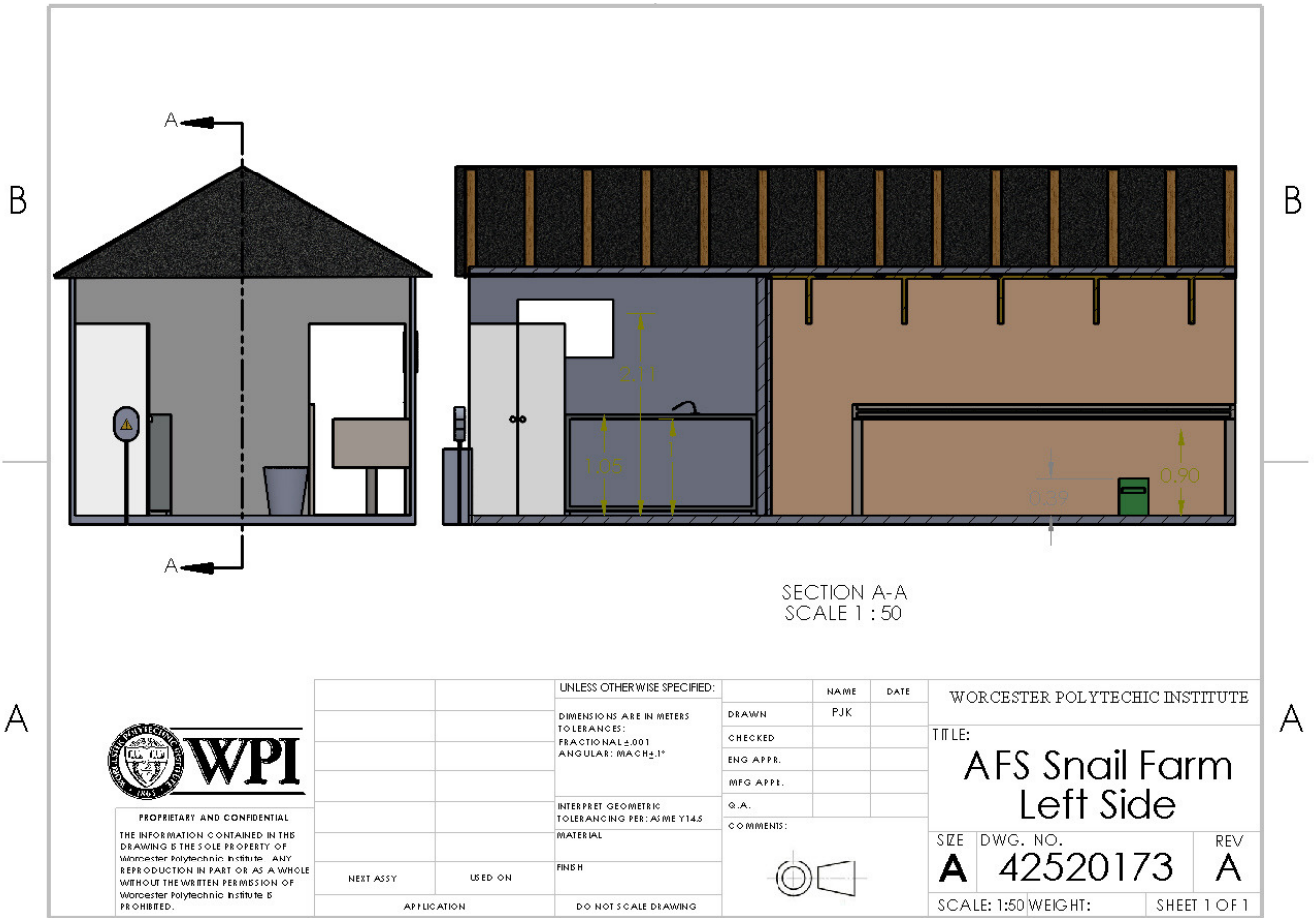


Figure 26 & 27: Left and right view of snail farm, SOLIDWORKS drawings

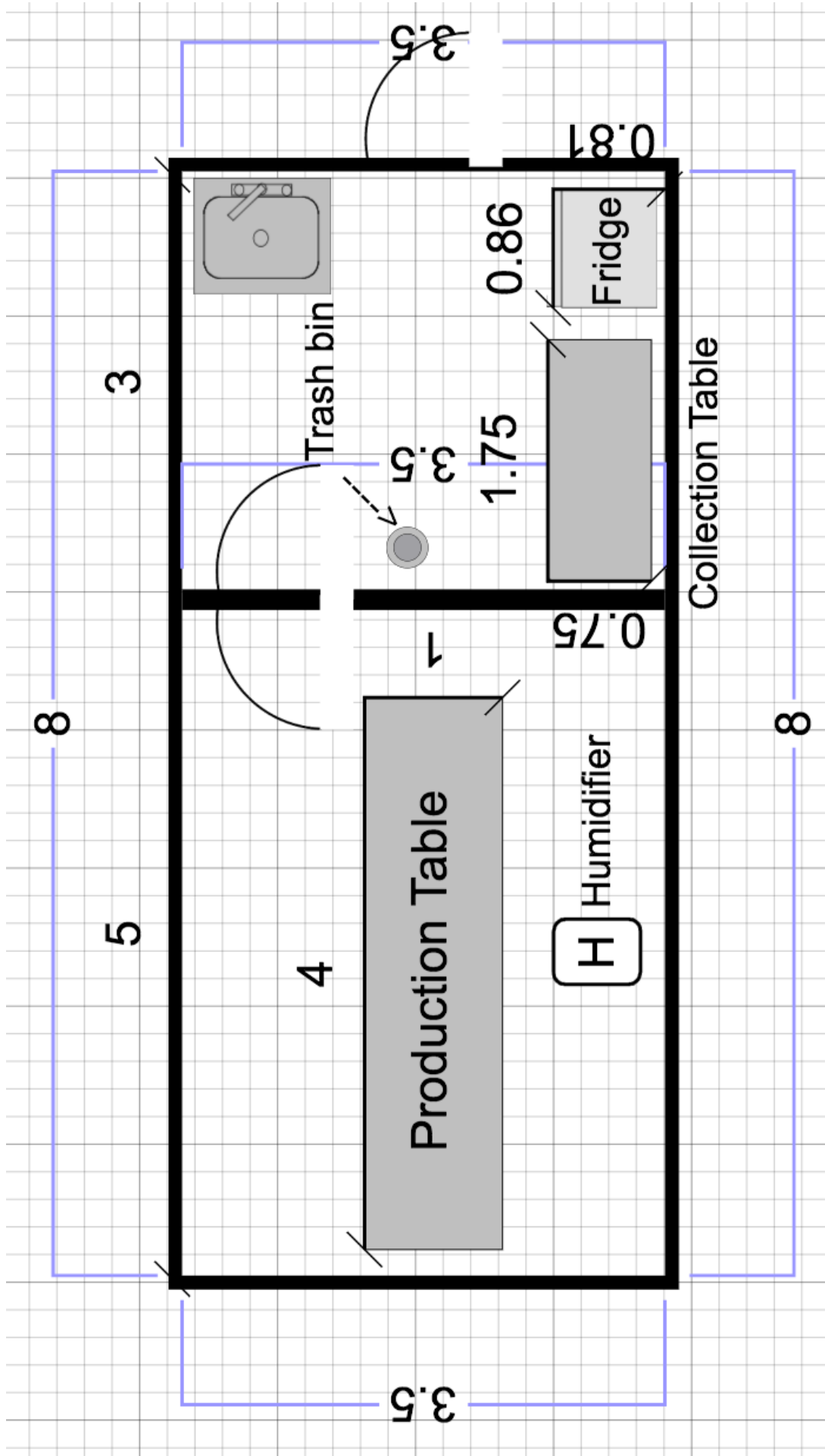


Figure 28: floor plan of snail farm, created on Smartdraw

Climate Requirements

Requirement	Range Based on Research and Interviews
Light	12 hours light, 12 hours dark
Humidity	90% +/- 5%
Temperature	22°C +/- 1°C
Ventilation	6 Air Changes/Hour (Hendrick, 2010)

Table 3

The walls will be constructed from brick, and wooden studs will be added on the inside so insulation can be added to the walls. The team researched three different insulation options shown below. Over the studs will be a cement board that tile can be attached to for the final layer of the wall. The production area of the building will have a ceiling for added insulation. The insulation in the ceiling will have the same R-value as the rest of the building.



Figures 29, 30 & 31: Images of insulation: Fiber glass batts, spray foam, and mineral wool

Insulation Type	R-Value	Cost per m ²	Cost to Insulate Entire Building	Fire Retardant
Fiberglass Batts	9.8	€5.70	€600	Yes
Closed Cell Spray Foam	17.7	€30.00	€3,200	No
Mineral Wool	12.4	€7.90	€850	Yes

Table 4

The values in the table above show the R-values and cost of insulation for the three different types at a thickness of 8 centimeters. The team recommends the American Farm School uses the closed cell spray foam insulation for the new snail farm design in order to create the best model for farmers to learn from. However, for farmers wishing to pay less on start-up, mineral wool is more affordable and still effective.

An online calculator was used to determine the heat loss of the production side of the building. Using this calculator, it was determined that the energy loss would be 1,300 Watts. The equation used to calculate the heat loss is $Q=U*A*\Delta T$ where: U is the inverse of the insulation's R-value, A is the surface area of the walls, and ΔT is the temperature difference between the air in the building and the outside air. For the outside temperature, the team used the average high for the summer and the average low in the winter for Thessaloniki. Q is the heat loss due to conduction; conduction is the transfer of heat through a material due to a temperature difference. In order to maintain these requirements, the farm will need climate control equipment

The heater and air conditioner need to have a minimal output of 1,300 Watts to keep the room at a controlled temperature. The team researched the various available appliances that would meet the specifications determined by the heat loss calculations. These appliances would also need to provide adequate ventilation. Based on the available appliances found on websites of local stores, the team determined energy and price estimates in order to calculate cost. The running cost is based on the cost of energy per kilowatt-hour in Thessaloniki. The usage costs were estimated assuming minimal insulation, and these costs can be decreased by improving insulation.

Appliance	Estimated Energy Usage per Year (kWh)	Running Cost per Year (€)	Cost (€)
Air Conditioner	5,500	400	200
Electric Heater	12,000	900	160
Humidifier	50	10	200
Ventilation Fan	30	5	125
Fridge	320	50	625
Lights	450	70	45 (for a pack of 10)
Wall and Flooring	-	-	1,200
Cold Pasteurizer (for Perrotis food technology department)	-	-	15,000
TOTAL	18,350	1,435	17,555

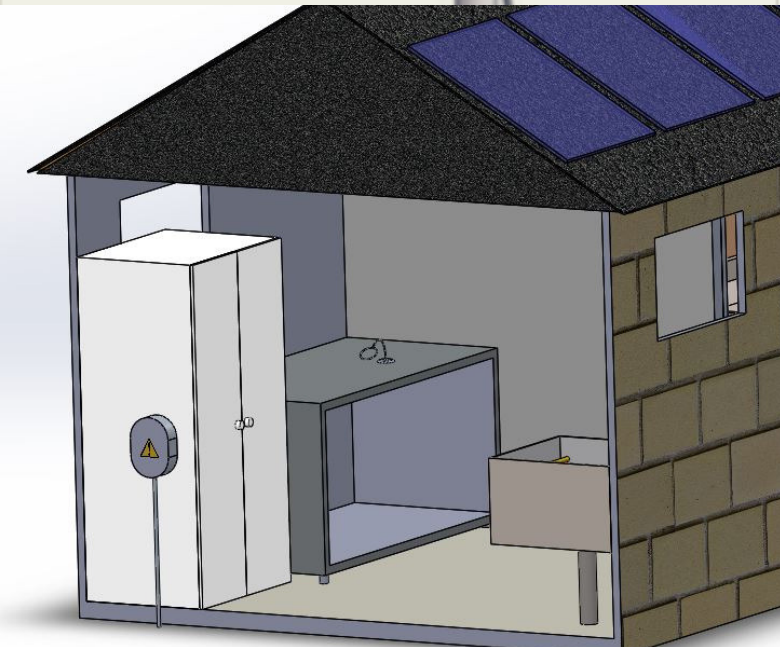
*Estimates calculated without 23% VAT tax

Table 5

Egg Collection Center

There is no climate control required for the egg collection room because workers will only be working there for limited amounts of time daily. A fan or space heater can be added as necessary by whoever is working in the lab. The only energy accounted for in the collection area is the refrigeration for the eggs and the working lights. Both of these can be seen in the table provided above. The room will also need a work bench, shelves, and sink which requires a water hookup. Two windows located on each wall will provide natural light and ventilation for the collection worker. Although the entire room will be open, the floor space will be divided in half in terms of hygiene control. The right half of the room (with respect to entering from the outside) will be dedicated to hygiene procedures. That half of the room will have sanitary equipment (disposable boot covers, hair nets, sanitary gowns) available for use to prevent the spread of microbes to and from the snail farm. The sink will also be on that half so that the workers may wash up after being in the snail farm. The other half of the room will be dedicated to work and egg collection.

Petros Evangelou also requested recommendations for different microscope equipment for inspecting the eggs as they are collected. Included is a magnifier lamp that will magnify at 3x the magnification. The light will allow defects to be more easily detected. A stereomicroscope is also provided as it will allow for greater magnification. Both of these products are produced by Fisher Scientific.



Figures 32, 33 &34 : Magnifying lamp, SOLIDWORKS drawing view of collection room, stereoscope

Innovations

Renewable energy through the form of photovoltaic systems would allow the snail farm to incur less cost in electricity per year. The group completed a cost analysis based on systems available online through third party vendors in order to provide an estimate of what the system may cost. The price of the system accounts for the solar panels, mounting, inverters, battery, and cables. As the farm school is located in Earth's northern hemisphere, the solar panels are most effective to be placed on a roof facing south west. The farm would have one side of the roof facing south west, leaving 15m² of roof surface area available to be dedicated to solar paneling. The systems available online show that we would not be able to generate the total electricity needed to run the farm using a solar system, however, the yearly cost can be offset.

Currently, the most applicable system for the farm would cost around €1,500.00 and has a watt power of 2,000. Using the equation, (PV watt power) x (hours of sunlight) x (75%) = daily watt hours, the system will produce an estimated 2,500 kWh/yr. The equation uses 2,000 for the watt power and 4.5 for the hours of sunlight. 4.5 is a number found online for Greece and refers to the number of hours in a day the solar panels will receive light equal to the intensity of midday sun. This will reduce the energy usage of the building by 14%. Based on Thessaloniki's average energy price of €0.144 per kWh, this would give an annual savings of €300 per year (CostToTravel, 2017).



Figure 35: Solar panels on a roof



Figure 36: Snail eggs in soil

The indoor snail farm at AFS is the perfect place for experimenting with new egg collection methods. Dividing the breeding space in half would allow for ample room to experiment with different techniques. The table can be split in half to allow for continued production with soil on one half and experimental techniques on the other half. These experiments should be based around decreasing microbes on the eggs.

We recommend the use of wet cotton in place of dirt for the snails to lay their eggs as the first experiment. A study conducted by Awah, et al., utilized this technique and showed it is possible that the snails, lacking another place to lay their eggs, would only lay in a moist cotton wad (Awah, 2001). This would allow eggs to be easily collected, and the cotton could be sterilized or thrown out and replaced. The cotton wool should be a color other than white to easily distinguish the eggs.

Egg cartons are another soil replacement technique to get snails to lay their eggs. Cutting a hole in the bottom of an egg crate that empties into a collection container would cut labor and soil usage and give collectors a visual indicator when the eggs are laid. Another material that may produce similar results is a large organic sponge with a hole cut into it. This would mimic soil while limiting microbes. In the case that snails will only respond to soil, the soil should be autoclaved at 121°C at 1.1atm for 20-30 minutes (Trevors, 1996). The sterilized soil should be added in minimal amounts to the experimental egg systems.



Figure 37 : Egg carton



Figure 38: Sponge



Figure 39 : Cotton Wool

Design #2: Smaller Farm

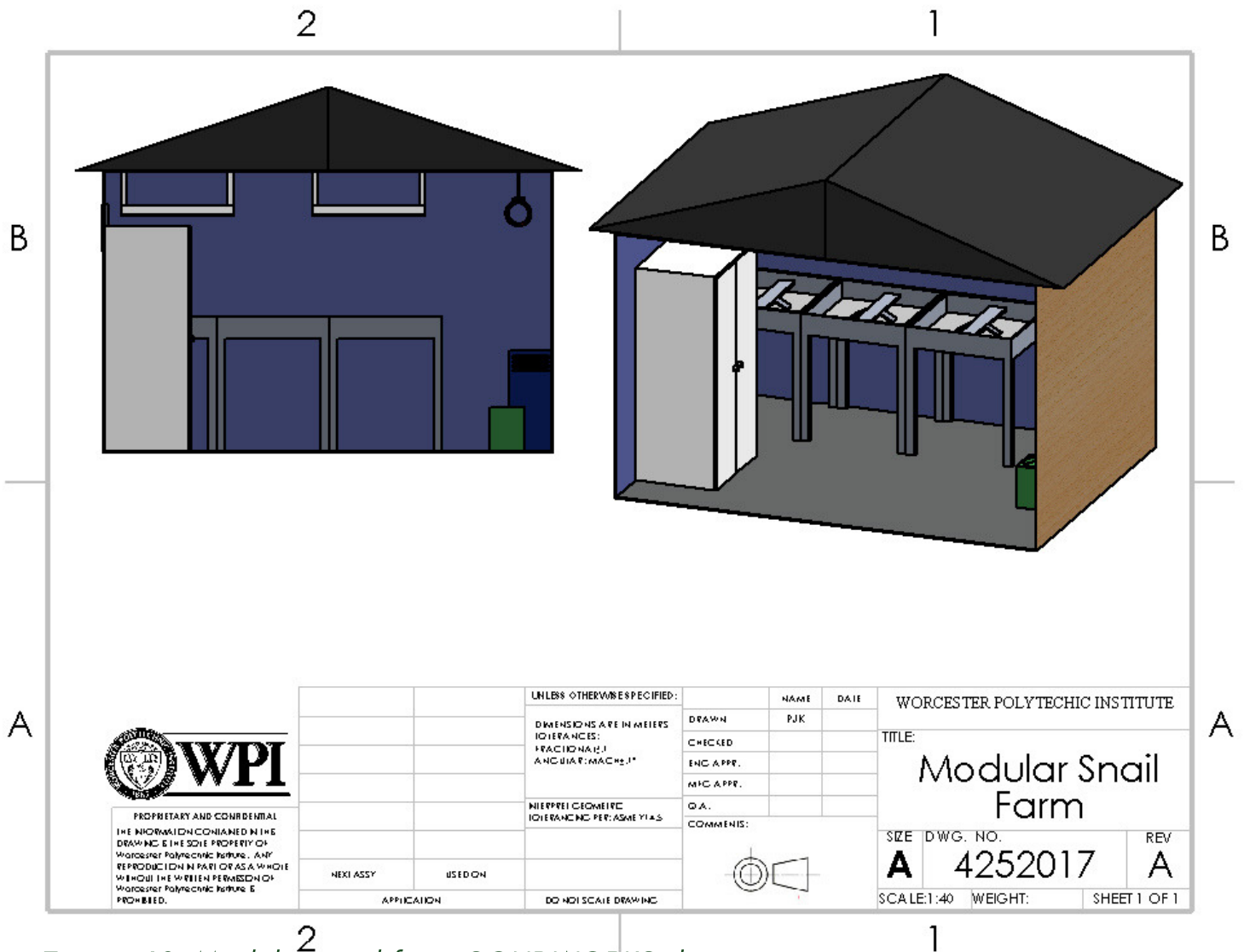


Figure 40: Modular snail farm SOLIDWORKS drawing

Additionally, we created a lower cost and simpler indoor habitat design for the snails that farmers can utilize for their own caviar farms. This modular design would be a series of 1x1 meter boxes that isolate individual populations of snails. Each box would hold 200 snails, the maximum density recommended for a healthy snail population. This would prevent disease from propagating throughout the whole herd. The floor of this box would be a plastic screen to allow debris and detritus to fall out, and allow for easy cleaning. Additionally, removing dirt from the structure removes a possible breeding point for bacteria and microbes.

To prevent the snails from escaping, the sides of the box will have an electrical deterrent woven through a protective netting or tape. This electrical system, commercially available, uses a 9 volt battery and a controller to run a low current through a copper weave. It isn't enough to affect humans, but the snails find it unpleasant and refuse to cross (Schnecken Elektrozaun, 2015).

This design was created to benefit current snail meat farmers that want to farm for snail caviar in the winter months when they can not produce meat outdoors. In order to determine the break even point of part time egg production, assumptions were made about the farms. Based on observations the team made while visiting various snail farms, we assumed the farms have an insulated building that can be adapted for indoor snail farming, and these buildings approximate the size of the production room at AFS. The only building costs would be from building the individual egg collection boxes. Given that chefs expect snail caviar to be in higher demand during the winter, we assumed the operation would only run for 6 months (late fall through early spring) and eliminate the need for an air conditioner. The table below outlines the costs accrued based on these assumptions.

For the first year, the total cost (e.g. purchase and running costs) would be approximately €2,300. In the years following, assuming no replacements or repairs to the system, the cost of the operation would only be the running cost of €950.

The cost analysis was calculated based on the AFS snail caviar operation. The current AFS snail caviar operation is an appropriate model to base our estimates on because these numbers are from the AFS's first six months of experimental snail caviar production. Additionally, the farmers will likely be learning their methods of snail caviar production from the AFS snail farm. AFS was able to produce approximately 2 kilograms of snail caviar in 6 months with 300 snails. If the caviar were to sell at €2.00 per gram, €0.20 below the top market price, the farm would make €4,000. Using these numbers, which assumes optimal egg production and sales, the farmer would need 175 snails for breeding in order to break even after the first 6 month period of production.

Item	Running Cost for 6 months (€)	Cost (€)
Heater	870	160
Humidifier	5	200
Vent Fan	5	125
Refrigerator	25	625
Lights	30	45 (For a pack of 10)
1 m ² Breeding box	-	125
Total	935	1,280

Table 6

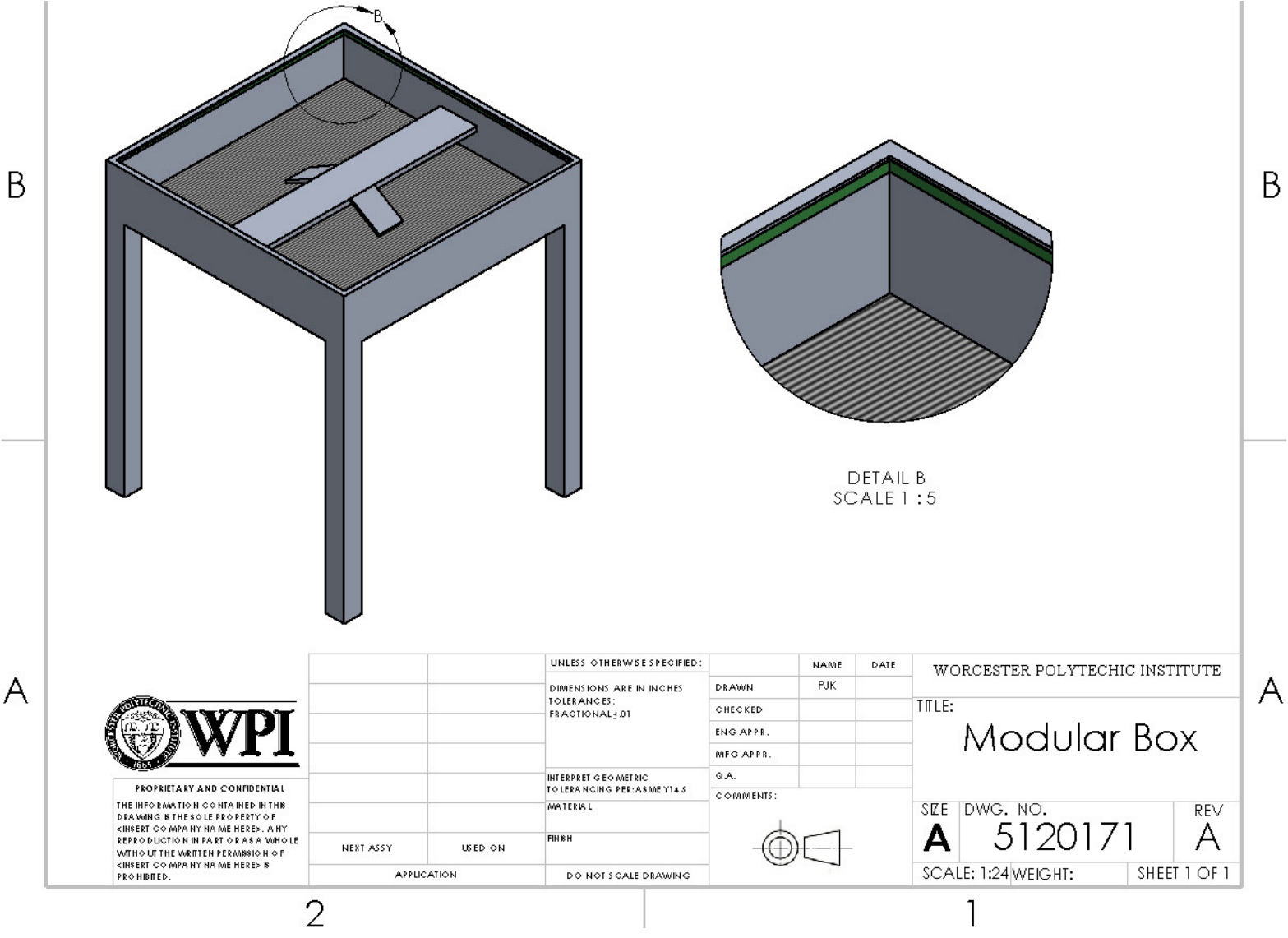


Figure 41: In the above drawing from SOLIDWORKS, we created a modular breeding table. The table will be 1x1 meter so that the farmers can pick the appropriate number of boxes per amount of snails they would like to take in for the winter. The green is the electrical circuit to keep the snails in, and the board in the center is for food, and egg collection pots.

6. CONCLUSION AND RECOMMENDATIONS



Conclusion

Although the AFS has been snail farming for the past 4 years, the school only began producing snail caviar six months ago. Little is known about snail caviar farming and best practices for processing the eggs, both in the academic and practitioner literatures. The snail farmers we interviewed were hesitant to begin farming snails for caviar. When they started snail farming for snail meat, there was very little information readily available about the best practices for snail farming. This lack of knowledge resulted in farmers spending their first years experimenting with the best methods to farm the snails, often learning as they went along, but few could make profit during this period.

As snail caviar farming has gained popularity in other parts of Europe, the Greek snail farmers began looking into the practice. The farmers noticed a recurring theme about snail caviar farming. Little information is available on how to successfully farm, harvest, and process snail caviar. Farmers are not inclined to invest in another new farming practice only to spend their first years experimenting. This causes them to be skeptical to the idea of starting to farm snail caviar without knowledge readily available. Another issue farmers face with snail caviar is the processing. Currently, they would have to invest in a cold pasteurizer which would cost €15,000. This machine would potentially be purchased by the cooperative to be able to process the eggs so the individual farmers do not need to buy their own processor. Snail farmers will be more willing to adopt snail caviar farming processes if they are confident that they know the proper procedures for farming and cleaning the caviar to produce a safe product.

Recommendations

We recommend that the AFS begin construction of the new indoor snail farm facility. The design we have provided should serve as a basis for the new building. The innovations the team has recommended should also be considered by the AFS. The use of photovoltaic systems should be considered in order to decrease operating costs. Once the building is running, the snail farming program at the AFS should consider using our breeding box innovations to try and improve their current farming methods.

Once a safe snail caviar product has been created by the Perrotis College food technology department, the AFS should partner with a high-end hotel or restaurant chef in order to introduce snail caviar to the public. Snail caviar needs to be introduced by a well known chef so that the consumers trust the product. The school and the business should work collaboratively to determine prices and marketing strategies that both parties are comfortable with. This should be done by considering the price the school needs to continue their experiments and production, and the price at which the restaurants feel they can sell to their patrons.

We recommend tactics such as branding and direct marketing in order to market the snail caviar. Creating their own unique brand name and slogan for the AFS snail caviar can draw increased consumer interest. The AFS should utilize direct marketing for their snail caviar by introducing it at a local gastronomic fair or food festival. These gastronomic fairs or festivals would help to display the AFS snail caviar brand name and slogan to the public. This form of direct marketing can increase the AFS's opportunities to create customer channels for selling their snail caviar. The popularity of snail caviar in the public should be assessed through collecting consumer feedback throughout the introductory process of snail caviar.

If snail caviar is found to have a market demand in the Thessaloniki region, the AFS should start a program that teaches snail caviar farming practices to farmers interested in partaking. The class should teach rearing and harvesting methods. The school can also update the second design we provided for a smaller snail farm with materials and appliances they deem successful. This design can be made into a pamphlet for farmers to use when building their snail farm. Additionally, the Perrotis College food technology department should talk with the snail farmers' cooperative about the cooperative's ability to obtain a cold pasteurizer. If the cooperative decides that obtaining a cold pasteurizer is not a feasible option, both parties should work to establish a way where the Perrotis College food technology department offers a caviar pasteurizing service.

In the event that snail caviar is not found to be viable in the market of the Thessaloniki region, the market in other areas should be explored. Domestically, Dr. Vergos has already received interest in the product from hotels in Athens and could possibly gain the interest of some tourist islands like Santorini or Mykonos. The AFS can reach out to high-end chefs in these locations and partner with them to advertise snail caviar to the public. With the help of a well-known chef, the AFS can interactively advertise their snail caviar on these islands utilizing the reputable AFS brand name. This can lead to increased opportunities for the AFS to obtain customer channels outside of Thessaloniki.

Work Cited

AFP. (2015). *Snail caviar a delight for sicilian startup*. Retrieved from

<http://www.thelocal.it/20151112/snail-caviar-a-slimy-delight-for-sicilian-start-up>

Agricultural census in greece. (2012). European Union.

http://ec.europa.eu/eurostat/statistics-explained/index.php/Agricultural_census_in_Greece

Alexander, H. (2011, 5/1). Europe calls it 'white caviar', we call it a pot of snails' eggs. *Sunday*

Telegraph (London, England) Retrieved from

<http://search.proquest.com/docview/864130846>

Alexander, H. (2011, 5/1). Snails slither into cookbooks as 'white caviar' captures imagination. Retrieved from

<http://www.telegraph.co.uk/news/worldnews/europe/spain/8485188/Snails-slither-into-cookbooks-as-white-caviar-captures-imagination.html>

Babalola, O. O. (2016). Performance, nutrient digestibility, carcass analysis and organoleptic assessment of snaillets of african giant land snail (*archachatina marginata*) fed diets containing graded levels of dried lettuce. *Animal Feed Science and Technology*, 216, 169-175.

[doi://dx.doi.org/10.1016/j.anifeedsci.2016.03.013](https://doi.org/10.1016/j.anifeedsci.2016.03.013)

Begg, M. S. (2003). Farming edible snails - lessons from italy RIRDC.

Beopoulos, N., & Skuras, D. (1997). Agriculture and the greek rural environment.

Sociologia Ruralis, 37(2), 255-269. doi:10.1111/1467-9523.00048

Better training for safer food (BTSF) - food safety - european commission. Retrieved from https://ec.europa.eu/food/safety/btsf_en

Beverly hills caviar | best caviar, truffles, gourmet food gift. Retrieved from <https://beverlyhillscaviar.com/>

Blanc gastronomy. (2015). Retrieved from http://www.blancgastronomy.com/portfolio_page/perlas-de-afrodita/

British Stainless Steel Association. (2017) Cleaning methods for stainless steel. Retrieved from <http://www.bssa.org.uk/topics.php?article=77>

BRITTON, C. (1987, 8/20,). Snail caviar slowly catching on : Eggs from garden-variety mollusks fetch \$40 an ounce. *Los Angeles Times* Retrieved from http://articles.latimes.com/1987-08-20/food/fo-3741_1_beluga-caviar

Bronzi, P., & Rosenthal, H. (2014). Present and future sturgeon and caviar production and marketing: A global market overview. *Journal of Applied Ichthyology*, 30(6), 1536-1546. doi:10.1111/jai.12628

Buffington, D., Bucklin, R., Henley, R., & McConnell, D. (2016). *Greenhouse ventilation*. University of Florida: EDIS. Retrieved from <http://edis.ifas.ufl.edu/ae030>

CAP expenditure in the total EU expenditure. (2016). European Commission.

Charles, E., & Paquotte, P. (1999). Product differentiation, labelling and quality approach: Developments and stakes in the french shellfish market. *Aquaculture Economics & Management*, 3(2), 121-129. doi:10.1080/13657309909380239

- Chen, X. (1993). *Comparison of inbreeding and outbreeding in hermaphroditic arianta arbustorum (L.) (land snail)*. *Heredity*, 71(5), 456-461. Retrieved from <http://www.nature.com/hdy/journal/v71/n5/abs/hdy1993163a.html#References>
- Damian, Mac Can Uladh. (2015, Jul 4,). Trail goes cold for greek snail producers as crisis halts exports. *The Irish Times (1921-Current File)* Retrieved from <http://search.proquest.com/docview/1775707223>
- Daudon, S., & Vergos, E. (2015). "Farmitization": Can agriculture take root for economically displaced Greeks? *Fork to Farm: International Journal of Innovative Research and Practice*, 2(1) Retrieved from <http://journalf2f.afs.edu.gr/index.php/f2f/article/view/53>
- Donadio, R. (2012, Jan 9,). With work scarce in athens, greeks go back to the land. *The New York Times* Retrieved from <http://search.proquest.com/docview/1705829659>
- Duggan, T., & Chronicle, S. F. EscarGrow farms' unusual snail business finds niche in food scene. Retrieved from <http://www.sfchronicle.com/restaurants/article/EscarGrow-Farms-unusual-snail-business-finds-7221359.php>
- Educated young greeks seek life as farmers. (2012, Mar 27,). Retrieved from <http://www.keeptalkinggreece.com/2012/03/27/educated-young-greeks-seek-to-life-in-the-countryside/#comments>
- Eisenberg, R. (1966). The Regulation of Density in a Natural Population of the Pond Snail, *Lymnaea Elodes*. *Ecology*, 47(6), 889-906. doi:10.2307/1935637
- Ejidike, B. N., Afolayan, T. A., & Alokun, J. A. (2004). Observations on some

climatic variables and dietary influence on the performance of cultivated african giant land snail (*Archachatina marginata*): Notes and records. *Pakistan Journal of Nutrition*, 3(6), 362-364. doi:10.3923/pjn.2004.362.364

EUROPA - european commission. (2016). Retrieved from

[https://europa.eu/european-](https://europa.eu/european-union/about-eu/institutions-bodies/european-commission_en)

[union/about-eu/institutions-bodies/european-commission_en](https://europa.eu/european-union/about-eu/institutions-bodies/european-commission_en)

EUROPA - european parliament. (2016). Retrieved from [https://europa.eu/european-](https://europa.eu/european-union/about-eu/institutions-bodies/european-parliament_en)

[union/about-eu/institutions-bodies/european-parliament_en](https://europa.eu/european-union/about-eu/institutions-bodies/european-parliament_en)

European Parliament. (June 2015). Supporting Young Farmers in the EU. European Parliament,

European Union. (2005). Commission regulation (EC) no 2073/2005 of 15 november 2005 on

microbiological criteria for foodstuff. *Official Journal of the European Union*, , L338/26.

Fitzgerald, J. (2011). The benefits of vinyl flooring. Retrieved from

https://www.homeimprovementpages.com.au/article/the_benefits_of_vinyl_flooring

García, A., Perea, J., Martín, R., Acero, R., Mayoral, A., Peña, F., and Luque, M.,

“Effect of two diets on the growth of the *Helix aspersa* Müller during the juvenile stage”, in Proceedings of the 56th Annual Meeting EAAP Uppsala, 1-9. 2005.

Hedrick, R., McFarland, J., Stanke, D., & et al. (2010). *Ventilation for acceptable indoor air quality*. Atlanta, Ga: Ashrae.

Hill, B., & Bradley, B. D. (2015). *Comparisons of farmers incomes in the EU member states*.

University of London.

Hsin-I Feng, C. (2012). *The tale of sushi: History and regulations*. *Comprehensive Reviews in Food Science and Food Safety*, 11(2), 205-220. doi:10.1111/j.1541-4337.2011.00180.x

National Advisory Committee On Microbiological Criteria For Foods (NACMCF).

Hazard Analysis and Critical Control Point Principles and Application Guidelines; (1997).

Lombard, M., & Snyder-Duch, J. (2001). Interactive advertising and presence.

Journal of Interactive Advertising, 1(2), 56-65.

doi:10.1080/15252019.2001.10722051

Jess, S., & Marks, R. J. (1995). Population density effects on growth in culture of the edible snail *helix aspersa* var. *maxima*. *Journal of Molluscan Studies*, 61(3), 313-323. doi:10.1093/mollus/61.3.313

Keefe, L. M. (2004). What is the meaning of 'marketing'? *Marketing News*, 38(15),

17. Retrieved from <http://search.proquest.com/docview/216422757>

Koutsou, S., Partalidou, M., & Petrou, M. (2011). Present or absent farm heads? A

contemporary reading of family farming in greece. *Sociologia Ruralis*, 51(4),

404-419. doi:10.1111/j.1467-9523.2011.00541.x

Market definition. (2010). Retrieved from

<http://www.netmba.com/marketing/market/definition/>

Martin, K., & Sommer, M. (2004). Effects of soil properties and land management on

the structure of grassland snail assemblages in SW germany.48(3), 193-203.

Retrieved from <http://dx.doi.org/10.1016/j.pedobi.2003.12.004>

Messari, S., & Pastore, S. (2014). HELICICULTURE AND SNAIL CAVIAR: NEW TRENDS IN THE FOOD SECTOR; Future Trends and Challenges in the Food Sector, , 79-90.

Moss, P. (2012, June 27,). Greeks turn to farming as economic crisis bites. *BBC News*

Retrieved from <http://www.bbc.com/news/world-europe-18592929>

Murphy, B. (2001). *Breeding and growing snails commercially in australia*. (No. 00/118). Australian Government: Rural Industries Research and Development Corporation.

Niche marketing. (2017). Retrieved from

<http://www.businessdictionary.com/definition/niche-marketing.html>

Ohta, T., Miyake, Y., & Hiura, T. (2011). Light intensity regulates growth and reproduction of a snail grazer (*gyraulus chinensis*) through changes in the quality and biomass of stream periphyton. *Freshwater Biology*, 56(11), 2260-2271. doi:10.1111/j.1365-2427.2011.02653.x

Parlapani, F. F., Neofitou, C., & Boziaris, I. S. (2014). Microbiological quality of raw and processed wild and cultured edible snails. *Journal of the Science of Food and Agriculture*, 94(4), 768-772. doi:10.1002/jsfa.6438

Pattinson, H. M., & Low, D. R. (2011). *E-novation for competitive advantage in collaborative globalization*. US: Business Science Reference. Retrieved from <http://replace-me/ebraryid=10480586>

PlumbNation Limited (n.d.). Heating Calculator. Retrieved April 25, 2017, from

<https://www.plumbnation.co.uk/heating-calculator/#hlcRoomHeight=2.25hlcRoomWidth=3.5hlcRoomLength=5hlcGlazedArea=0&wallType=woodFrame&belowRoom=soilUnderConcreteFloor&windowType=noWindows&roomType=bedroom&externalWalls=3&aboveRoom=pitchedRoofInsulated50>

Psaropoulos, J. (2013). Greeks go green thumb to fight recession. Retrieved from <http://www.aljazeera.com/indepth/features/2013/06/201361812573351473.html>

PurSolar & Electrical. Solar panel efficiency and the factors that affect it. Retrieved from <http://www.pursolaraz.com/learn-about-solar/what-affects-solar-panel-efficiency-2/>

REGULATION (EC) no 178/2002 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 28 January, 2002, (2002).

Rummell, N. (2012). The sluggish and the sumptuous: Snail caviar slips onto a few menus. Retrieved from <http://www.starchefs.com/cook/savory/product/escargot-caviar>

Snail Farmers' Cooperative of Greece. Goods. Retrieved April 11, 2017, from <http://snailcoop.eu/index.php/proionta>

Schnecken Elektrozaun. (2015). Electric fence - our electric fence for do it yourself. Retrieved from http://www.schnecken-elektrozaun.de/shop_content.php?coID=20

Solem, A. G. (2015). *Gastropod* Encyclopædia Britannica Inc.

Sutherland, L. (2015). New entrants into farming: Lessons to foster innovation and

entrepreneurship. EIP-AGRI Agriculture and Innovation.

Thompson, R. (1996). *Raising snails*. United States: United States Department of Agriculture.

Tilley, N. (2011). Sterilizing soil: How to sterilize soil. Retrieved from <https://www.gardeningknowhow.com/garden-how-to/soil-fertilizers/sterilizing-soil.html>

Toften, K., & Hammervoll, T. (2009). Niche firms and marketing strategy. *European Journal of Marketing*, 43(11/12), 1378-1391. doi:10.1108/03090560910989948

Trevors, J. T. (1996). Sterilization and inhibition of microbial activity in soil. *Journal of Microbiological Methods*, 26(1), 53-59. doi:10.1016/0167-7012(96)00843-3

United Kingdom. (2014). *Guidance on producing, harvesting and importing terrestrial edible snails for human consumption*. Online: United Kingdom.

United States Department of Agriculture. (2016). United states department of agriculture animal and plant health inspection service plant protection and quarantine. Retrieved from https://www.aphis.usda.gov/plant_health/permits/downloads/snails_containment_guidelines.pdf

Varro, M. T. *De Re Rustica (Country Matters)*, (Thayer, B Trans.), University of Chicago http://penelope.uchicago.edu/Thayer/E/Roman/Texts/Varro/de_Re_Rustica/3*.html

Voichita Gheoca. (2013). Can heliculture act as a tool for edible land snails' natural

populations' management in romania? Management of Sustainable
Development, 5(2), 21-25. doi:10.2478/msd-2013-001

Winter, K. (2013, October 9th,). Snail farms on the rise in britain as snail meat – and
their 'earthy, salty' eggs - become latest low fat food trend.

<http://Www.Dailymail.Co.Uk/Femail/Article-2450954/Aylesbury-Escargot>

[Snail-Farms-Rise-Britain-Snail-Meat-Eggs-Latest-Food-Trend.Html](http://Www.Dailymail.Co.Uk/Femail/Article-2450954/Aylesbury-Escargot)

Photo sources:

Stock photos:

Cover Photo, Retrieved from

<http://media.wsimag.com/attachments/9957f1ae6736a760a37de64f65ef36d4af77038a/sto re/fill/860/645/f4b71d815148d6f8c62e130d 275ca162a76f90413bd3af64efbabec138e/S nail-Caviar.jpg>

Abstract, retrieved from

https://pixabay.com/p-65358/?no_redirect

Table of contents, Retrieved from

<https://sc02.alicdn.com/kf/UT8lQ41XrxaXX agOFbXa/Snail-Caviar-White-Pearl-Caviar- Afrodite-MADE.jpg>

Introduction, created by Paul DeMarco

Background, in order of appearance,
retrieved from

Retrieved from

https://pixabay.com/p-547594/?no_redirect

Retrieved from

https://upload.wikimedia.org/wikipedia/com mons/thumb/b/b7/Flag_of_Europe.svg/500p x-Flag_of_Europe.svg.png

Methods

https://pixabay.com/p-65358/?no_redirect

4.5 (Snow) retrieved from

https://pixabay.com/p-1024923/?no_redirect

Conclusion and recommendations, Photo
taken by Paul DeMarco

Conclusion, Photo taken by Patrick Kroyak

Figures:

1. Graph created by Lily Randle
2. Graph created by Lily Randle
3. Photo taken by Lily Randle
4. Photo retrieved from (Beggs, 2003)
5. Photo retrieved from
<http://www.escargot-world.com/wp-content/uploads/2016/03/ric-brewer-2.jpg>
6. Photo retrieved from
https://upload.wikimedia.org/wikipedia/com mons/0/06/Helix_pomatia_laying_eggs.jpg
7. Photo provided by Evangelos Vergos
8. Image created by Paul DeMarco
9. Image retrieved from
https://upload.wikimedia.org/wikipedia/com mons/b/b8/HK_CWB_%E9%A6%99%E6%B8%AF%E6%80%A1%E6%9D%B1%E9%85%92%E5%BA%97_Excelsior_Hotel_%E5%A3%BD%E5%8F%B8_Sushi_%E7%9B%A4_Dec-2011.jpg
10. Image taken by Lily Randle
11. Sketch drawn by Lily Randle
12. Photo provided by Evangelos Vergos
13. Photo retrieved from
<http://www.olympuseducation.com/wp-content/uploads/2017/01/amreican-farm-school.png>
14. Photo taken by Patrick Kroyak
15. Photo taken by Evangelos Vergos
16. Photo taken by Patrick Kroyak
17. Photo taken by Patrick Kroyak
18. Photo taken by Patrick Kroyak
19. Photo taken by Patrick kroyak

20. Photo retrieved from <http://www.milkplan.com/site/index.php/en/products/solutions/mp-pasteurizer>
21. Photo taken by Lily Randle
22. Photo taken by Patrick Kroyak
23. Photo taken by Patrick kroyak
24. Photo taken by Paul DeMarco
25. Photo created in *SOLIDWORKS* by Patrick Kroyak
26. Photo created in *SOLIDWORKS* by Patrick Kroyak
27. Photo created in *SOLIDWORKS* by Patrick Kroyak
28. Photo created in SmartDraw by Paul DeMarco
29. Photo retrieved from https://c1.staticflickr.com/6/5217/5536629424_32acbedd78_b.jpg
30. Photo retrieved from https://c1.staticflickr.com/8/7185/6950426743_abf3c76f0e_b.jpg
31. Photo retrieved from https://upload.wikimedia.org/wikipedia/commons/5/55/Rockwool_4lbs_per_ft3_fibrex5.jpg
32. Image retrieved from Fisher Scientific purchasing website
33. Photo created in *SOLIDWORKS* by Patrick Kroyak
34. Image retrieved from Fisher Scientific purchasing website
35. Image retrieved from https://pixabay.com/p-283775/?no_redirect
36. Image retrieved from https://pixabay.com/p-283775/?no_redirect
37. Image retrieved from https://c1.staticflickr.com/4/3805/11164910946_4512b8a788_b.jpg
38. Image retrieved from https://pixabay.com/p-232368/?no_redirect
39. Image retrieved from <http://www.publicdomainpictures.net/pictures/100000/velka/balls-of-cotton-wool.jpg>
40. Photo created in *SOLIDWORKS* by Patrick Kroyak
41. Photo created in *SOLIDWORKS* by Patrick Kroyak

Appendix A:

Biology of Snails

Under the phylum of *Mollusca* and in the class of *Gastropoda*, is a group of animals commonly known as the gastropods. It is under this taxonomy classification that the snail can be found. These gastropods are unique from other animals as they can survive in fresh water, the ocean, and on dry land. The variety of habitats that snails can live in allow for a broad range of shapes and sizes to appear amongst different species. These sizes can range anywhere from less than 1 millimeters to greater than 130 centimeters (Solem, 2015). When in Greece, the species of snail that will be utilized is a land breed of snail known as *Helix aspersa maxima*, shortened to *Helix aspersa*.

Although the sizes vary amongst different species, all snails have the same basic, anatomical structure. The body of the snail can be divided into 3 segments. The first is the head, which contains 2 sets of tentacles. The first set contains the eyes and is used for seeing, and the second set is used for feeling (Murphy, 2001). In land snails, the tentacles containing the eyes are able to retract into the head (Solem, 2015). The mouth is also located on the head and contains a tongue that is covered in teeth (Murphy, 2001). The snail's tongue is called the radula. The radula continues to grow throughout the entire lifespan of the snail, and new teeth grow with the radula in order to replace the old teeth as they become dull. The size and shape of the radula, as well as the number of teeth on the radula are species specific (Solem, 2015). Additionally, the genital orifice of the land snail is located on the snail's head. It can be located on the snail's right side (Murphy, 2001). In other species of snails, the genital orifice is located in part of the tissue that connects the head to visceral mass together as well as to the shell. This connective tissue is called the mantle tissue (Solem, 2015).

The second portion of the snail's anatomical structure is known as the visceral mass. The visceral mass can most generally be described as the main body of the snail. Inside of the visceral mass is where all of the internal organs are contained (Murphy, 2001). The visceral mass can be found largely up into the shell of the snail. The shell protects these vital internal organs which include those involved in the digestive, excretory, reproductive and respiratory systems. The visceral mass has three openings on the posterior end. There are the nephridiopore, an opening for the kidneys, the gonophore, which is where the snails will give birth from, as well as the anal opening for food byproduct waste to be excreted (Solem, 2015).

The final of the three main portions of the snail structure is the foot. The foot is used as the snail's primary form of movement. The foot produces a slime that limits friction during movement as well as provides a protective layer against parasite infestation (Murphy, 2001). The foot itself is flat and muscular. There are glands across the foot utilized for the slime excretion as well as cilia that cover the foot. The foot can be used on land, or in sea. There are some species of snails that are able to amputate part of their foot to use as a distraction against predators (Solem, 2015).

Snails are considered to be a hermaphroditic species as each snail contains both male and female reproductive organs (Murphy, 2001). An important note, however, is that snails cannot self-fertilize (Murphy, 2001). The only method of reproduction is through two separate snails mating (Thompson, 1996). During mating, each snail will either assume a role as male or female, or there will be reciprocation between each snail and both snails will assume both roles (Solem, 2015).

Appendix B:

Interview with Greek Snail Farmers

Introduction: Hello, we are American students working with the American Farm School and are researching snail farming in Greece. Your experience in this subject matter is valuable to our understanding and we are wondering if you would be willing to answer some questions we have with regards to snail farming. Would you mind if we recorded this interview and used the information we gather in our final report?

1. What led you to start farming?
 - a. Why snails?
2. What problems have you faced with regards to snail farming and how have you overcome them?
3. Do you sell any other escargot products besides snail meat?
 - a. What are these products?
4. Can you estimate annual revenue and net income?
 - a. Can you estimate annual costs of running your operation?
 - b. What do you see as the market for snail meat in the next 5 years?
5. Snail caviar is an expensive product and can be sold at €65 for 30 grams. This more expensive product requires more labor and a higher start-up cost to build the facilities needed, but could result in greater profits than just snail meat. What factors would affect your decision in producing snail caviar instead of just snail meat?
 - a. How would you handle an increase in labor?
 - b. How could the cost of conversion deter you from switching to farming snails for caviar?
6. What would interest you in attending a class/seminar that taught snail caviar farming techniques?
 - a. What would you like to learn in a class/seminar regarding snail caviar?

Appendix C:

Interview with Restaurant Chefs

Introduction: Hello, we are American students partnering with The American Farm School to better market a snail caviar product they plan to be introducing this summer. With your expertise on the local cuisine of Thessaloniki, we are wondering if we would be able to ask you some questions to gauge how snail caviar will fit? Would we be able to record this interview and use the information gathered in our final report?

1. Could you describe how you've included specialty items on your menu to enhance your dishes?
2. Escargot caviar, or snail eggs, was a delicacy in ancient Greek and Roman times. Currently, it has seen a resurgence as a luxury food item in parts of Europe. As a chef, what sort of information would you like to know about snail eggs before you would use them in your cooking?
 - a. Could you explain how you might use snail eggs in your cooking?
3. What types of dishes do you think escargot caviar could be incorporated in?
4. As mentioned earlier, snail caviar was considered a delicacy in antiquity. How do you think that a dish including snail caviar would appeal to some of your clients?
5. Snail caviar could potentially cost € 2.16 per gram (€65 for 30g jar). Would the cost be a disincentive for you to include snail caviar in a dish?

Appendix D:

Dan Carmody

Introduction: Hello, we are American students from Worcester Polytechnic Institute, in Massachusetts. We're in Thessaloniki and doing an 8-week project with the American Farm School on snail caviar. Since we're engineers/science students, part of the project is to design a production facility for snail caviar that could be attractive to current snail farmers who might be interested in producing snail eggs. But we are also investigating potential markets for snail caviar. We are hoping to find out how you see both the potential and challenges to market Greek produced snail egg caviar in the US. Would we be able to record this interview and use the information gathered in our final report? Can we quote you in our report or would you prefer to have your comments remain confidential?

1. Snail eggs were eaten in antiquity but for most people are a little known product. How much familiarity do you have with snail eggs as a product?
2. Escargot caviar, or snail eggs, was a delicacy in ancient Greek and Roman times. Currently, it has seen a resurgence as a luxury food item in parts of Europe. What information would you want to know about snail caviar?
3. Research has shown snail caviar could potentially cost \$100 for a 1oz jar. Given the high cost, what is the market niche for snail caviar?
4. Snail eggs are produced primarily in Italy, France, and Spain with distributors in the U.S. What marketing strategies could help Greek producers distinguish their product from competitors in other countries?
5. What are some of the challenges Greek producers would face getting a foothold and then expanding in the US market?
 - a. Given these challenges, how have you seen international producers overcome these obstacles?
6. What do you see as the opportunities for the product in the U.S.?
7. What strategies do you see being successful for Greek caviar producers attempting to market in the U.S.?
8. How can international producers gain access to distribution channels in the U.S. marketplace?
9. Can you describe resources that are available for Greek producers exporting into the U.S.?

10. Can you describe any special regulations that internationally grown products are subjected to with regards to hygiene or imports?