November 10, 2017

Feasibility Study for Cowboy Cricket Farms
Final Report

Prepared for Prospera Business Network
Bozeman, MT

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Contents

Cowboy Cricket Farms Feasibility Study Final Report: 11/10/17

Executive Summary

Human consumption of insects is known as entomophagy, and currently estimated to feed about 2 billion people daily. Founded in 2016, Cowboy Cricket Farms (CCF) seeks to exploit opportunities to enter the entomophagy and related markets. CCF has established a foothold in these markets, and operates a pilot scale cricket production facility in Belgrade, MT.

As a new manufacturing business CCF faces many challenges, not the least of which is overcoming the natural aversion many domestic consumers have with regard to consuming insects. Additionally, CCF is presented with the challenge of managing a herd of several million crickets along with developing and refining the processes required to convert living assets into consumable products. The manufacturing elements of CCF's enterprise are known, and can be overcome with diligent effort. Nearly any issue CCF faces with respect to manufacturing has likely been solved at least in some manner by mainstream food producers.

As an emerging industry, entomophagy presents many opportunities for entrepreneurs such as CCF. Research and analysis conducted for this report illuminated the value of cricket Frass (manure) for use as a horticultural fertilizer as the primary revenue generator for CCF. Exploration of emerging market alliances with entities such as Dane Creek Capital and Aspire Food Group present CCF with strategic opportunities for collaboration.

Focus of Report

Montana Manufacturing Extension Center (MMEC) entered into an agreement with Prospera Business Network to provide a feasibility study funded by the USDA for Cowboy Cricket Farms (CCF) LLC. The expected outcome of the study will provide CCF with a documented manufacturing plan, the required investment, the expected ROI, and all documentation including costs, to scale manufacturing operations to full production for cricket product manufacturing using research obtained and documentation of manufacturing requirements, Value Stream Mapping (VSM), the Cost of Goods Sold (COGS) and the Return on Investment (ROI).

Cowboy Crickets Company Overview

History and Goals

After serving as a Gunners Mate in the US Coast Guard, Kathy Rolin founded CCF in 2016 while studying nutrition at Montana State University. Along with her husband, James, Marketing Manager for Cowboy Cricket, they proudly make their home in Bozeman, MT with three lovely young children. They see consumption of crickets as a way to provide a sustainable alternative to many other animal products such as beef and chicken at a fraction of the environmental cost and in a way that can be grown to benefit the expanding population of our planet.

CCF focuses on being a market leader supplying Frozen Whole Crickets, Dried Whole Crickets and Cricket Powder with a future focus on serving additional market segments within the entomophagy (edible insects) market in America and beyond.

Strategies and tactics

The initial business focus of CCF is to grow and market primarily Frozen Whole Crickets. The processes and technologies evaluated in this report will provide CCF with better insight as well as empirical data to evaluate what additional market segments they should focus on in the future.

Products

Current Product List

Frozen Whole Crickets (FWC) – FWC constitutes the majority of CCF inventory. FWC product is supplied to customers as a frozen (not dried) product having completed the mature growth stage, purging of their intestines and euthanasia by freezing.

Dried Whole Crickets (DWC) – DWC product is supplied to customers as a shelf stable product having completed the mature growth stage, purging of their intestines, euthanasia by freezing and a final drying process. The drying process reduces moisture content to allow a longer shelf life, and provides a unique flavor and consistency.

Cricket Powder (CP) – CP product follows the same process as the DWC product with an additional step of grinding after the drying process. It is supplied as an on the shelf product to the customer.

Frass – Expelled fecal material from crickets which has substantial market potential as a fertilizer for plant growers.

Ready to Eat (RTE) Product List (manufactured at CCF commercial kitchen) -

- Chocolate Chirp Cookies
- Smokey Jumper Whole Roasted Crickets
- Ancient Amber Cricket Suckers

Potential Products

Extracted Cricket Oils (ECO) – Investigation into the market and processing requirements for ECO will continue as CCF continues growth and development of their Initial Product List, and then looking at the stand-alone dietary supplements market.

Figure 1 - Current CCF Products

Market Overview and Analysis

Research Approach

Market, product, supply chain, and related information was collected from a variety of sources and organized into an overview Idea Map as seen in Figure 2. The detailed ***Idea Map*** with all source documents will be with this document. Sources included publicly available market research, topical journals, web searches, industry trade show materials, Hoover's reports, and product information. Interviews were conducted with two companies on the value chain for cricket products.

The idea map has links to hundreds of resources and articles, organized in the sections shown here:

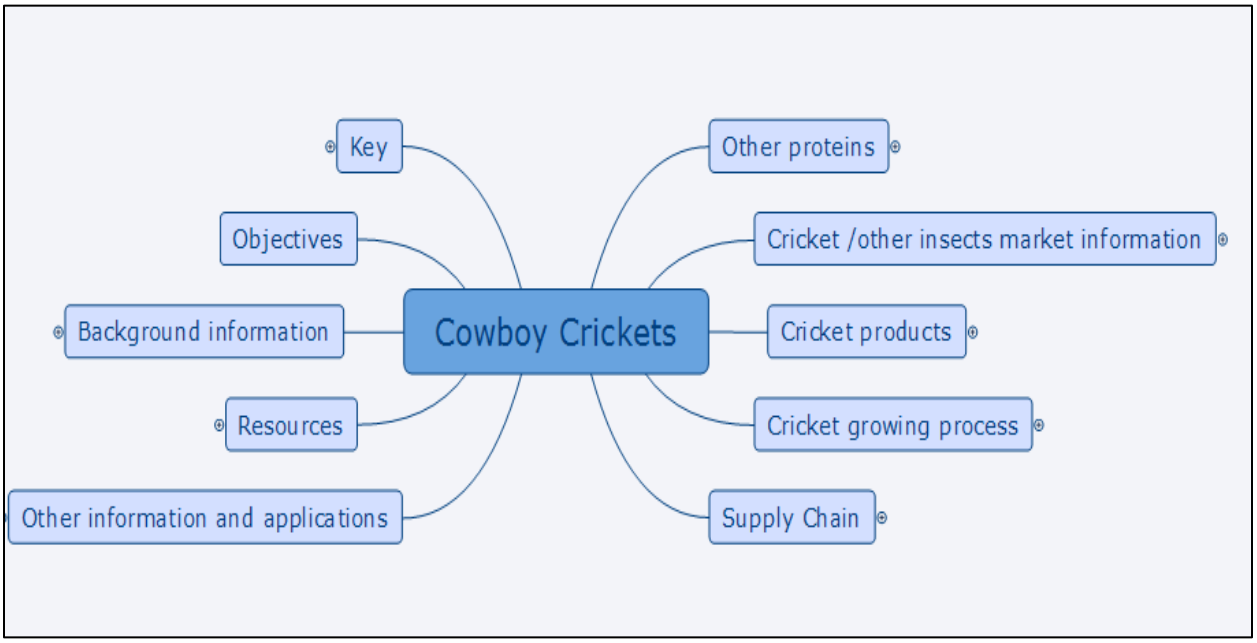


Figure 2 - Idea Map Summary

The research phase included:

- Reviewing blog posts, press releases, and related materials for market information
- Identifying scientific and technical data related to cricket and insect farming
- Considering other protein sources available to consumers
- Identifying 20 companies related to cricket production and products, some who have folded in the past 3 years
- Interviewing two companies in the value chain
- Reviewing Hoover's reports for nine companies

Insights

To better understand the market and value chain, a sub-set of companies on the cricket value chain were evaluated for market size and funding as seen in Figure 3. CCF is the subject of this report, and the other companies listed below were reviewed to learn more about funding, market activities and value chain fit and activities.

Figure 3 - Cricket Market Companies

Overall, the U.S. cricket market across the value chain is fairly new, with most companies starting since 2011. While the Hoover's reports suggest that even the more well-known products such as Chapul are still only $500,000/year businesses, this seems to contradict the level of funding many companies are receiving. Very little public information is available to confirm investment amounts claimed in press reports from companies receiving funding. A Forbes article (link included on Idea Map) states that Exo received $4mil in Series A funding from AccelFoods Collaborative Fund and other angel investors. Many companies on the cricket value chain, for example Entomo and Exo, are privately held so their sales are not reported. The largest brand in this category is Chapul, and according to founder Pat Crowley 'they are projected to have sales of $1 million this year due to a distribution deal with UNFI, a national distributor of health food products.' See graphic display of information in Figure 4.

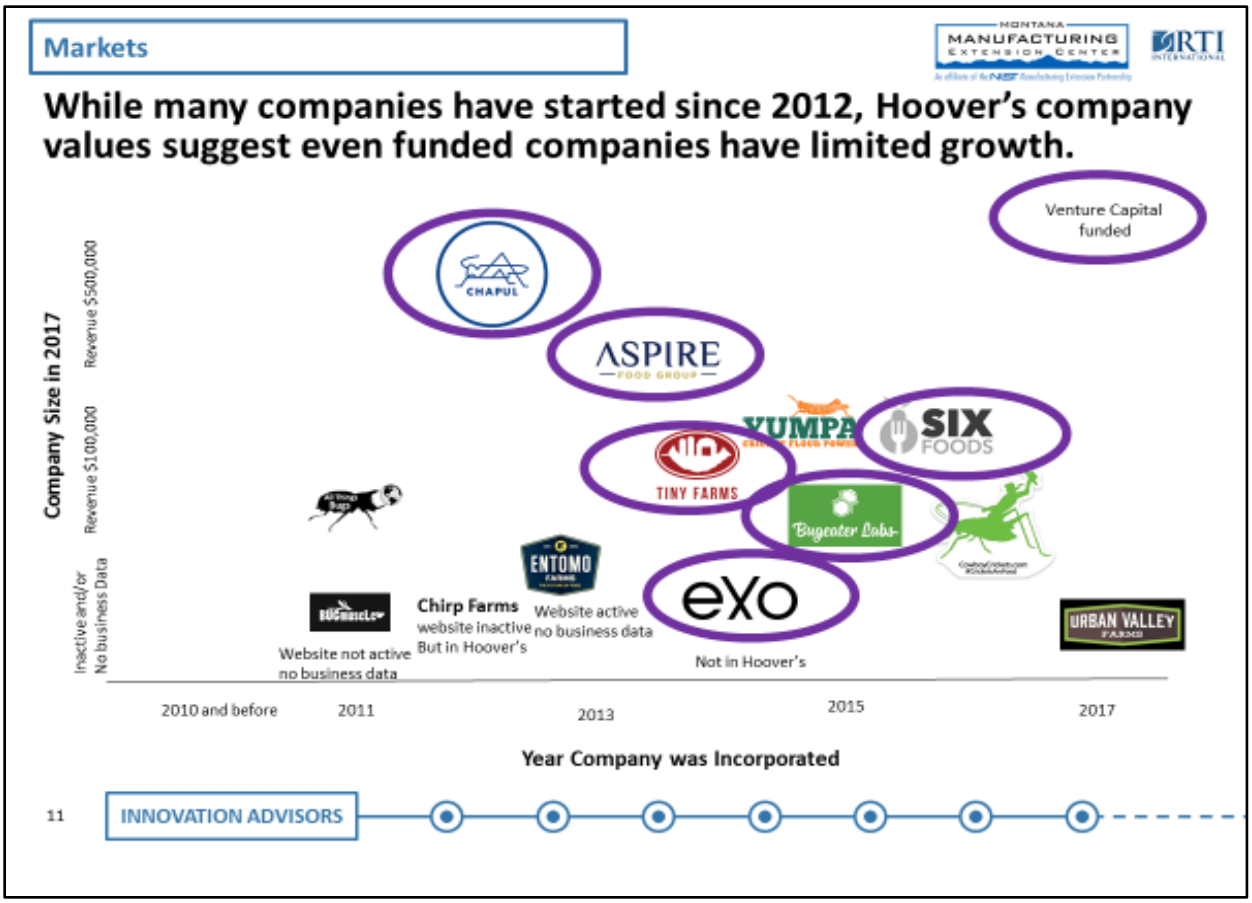


Figure 4 - Venture Funded & Revenue Generated Cricket Companies

Funding across the value chain (see Figure 5) – from grow-out and cricket powder production through packaged goods such as bars and chips - has been strong in the past 3 years. That funding appears to be based on the promise of an assumed-to-be growing market. When Abir Syed, Director of Finance for Aspire, was interviewed at the recent Natural Products Expo in Baltimore and asked if the new robotic farming facility in Austin, TX was filling a market need or creating a glut of product, he pivoted on his answer and said 'there's a long history of cricket consumption in Mexico and South America, so Austin is a good location to supply that market.'

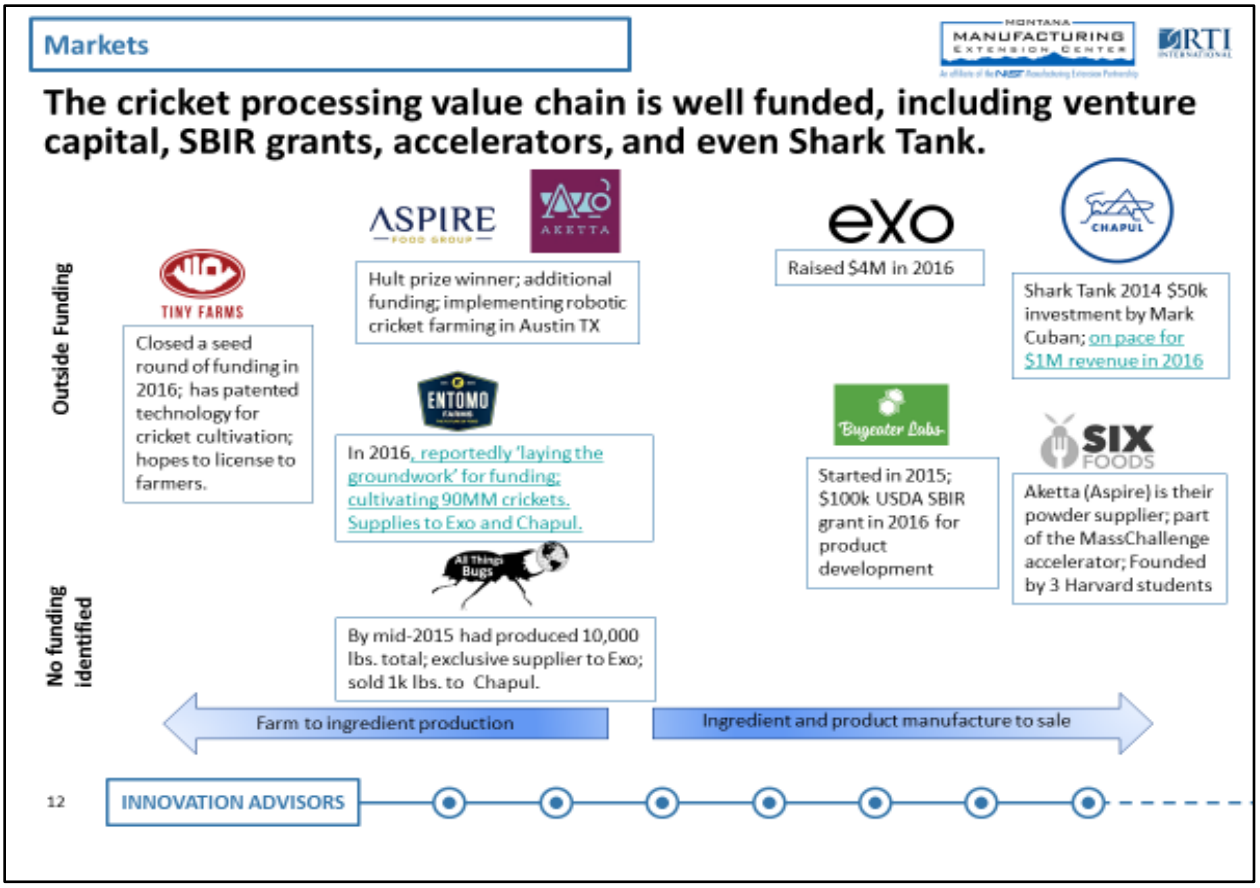


Figure 5 - Funding Summary Cricket Companies

The dichotomy between the US cricket market and the global edible insect market may be largely due to local consumption norms. Research And Markets reported in Feb 2017 that 'Global Edible Insects Market to Reach $1.53 Billion in 2021', while GlobeNewswire (NASDAQ) reported in July 2016 that 'Edible Insects Market size set to exceed USD 520 Million by 2023, with over 40% Compound Annual Growth Rate (CAGR) from 2016 to 2023.' In both reports the increase of insect consumption is tied to the growing energy bar market in the US. If more US consumers do not specifically select energy bars containing insect protein from the many products available, then the US projected growth may be overestimated in these reports. The GlobeNewswire report calls out that Asia-Pacific (APAC) is the largest consumer region. The EU is expected to show some increase, and Latin America 'dominated by Brazil, is predicted to expand substantially in the future.'

Consumers have many choices when looking for protein sources. At the Natural Products Expo East in Baltimore in September 2017, there were over 1,500 exhibitors; 107 of these used the word 'protein' in their company description. There were six companies who listed offerings of 'plant protein', 11 who used the word 'chickpea' in their description, and 21 who had products from hemp. Only two companies – Six Foods and Aketta – featured cricket products.

Consumers in the US are showing a larger interest in plant protein options compared to other protein sources like crickets or algae. Food Navigator reported in September 2017 that the US plant protein market was up 8% this year.

In July 2014, New Hope Network published an article on 'Cricket Consumption: can edible insect products like Chapul Bars find a market?' The article states the benefits of consuming insects, but then quotes David Sax as saying, 'If it doesn't deliver any greater experience than the novelty, then what is the ultimate end?' The article discusses that cricket flour sells wholesale for $30/lb while whey protein concentrate is $1.34/lb. When looking at the protein in a Chapul bar, the article points out that a consumer would need more than a dozen bars to reach their Recommend Daily Allowance (RDA) for protein, and that crickets are the fourth ingredient – behind peanuts which are known as a plant-based protein. Furthering the comparison, the article points out that 'a shopper could buy more than 11 pounds of peanut butter for the price of one pound of cricket flour.' A product like an energy bar with cricket powder is only a value-added product to consumers if the consumer believes there is value in the product.

One market for insects on the horizon is pet food. In November 2016, Dockside Pets was founded with funds from Dane Creek Capital and a mission to create sustainable pet foods which removes meats and produce from the food waste stream. Dane Creek has made investment and acquisitions in their short tenure as a funding partner in a number of companies on the pet food supply chain in Canada including Midgard, a startup growing crickets for the pet food industry. Dane Creek is actively pursuing other opportunities for investment in the pet food supply chain as stated on the homepage of their website.

While crickets are promoted as being a more sustainable source of protein, a study highlighted by Lux Research (Figure 6) suggests that while more sustainable than beef, crickets are not more sustainable than other protein sources such as peas and soybeans.

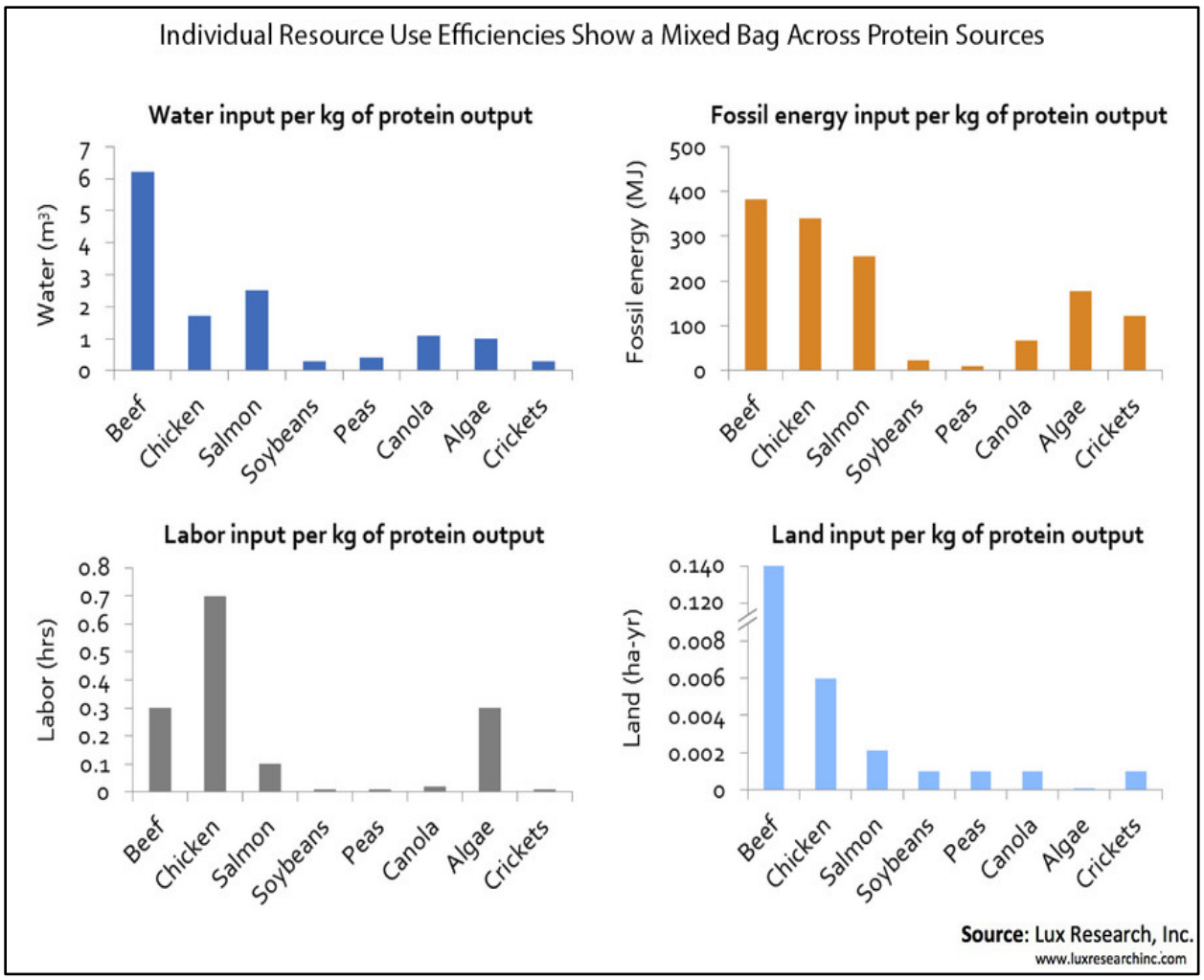


Figure 6 - Protein Resource Use

An additional challenge the cricket powder market faces is price. While cricket powder often sells for $20-$30/lb wholesale ($0.04-0.07/ gram), most other proteins are available at lower costs, as seen in this 2014 chart from the Australia Grains and Legumes Nutrition Council in Figure 7.

Source of protein		Estimated Average Cost per 100g	Estimated Cost per gram of Protein
Legumes	Baked beans	$0.29	$0.06
	Beans (canned varieties)	$0.32	$0.04
	Chickpeas (canned)	$0.32	$0.04
	Lentils (dried)	$0.50	$0.02
	Lentils (canned)	$0.35	$0.04
	Peas (dried)	$0.35	$0.02
Other sources of protein	Beef (rump)	$1.40	$0.04
	Chicken (breast)	$1.40	$0.05
	Eggs (free range)	$0.60	$0.04
	Nuts (almonds)	$2.00	$0.10
	Fish (salmon fillet)	$2.70	$0.10

Figure 7 - Cost for Protein

Opportunities on the value chain may depend on how quickly the US market, and to a certain extent the EU and other markets, will respond favorably to cricket products. The value chain appears to be ready to meet the additional demand with funding either in place or being considered from Tiny Farms for cricket grow-out, to Aspire Foods for factory farming, to Six Foods and Chapul retail products securing investments on Shark Tank. With many articles written about the rise of cricket products, there are still challenges. Laura D'asaro, co-founder of Six Foods LLC, reflected on these challenges when talking about sourcing cricket powder for their products at the Natural Products Expo recently. 'Sure, lots of people say they can produce cricket flour for less than $30 a pound. So far that's been empty promises. We buy from Aketta. With all they've invested in robotics they will probably be providing a lower price soon.'

Can US consumers overcome their aversion to eating crickets? Perhaps not, but perhaps they are comfortable feeding crickets to their pets as part of a more sustainable food source.

Marketing Strengths, Weaknesses, Opportunities, and Threats

Strengths	Weaknesses
Demonstrated ability to grow-out Products developed	Process efficiency Powder quality/particle size inconsistent
Opportunities	**Threats**
Funding across the value chain is creating more media attention, which may increase consumer trial Pet food companies focused on sustainable ingredients	Well-funded companies already across the value chain - Tiny Farms and Aketta/Aspire in flour production Consumers have other protein choices with good nutrition, lower cost, and are already part of the US diet

Manufacturing Requirements

Location and Building

CCF is located in commercial space near the Bozeman Yellowstone International Airport in Belgrade, MT. Currently they occupy 1,800 ft^2 space used for their farming facility – which includes a cricket nursery separated from the growing, harvesting and processing facility. Separation of these facilities are required for control of precise growing temperature and humidity conditions. Nursery conditions are optimally held at 85-90 degrees F and 45% relative humidity (RH) in the room, with the interior of the bins around 90-100% RH. Conditions of approximately 85°F and 45% RH are best for healthy cricket maturation during the growth cycle.

Upon completion of a conjoining building, CCF will gain access to another 1,800 ft^2. This space will accommodate cricket processing as the current facility will be used to manage the increased herd size. By Jan 2018, CCF expects to have 2,400 ft^2 of production space accommodate a 20,000,000 cricket herd size for incubation, growth, harvesting, processing and shipping of all cricket products.

Labor

Fully staffed, CCF will employ 5 full-time (40 hours/ week) and 2 part-time employees. Owners James and Kathy Rolin will be involved in all aspects of the business and included in the full-time staff count. The three other full-time positions include a farm manager, a lead researcher and a software engineer. The two part-time employees will be a kitchen manager at 1/3 time for CCF farm responsibilities and a secondary researcher at ¼ time.

Name/ Title	Percent FTE
Kathy Rolin/ Owner & Operator	100%
James Rolin/ Marketing Manager	100%
Kitchen Manager	33%
Lead Researcher	100%
Assistant Researcher	25%
Software Engineer	100%
Farm Manager	100%

Machines

Machine requirements for production processes are documented with VSM processes to match with specific process flow diagram for each production step. Special emphasis is placed on drying and grinding processes as these require specialized equipment, set up and handling.

Regulatory

CCF is currently working on a Hazard Analysis and Critical Control Points (HACCP) plan. A copy of the HACCP plan was not provided for review and comment.

Due to process duration and degree of manual operation, the potential for foreign object and metals inclusion will need to be addressed in the HACCP plan.

As CCF does not appear to have short-term plans to exceed $1MM in sales, they are exempt from immediate compliance with the Food Safety Modernization Act (FSMA). However, many retailers will require any company providing food products to be FSMA compliant prior to reselling. The sale of RTE (Ready to Eat) products by CCF through other retail venues is especially vulnerable to FSMA compliance requirements being imposed by market forces.

Inventory

CCF will carry a lean supply of inventory including cookies and cricket powder for supplying customers. They will work closely with their wholesale buyers for production and shipping of FWC and DWC.

Value Stream Map/ Process Flow

VSM for CCF includes illustrations and discussions of process flow and accompanying time required for manufacturing cricket end products starting with breeding and growing through packaging and shipping. Additionally, discussion includes specificity of process requirements and equipment throughout the manufacturing lifecycle. Illustration of the overall manufacturing process is outlined below.

Overall Process and Timeline Process Flow Diagram

Figure 8 outlines the current overall process for cricket manufacturing at CCF which includes breeding, growing, harvesting and processing crickets to be ready for shipment to customers. Each of these processes are outlined in detail in the following figures.

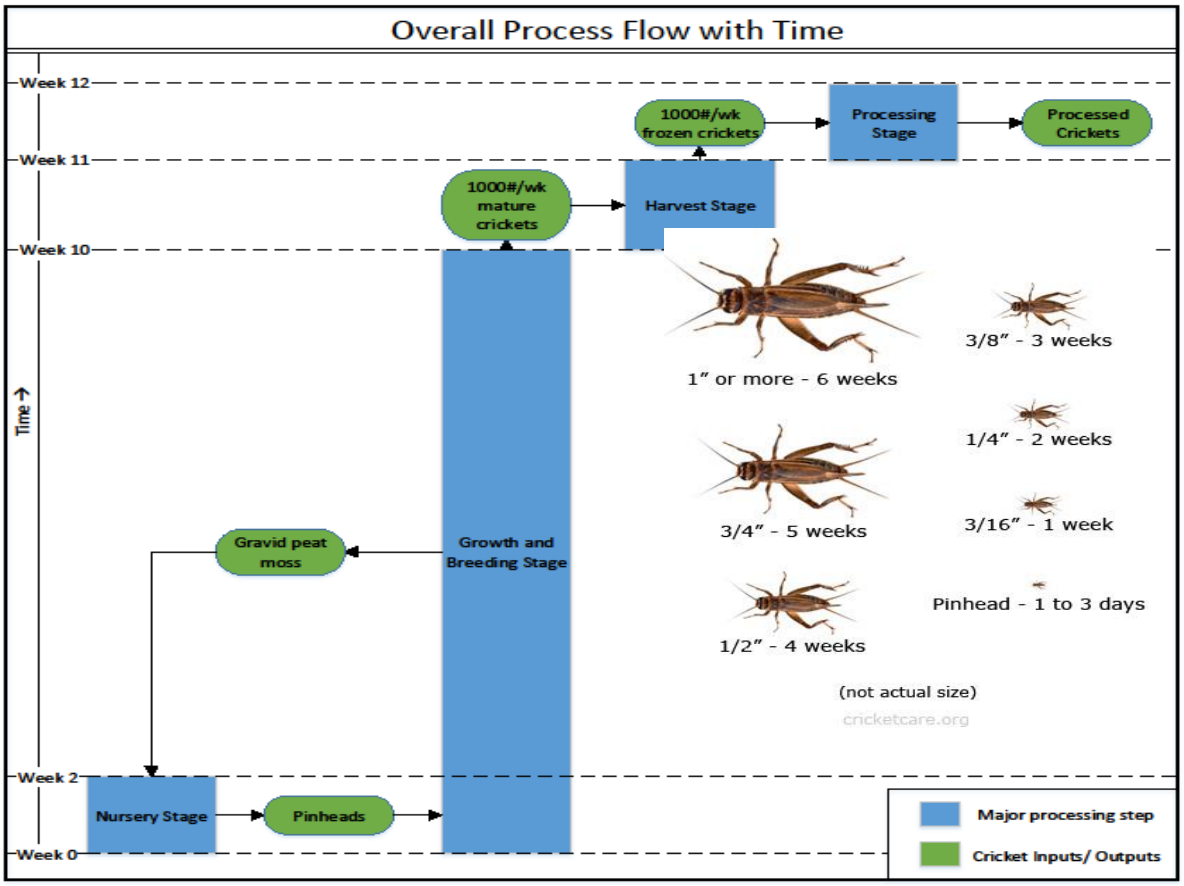


Figure 8 - Overall Process Flow

Growth and Breeding process

Cricket growth and breeding occur simultaneously and continuously during the CCF manufacturing process. To facilitate breeding when crickets are sexually mature, a container of egg laying medium is introduced to the bin. After sufficient time, the medium containing fertilized eggs is removed from the growth bin and placed in a separate hatching environment. Once juvenile crickets/ pinheads (approximately 3,000 in quantity) hatch from the nursery, they are moved into the growth and breeding bins. These bins are covered by a perforated lid and labeled with lot number/ID and date. Bins are stored in tiered racks in the facility main growth area. To facilitate healthy growth and breeding the growth bin facility is environmentally controlled to maintain temperature of approximately 85°F and 45% relative humidity (RH). Growth bin environmental conditions are not individually controlled, although this is a future goal. Further growing requirements include empty egg cartons for growth habitat, food, clean water sponges and specific temperature and humidity conditions. Food and water are typically monitored daily. Cricket growth stage is generally eight – ten weeks. Throughout the growth cycle, crickets consume food and water, and produce Frass (insect manure). Frass is periodically removed from the growth bin and stored to be sold as a fertilizing product. At approximately ten weeks of growth mature crickets are moved into the harvesting stage outlined in the next process flow diagram. See Figure 9 for Process Flow Diagram.

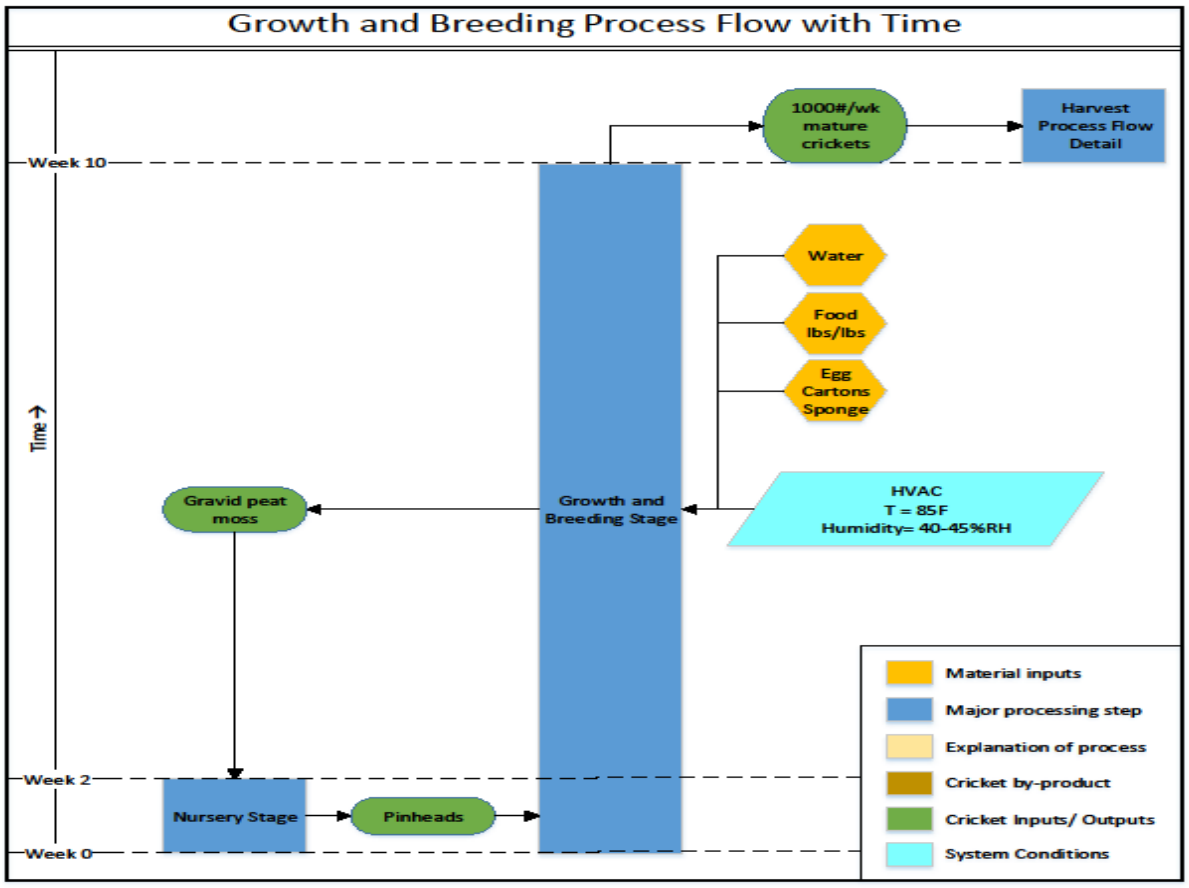


Figure 9 - Growth and Breeding Process Flow

Growth Stage Plan Discussion

CCF plans to develop automated feeding systems and environmental monitoring controls. CCF will work with Fall semester 2017 Montana State University (MSU) Software Factory students – a group of four upper division undergraduate students studying Computer Science – to develop these systems. The Software Factory students will develop a software system solution to monitor environmental controls and automate feeding. James Rolin, of CCF, will lead design and implementation of the needed mechanical hardware for the monitoring and automation systems.

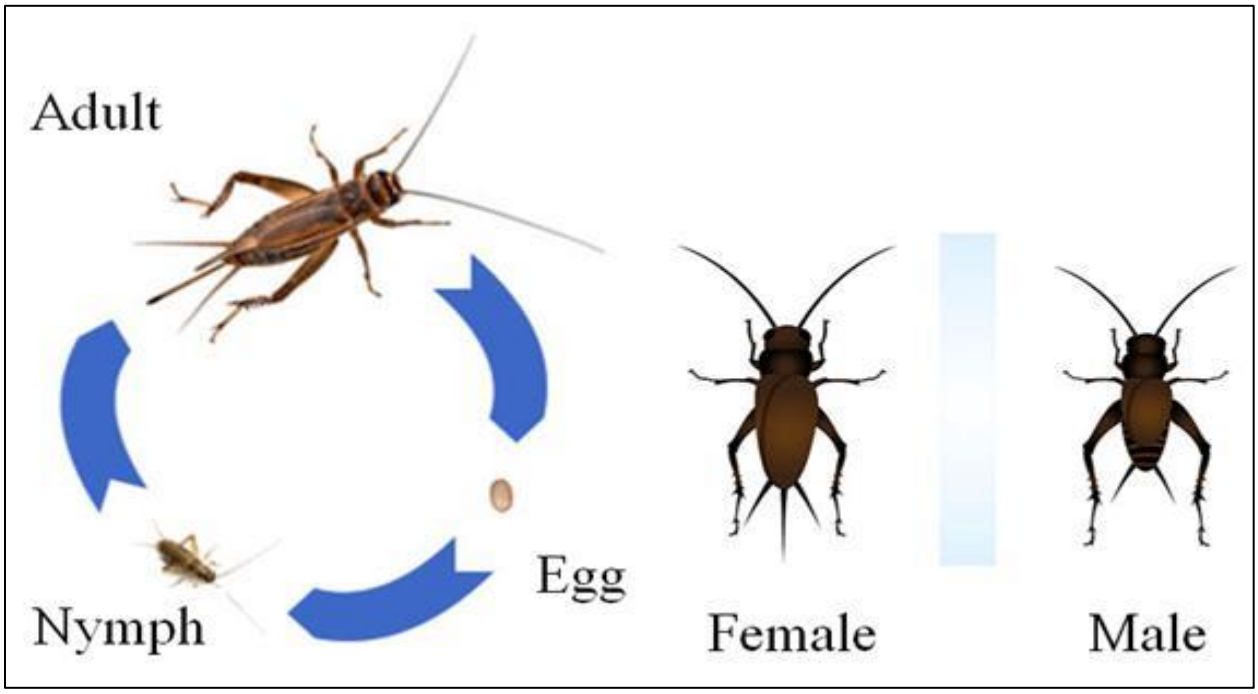


Figure 10 - Cricket Lifecycle

Harvest process

The harvest process begins at approximately eight to ten weeks with the completion of the growth cycle by separating the crickets from the remaining Frass and food. Live crickets are purged by ceasing addition of food or water for approximately 24 hours. The purge cycle is performed in order to reduce moisture content and partially digested food from the digestive tract. Once purged, live crickets are transferred to a clean processing bin, which is sealed and placed into the process freezer. As body temperature lowers, crickets transition into stasis (hibernation). Continued cooling results in euthanization.

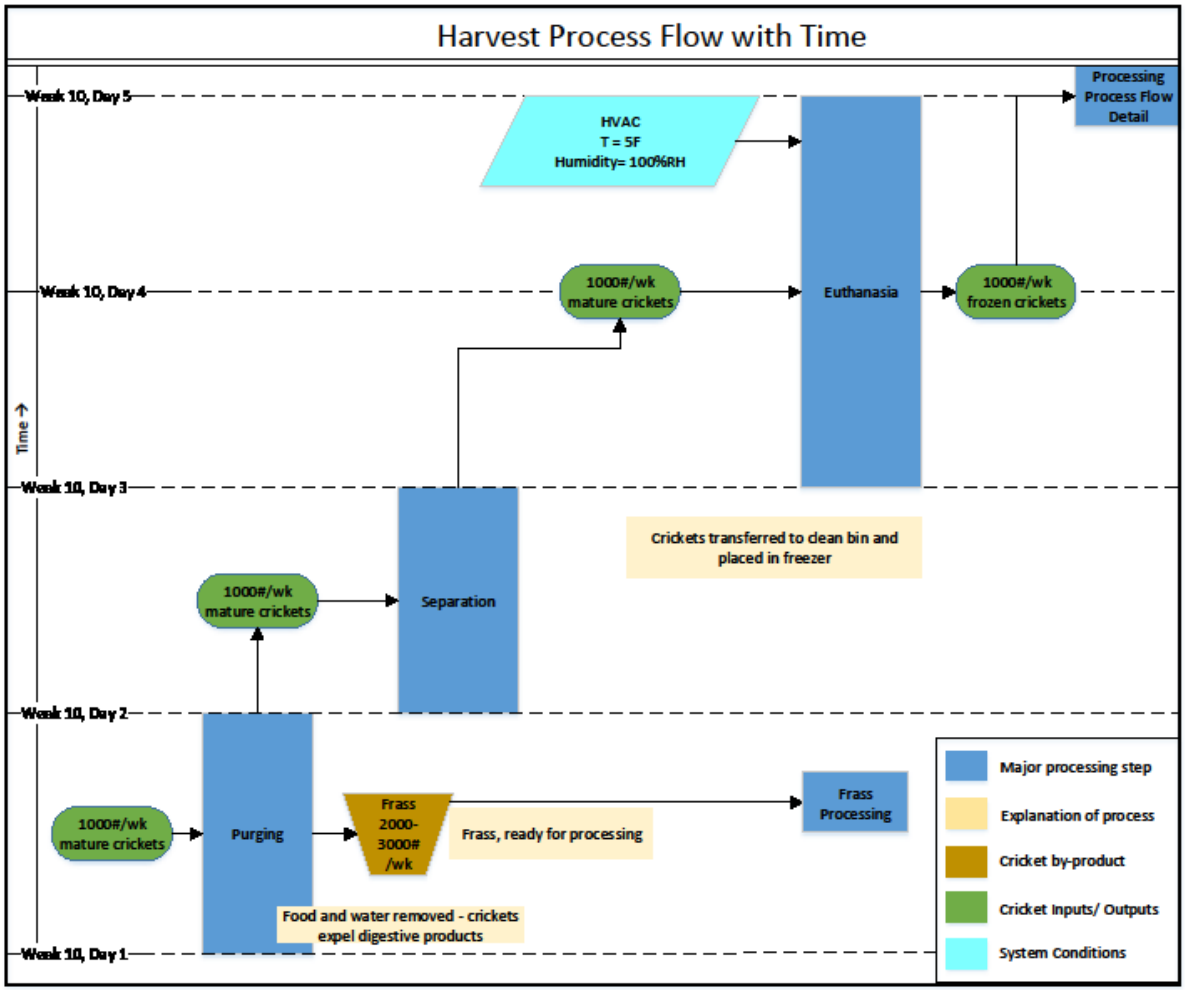


Figure 11 - Harvest Process Flow

Harvesting Discussion

The steps and methods of harvesting mature crickets are straightforward. Refinement and optimization of the harvesting processes do present opportunities for increases in efficiency and subsequent operating cost reductions. However, these potential advancements are secondary to potential efficiency gains in other process steps such as drying and grinding.

Processing

Processing of crickets transforms the raw ingredient, euthanized cricket, into finished product at CCF. Figure 12 illustrates the CCF manufactured product by percent, excluding Frass. Finished products coming out of the processing step are*:*

- Frozen Whole Crickets (FWC)
- Dried Whole Crickets (DWC)
- Cricket Powder (CP)
- **Byproduct** of cricket growth - cricket Frass

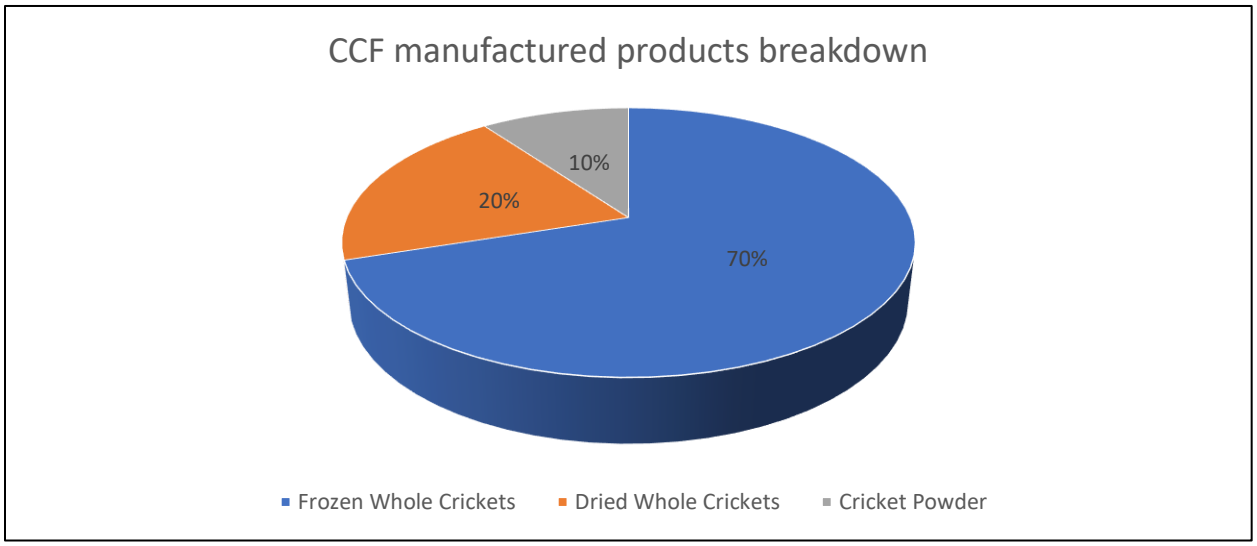


Figure 12 - Manufactured Products by Percent

Mass flow balances

The mass flow balance is included to understand capacity needed for processing crickets into finished product. The following table outlines the mass flow balance for CCF to produce their weekly goal of 1,000 lbs of FWC per week with total annual capacity of 50,000 lbs (assuming 50 production weeks). 1,000 lbs/wk annually yields 39,000 lbs of FWC, DWC and CP finished products, combined.

Product Description	% Start	Wt. Start	UoM	% Yield	Product QTY	UoM	Freq	Annual Total	UoM
Frozen Whole Crickets	70%	700	lbs	100%	700	lbs	Week	35,000	lbs
Whole Dried Crickets	20%	200	lbs	30%	60	lbs	Week	3,000	lbs
Cricket Powder	10%	100	lbs	20%	20	lbs	Week	1,000	lbs
TOTALS:	100%	1,000	lbs		780	lbs	Week	39,000	lbs
Frass				300%	3,000	lbs	Week	150,000	lbs

Illustration of the processing steps are outlined in Processing Process Flow in Figure 13 with discussion of the processing specifics to obtain a finished product. Process steps of drying, grinding and packing will be assessed separately in following discussions outlining needed equipment.

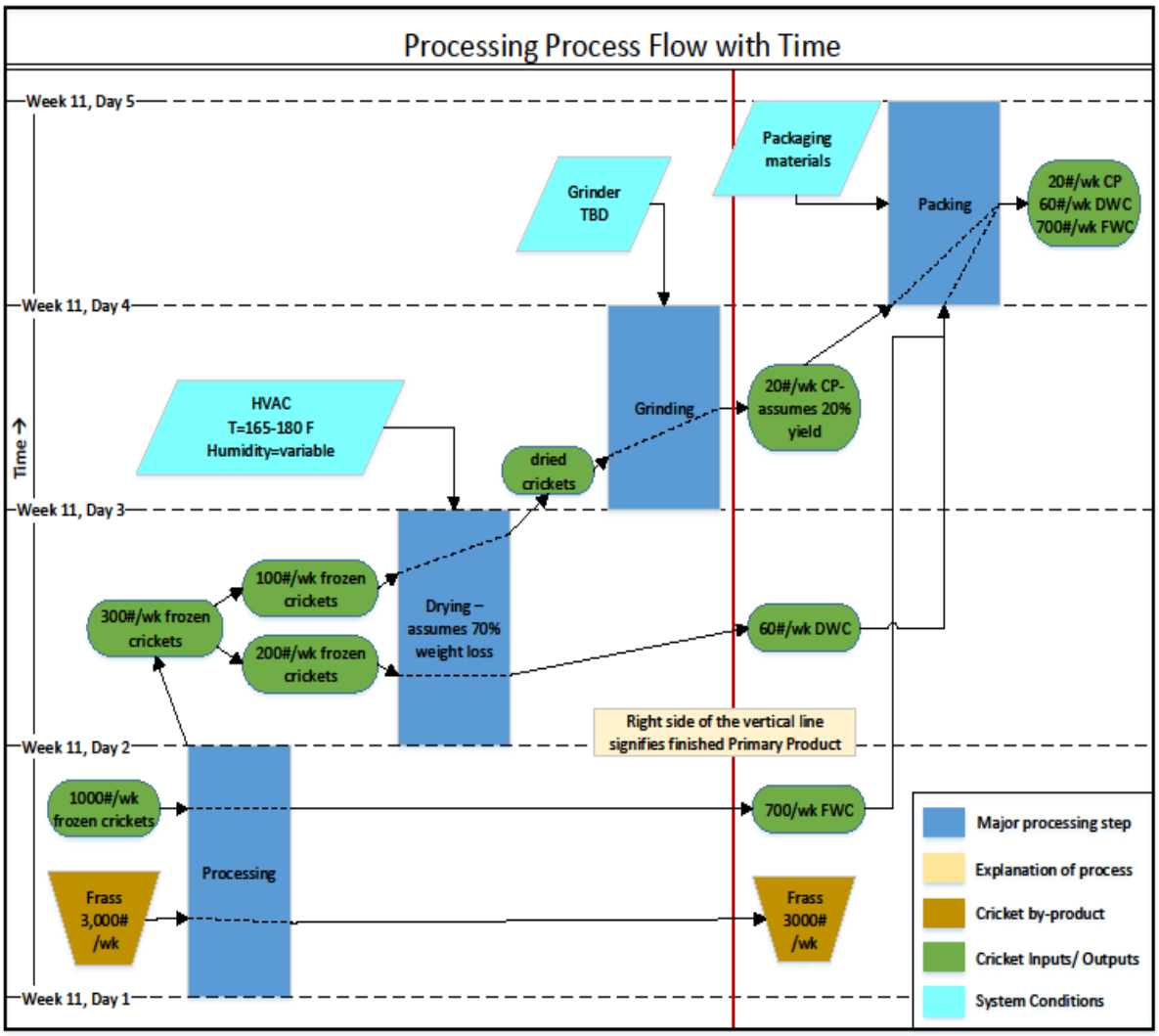


Figure 13 - Processing Process Flow Diagram

Frass Production, Processing and Product Discussion

Frass needs little processing to take it from farm to final packaging and shipping. However, careful considerations of Good Manufacturing Practice (GMP) will ensure appropriate handling to finished product. GMP dictates that Frass handling, processing and storage be segregated from edible CCF products. Due to inherent processes and similarity between cricket powder and Frass, the potential for cross contamination is considerable. Solid administrative and physical measures to prevent cross contamination should be developed and implemented.

Successful marketing and selling of Frass is of critical importance to the long-term viability of CCF. As can be seen in the financial analysis sections of this report, Frass sales are the most significant revenue and profit generator in the current business model.

Efficiency in Frass collection should be made a priority, as it is a low cost but clearly profitable material.

Drying

Drying of whole crickets presents a number of challenges. Crickets have a highly evolved exoskeleton that effectively resists moisture loss and enhances their climate tolerance. This same characteristic makes the process of removing moisture from the internal structure both difficult and time consuming.

Heat and time are the two main parameters available for the efficient drying of crickets. Increased heat during insect drying is an effective way to speed up the process. Higher temperatures increase the efficiency of drying, but can come at a cost with respect to product quality. As temperatures increase, other product attributes can be affected; oils and fats can oxidize, proteins and vitamins can be chemically altered, appearance and aroma can be negatively impacted etc.

Improper drying can also lead to issues with subsequent processing such as grinding and friability.

Continuous flow drying is commonly used in the food industry. The technology is mature and equipment is readily configured for most any drying application. Low operating costs are a benefit of continuous flow drying, but at the cost of substantial capital investment. CCF's current production capacity requirements do not justify the capital expenditure requirements of continuous drying equipment.

Freeze Drying methodologies are effective and have some positive attributes. However, the capital and operational costs for that approach are orders of magnitude above traditional time/temperature drying.

Current CCF Batch Drying

Assuming a drying requirement of 300 pounds of frozen whole crickets start weight each week, a batch dryer is still the most economical solution. CCF has been utilizing a small commercial batch dehumidifier for drying/roasting crickets with satisfactory results. Basic capacity information for this dryer can be found in the table below:

Parameter	QTY	Units
Pounds/batch:	7	lbs
Time/batch:	5	Hrs
Load/Unload:	1	Hrs
Total cycle time:	6	Hrs
Nominal cycles/week:	10	5 days/week
Nominal process Capacity:	70	lbs/week
Maximum cycles/week:	21	7 days/week
Maximum process Capacity:	147	lbs/week

At the maximum calculated capacity of 3 cycles/day; 7 days/week, the existing dryer will process about half of the required forecast capacity. Obtaining maximum process capacity would require personnel on-site at odd hours to assure completion of 3 cycles/day. Adding an additional dryer of the same capacity is an option to meet forecast production requirements of 300 pounds/week, but not seen as a viable solution due to scheduling and process setup issues.

Batch drying equipment options for CCF

This section outlines two potential batch drying options for CCF while not exhaustive of all options available on the market, these provide general information for market availability.

1. **Option 1** - Microwave assisted drying has been used for insect processing. Max Industrial Microwave, a Chinese company has a website offering insect drying equipment: http://www.maxindustrialmicrowave.com/microwave-drying-equipment-for-insect-and-bug-p-4.html. A quote from Max Industrial was solicited for CCF's drying application. Following is a synopsis of dryer data:

Type: Microwave Dryer MAXB-6
Dimension: 51"x 36"x 59" (L*W*H)
Drying Chamber: 705×700×500(mm)(L*W*H)
Microwave Power: 5KW
Rated Input Power: 9kvA
Microwave Magnetron 6 sets
Electrical Components: Delixi Components
Microwave Chamber: 304 Inner Stainless Steel(1.5mm)
Layers of Tray: 1 PP tray(two trays in total)
Diameter of Tray: ϕ500mm (16")
Rotating Speed of Tray: Frequency
Moisture Discharge : Axial Flow Fan
Timer Control: Flexible
Temperature Sensor: YES
Material Input: 1.5~1.8 kg/h at one time (3.3 – 4 lbs)
Weight: 230Kg (500 lb)
Microwave Frequency: 2450Mhz Power: 220 VAC (phase requirements not supplied) COST: $6500 EXW Thailand (installation and start-up assistance not included in price, but available at buyer's cost. Details in quote)

Based on photographs seen in Figure 14 and other web information, this technology appears to be viable. However, when purchasing equipment from an unknown source functionality, operational costs, equipment support and cost spares should be carefully evaluated prior to investment.

Figure 14 - MAX Industries photo of finished crickets

Additional quote details can be found in the Drying Equipment section of the CCF Mind Map. Capacity information provided by MAX Industries is contradictory; the written quote state a capacity of 13 – 20 lb/h, while data table shows capacity to be 3.3 – 4lb/h.

2. Option 2: A "lab scale" pasta dryer has been identified that matches the CCF production volumes and drying requirements. This unit consists of several trays, and is capable of drying approximately 100 pounds of crickets per load. Actual drying time would need to be determined empirically, but initial estimates put total drying time at between three – five hours.

   This dryer utilizes conventional conductive/convective heating and resembles a large commercial upright refrigerator. A removable wheeled cart that holds 34 drying trays is included. The cart is loaded and unloaded outside of the dryer. The multiple trays allow for consistent loading density, along with much higher capacity than the batch dryer currently used by CCF.

Additional Dryer System information (dimensions in mm):

AUTOMATIC DRYER FITTED WITH PLC FOR LAB TESTS COMPLETE WITH ELECTRICAL PANEL, AND SCREEN TRAYS AND CARRIAGE
• Suitable for drying of short pasta AND OTHER PRODUCTS • Composed of ONE drying chamber and 1 pc carriage equipped with the following: ○ Chamber and access door made up of modular panels in STAINLESS STEEL sheet-panels, thickness ms. 60 and cofferdam in high-density polyurethane. Dimensions: mm. 750 x 2150 x h 2890 (3470); ○ Ventilation unit composed of 1 pc reversible, high-lifting fan with motor high temperature; ○ Heating group made up of finned resistance for thermal exchange; ○ Air exchange group made up of electric exhauster and motorized shutter connected to analogical probe for detection of relative humidity ○ Set of air conveyors for optimization of ventilation during DRYING ○ Made up of IP55 casing, equipped with PLC, brand Eaton model XV102 (5.7"), relevant operating panel and color graphic HMI (*Human-Machine Interface*), from which running of one or more dryers as well as independent programming of all drying phases can be controlled.
• <u>Cycle Programming Options:</u> ○ Independent manual control of ventilation, heating, exhausting and air exchange ○ Phase duration (in minutes) ○ Temperature and humidity - considers the minimum humidity threshold compared to the ideal temperature at the end of drying ○ Customized control of languages which can be entered by the simple filling of an Excel spreadsheet ○ Software and recipes to be stored on “SD memory card” for easy removal / loading of data in case of breakdown
The program is also pre-arranged for the following optional functions: • Electronic speed variation ventilation speed, Network printer, -Networking with supervision program controlled by PC
N. 1 LOOM-HOLDING CARRIAGE for looms (drying trays) measuring 60mm x120mm - thickness 50mm Suitable for static drying of short pasta. Composed of the following: • Base in stainless steel fitted on pivoting wheels

- 34 looms in anodized aluminum and thermal resistant, polyester mesh

Additional Specifications:

Code CPC50A
U.S. VOLTAGE 60HZ - UL/CSA COMPONENT AND
WIRING; THREE-PHASE
DELIVERY TO ITALIAN PORT: 70 DAYS FROM THE ORDER
PAYMENT: 30% DOWN PAYMENT AT THE PO; 70%
AT MERCHANDISE READY
SHIPPING COST: EXW-ITALY

Pricing:
Unit as described above is $42,000. A smaller, similar system is $36,000, but only has 25% of the capacity.
A manually controlled drying system similar to that described above would be about $10,000 less.
Shipping weight is approximately 1500 pounds including crate.
The manual system is a viable option. However, having real-time control of drying parameters including actual humidity and temperature process control inputs would be valuable with respect to developing and refining efficient and high quality drying programs. Additional PLC system benefits include, but are not limited to:

- Process is controlled for differences in drying volumes/weights
- Process is controlled for variation in tray loading and insect size variations
- Automatic operation
- Data logging of process parameters may be required for HACCP / FSMA compliance

Grinding & Sifting

Based on discussions with commercial food-grade grinding subject matter experts (SME), and equipment vendors the consensus is a hammer mill would be the appropriate process for size reduction of whole dried crickets into cricket powder.

The use of hammer milling for foodstuff size reduction is widespread, and considered mature technology. However, there is not much publicly available data with regard to specific set-up or configuration of hammer-milling equipment for cricket grinding. While there appears to be several operations that utilize hammer mills for cricket power production, operational parameters and specifics are likely considered to be intellectual property (IP) and treated as trade secrets.

MMEC found that industrial hammer mills suitable for cricket grinding start around $20,000. Secondary market (used) equipment is not uncommon, but the buyer would need to research used equipment suitability and condition prior to purchasing.

Some form of sifting is generally required for milling processes. Sifting assures removal of foreign objects and oversized material as well as the ability to separate ground material into different size classes.

New, automated commercial grade two or three-stage sifting equipment for cricket powder is estimated to be $10,000 - $15,000. Secondary market equipment is available, with the standard

admonition of making sure to research used equipment suitability and condition prior to purchasing. Due to low production levels, manual sifting of cricket powder is a viable option for CCF.

Among the benefits or purchasing new grinding equipment is vendor support with start of and system configuration. Used equipment can offer good value, but the need for start-up assistance should be taken into account in order to determine true cost of ownership.

Numerous consumer grinding products may be viable for grinding the CCF forecast production plan of 20 pounds/week of cricket flower. CCF personnel have had some experience in this area with less than satisfactory results.

Size distribution requirements of ground product should be accurately characterized for all commodities. Internally consumed cricket flower for RTE foods production such as Chocolate Chirp Cookies may not need the same level of homogeneity and particle size as does cricket powder intended for retail sale.

Wet Milling

Grinding crickets prior to drying is also an option. After grinding into a homogeneous paste, the resulting material could be effectively dried by a number of different methods.
Among the advantages of this approach:

- Potential retention of some nutritional and compositional attributes that may be adulterated during the drying process
- Flexibility with respect to milling equipment

Abundant information on wet grinding is available, as are potential contract wet grinding services. Additionally, United States Patent Application 20150132433 filed by Aaron Dossey (All Things Bugs) related to wet grinding and spray drying appears to have been abandoned in 2015. Links to this patent can be found in the CCF Mind Map.

Wet milling is viable technology for production of uniform, high-quality cricket powder and should be fully evaluated if CCF plans to substantially increase cricket powder production capacity in the future.

Cricket Oil Extraction

While not currently a process at Cowboy Crickets, there is interest in providing purified cricket oil products. An overview of the oil extraction process is given below:

Cricket oil extraction can be accomplished by a variety of methods. Extraction of food-grade oils is a multistep process, usually consisting of:

1. Compression – Ground crickets are compressed to increase density, reduce free oxygen content and concentrate oils. Some portion of oil recovery can be achieved during compression step.
2. Solvent Extraction – An organic solvent is introduced to remove desired oils. Supercritical CO_2 has also been used successfully for insect oil removal.
3. Recovery – Cricket oil is removed from solution with organic solvent via distillation or evaporation.
4. Purification – Removal of any solids from cricket oil product.
5. By-product Management – Remaining cricket material from extraction step is dried and further processed and packaged.
6. Solvent Recovery – Solvent used to extract oil is cleaned and purified for reuse in the process.

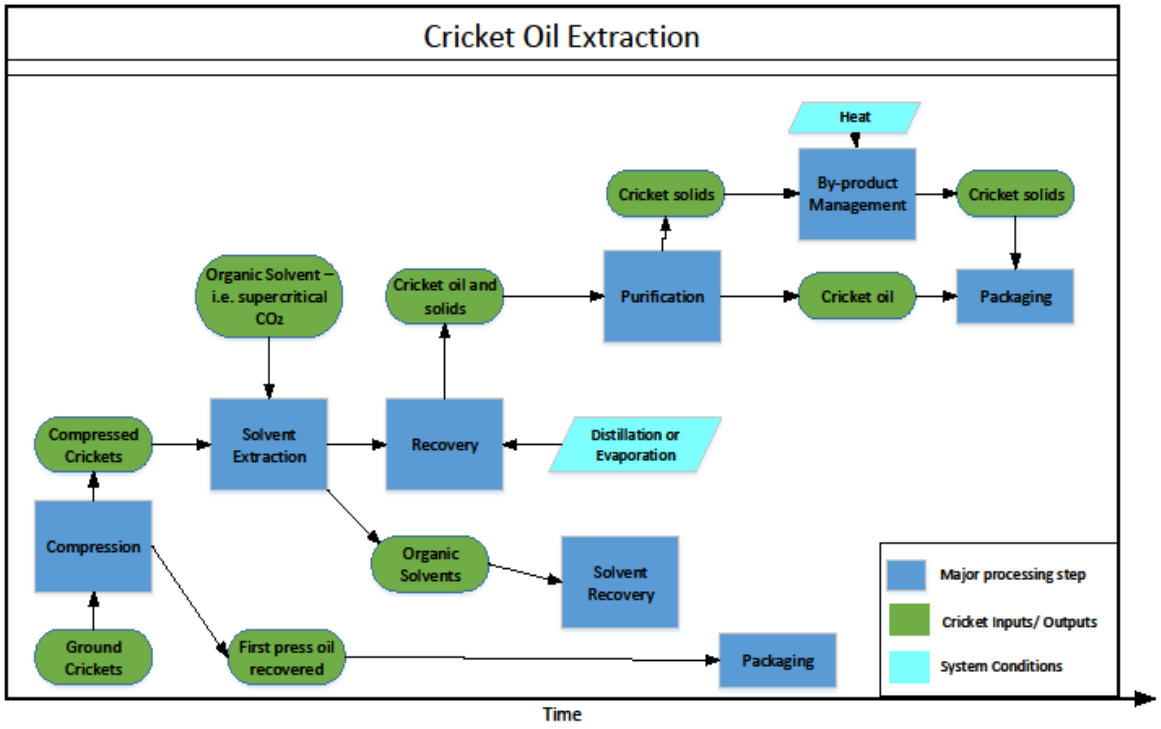


Figure 15 - Cricket oil Extraction

Due to the relative complexity of insect oil extraction processes, capital expenditures for entering this market are significant. In order to achieve economically viable economies of scale, minimum capital equipment investment to support food-grade cricket oil extraction are estimated to be $250,000 - $500,000. Additionally, market demand, pricing and the ability to provide sufficient ground cricket feedstock materials would all require additional investigation.

Packaging and storage

FWC constitute the majority of food product packaging requirements. Currently FWC is vacuum packaged in thermally sealed poly bags. Automated vacuum bagging equipment is readily available, with many vendor and configuration options. An estimated cost of $4,000 for a commercial, partially automated FWC bagging system was been included in the financial analysis.

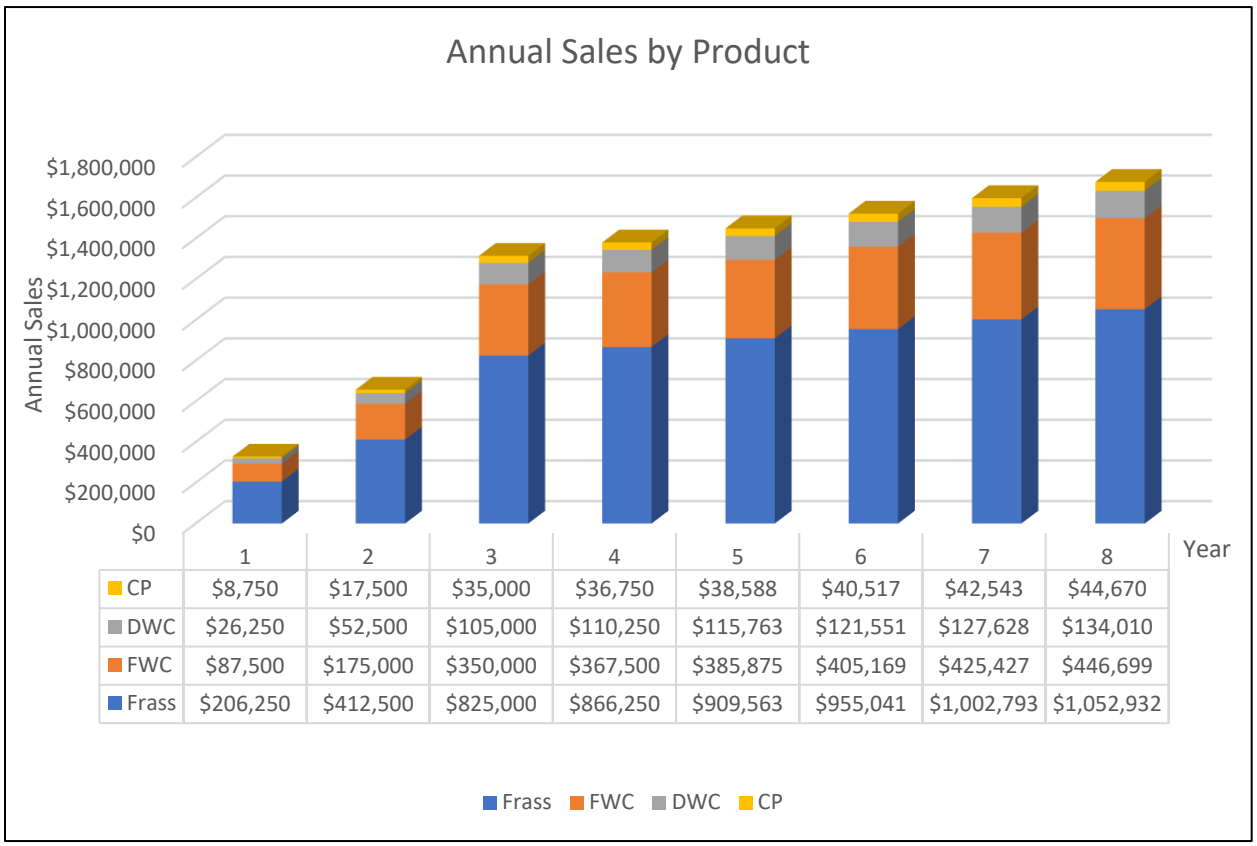
An estimated cost of $3,500 was used for RTE products bagging automation equipment. Specific packaging details along with degree of automation and subsequent staffing requirements need to be more fully defined prior to requesting actual bagging equipment quotes.

Financial Summary

A detailed spreadsheet analysis (***included in the detailed Idea Map***) provides the following summarized information with sales revenue, startup costs, operating costs, cash flow, breakeven volume, Cost of Goods Sold and ROI projection for eight years of production for CCF.

Sales Revenue

Sales data for CCF is based on ramping up production to 10,000,000 crickets in CCF herd and another 10,000,000 crickets from outsourced cricket farmers. Herd size of 20,000,000 will supply the needed 126,000,000 crickets for full annual production in year three. Resulting sales included in this analysis are from the production of FWC, DWC, CP and Frass. Figure 16 illustrates sales projections at 25%, 50% and 100% production in years one through three with 5% growth year four through eight.



	1	2	3	4	5	6	7	8
CP	$8,750	$17,500	$35,000	$36,750	$38,588	$40,517	$42,543	$44,670
DWC	$26,250	$52,500	$105,000	$110,250	$115,763	$121,551	$127,628	$134,010
FWC	$87,500	$175,000	$350,000	$367,500	$385,875	$405,169	$425,427	$446,699
Frass	$206,250	$412,500	$825,000	$866,250	$909,563	$955,041	$1,002,793	$1,052,932

Figure 16 - Annual Sales

As illustrated in Figure 17, Frass accounts for a large percentage (63%) of the CCF sales revenue. Sales revenue breakdown by product is shown in Figure #.

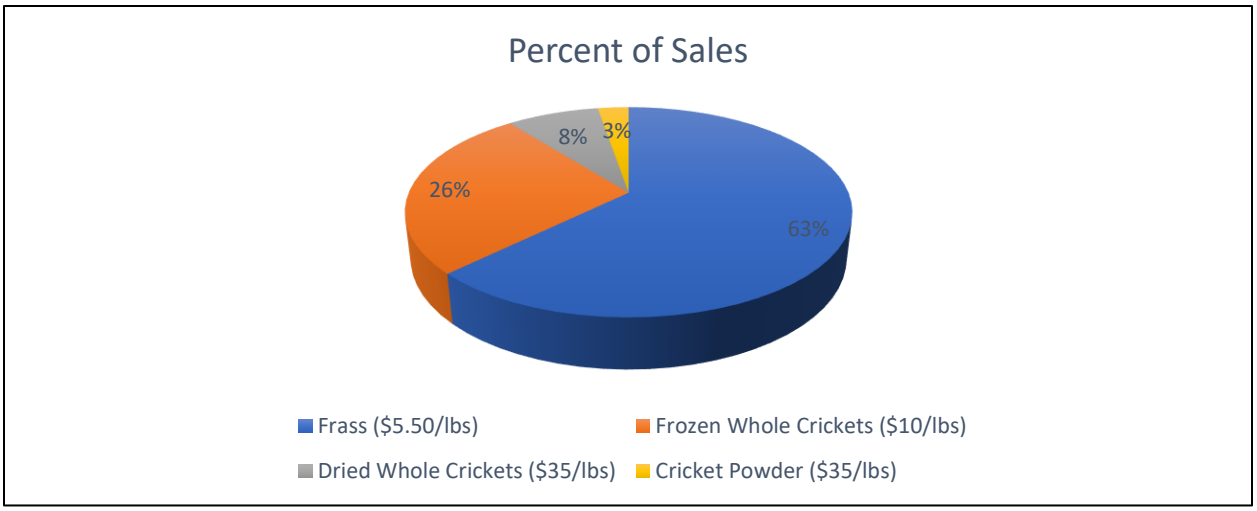


Figure 17 - Percent of Sales

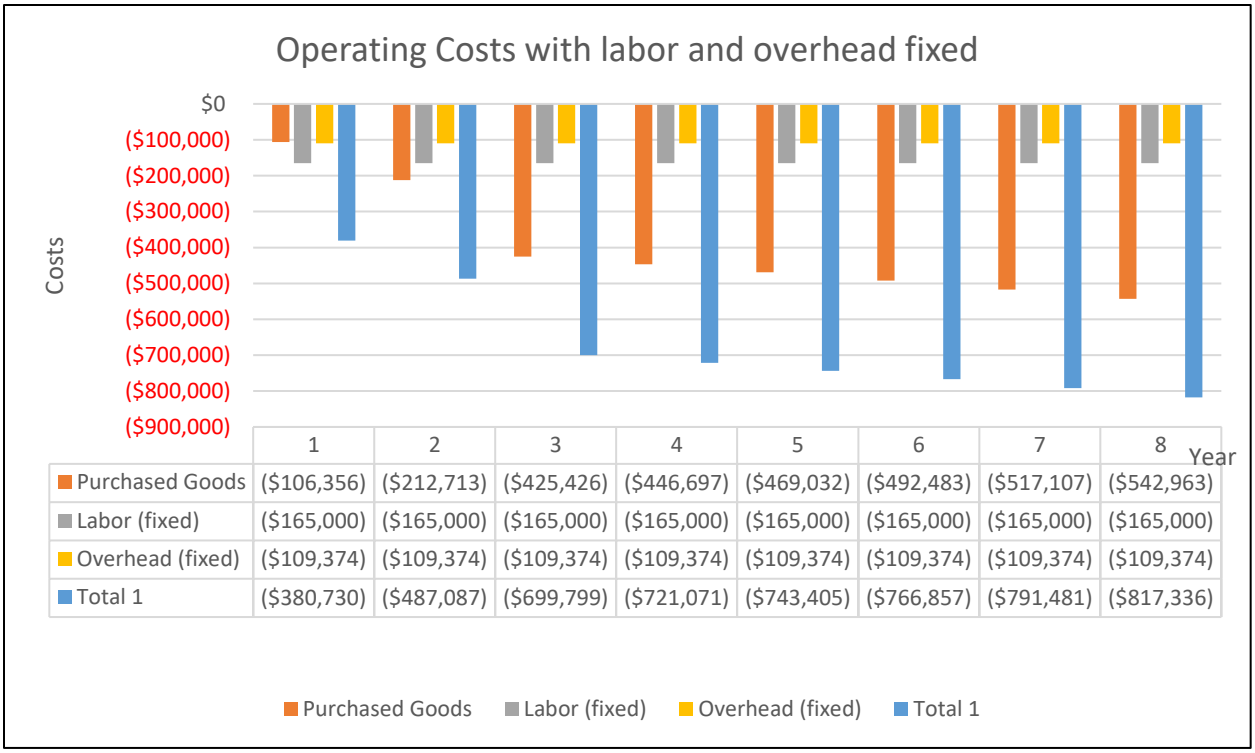
Startup Costs

Startup costs for CCF include capital intensive equipment purchases, equipment shipping and installation costs, rent deposit, Two months of working capital and 20% contingency reserves. Two months of working capital are the largest startup cost. The table below summarizes the startup costs for CCF to reach full production.

Startup Costs	
Building Rent Deposit	($3,100)
Cricket Grinding Machinery	($25,000)
Cricket Drying Machinery	($45,000)
Vacuum Sealer/ Packaging Machine	($4,000)
RTE Bagging Equipment	($3,500)
Refrigeration and Freezing Equipment	($38,000)
Cricket Housing Bins	($10,000)
Machinery Shipping Costs	($5,000)
Machinery Installation Costs	($5,000)
Machinery Electrical/Plumbing Installation Costs	($5,000)
Working Capital (2 months of revenue)	($220,043)
Concrete Work	$0
Building Modifications	$0
Contingency - 20%	($72,529)
TOTAL	($441,172)

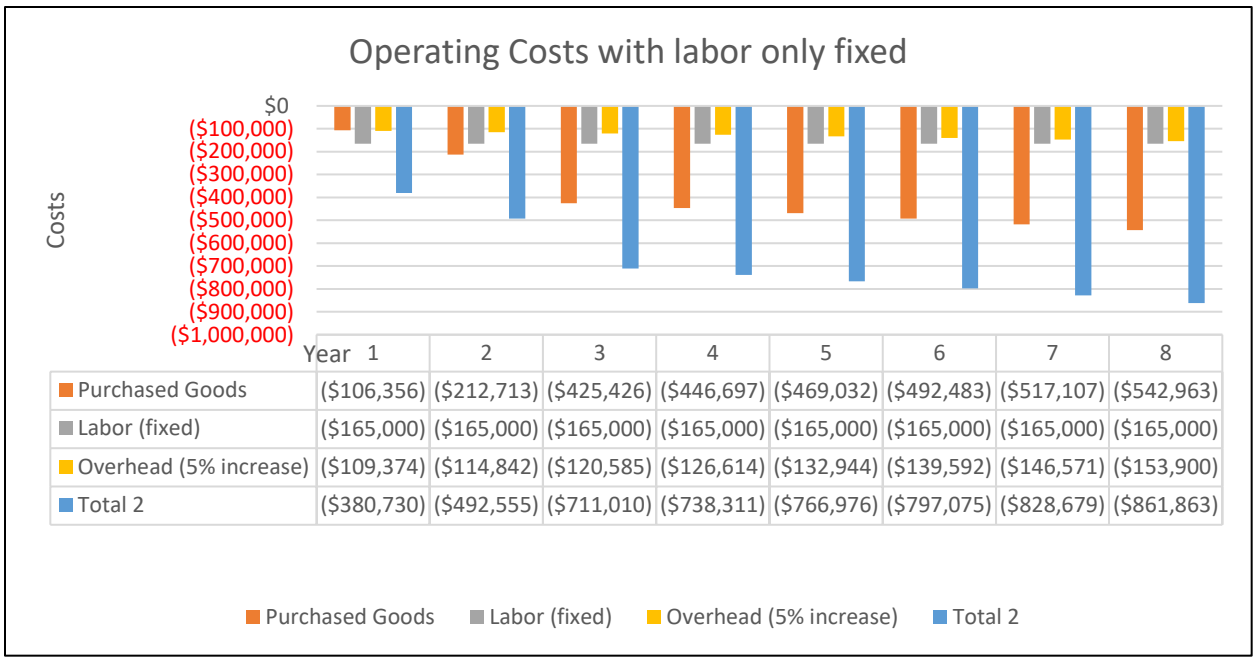
Operating Costs

Operating costs for CCF include purchased goods, labor and overhead. Purchased goods costs are increased at 5% starting in year four at the second year of full production with labor and overhead staying fixed for eight years with results seen in Figure 18. Figure 19 includes purchased good costs increased and overhead increasing annually at 5% starting in year two with labor fixed.



	1	2	3	4	5	6	7	8
Purchased Goods	($106,356)	($212,713)	($425,426)	($446,697)	($469,032)	($492,483)	($517,107)	($542,963)
Labor (fixed)	($165,000)	($165,000)	($165,000)	($165,000)	($165,000)	($165,000)	($165,000)	($165,000)
Overhead (fixed)	($109,374)	($109,374)	($109,374)	($109,374)	($109,374)	($109,374)	($109,374)	($109,374)
Total 1	($380,730)	($487,087)	($699,799)	($721,071)	($743,405)	($766,857)	($791,481)	($817,336)

Figure 18 - Operating Costs with labor and overhead fixed



Year	1	2	3	4	5	6	7	8
Purchased Goods	($106,356)	($212,713)	($425,426)	($446,697)	($469,032)	($492,483)	($517,107)	($542,963)
Labor (fixed)	($165,000)	($165,000)	($165,000)	($165,000)	($165,000)	($165,000)	($165,000)	($165,000)
Overhead (5% increase)	($109,374)	($114,842)	($120,585)	($126,614)	($132,944)	($139,592)	($146,571)	($153,900)
Total 2	($380,730)	($492,555)	($711,010)	($738,311)	($766,976)	($797,075)	($828,679)	($861,863)

Figure 19 - Operating Costs with labor only fixed

Cash Flow

Figure 20 shows cash flow as revenue minus cost per year. Revenue generated will increase from 25%, 50% to 100% production plus a 5% increase for years four through eight. Costs used for this calculation are annual costs in that year. The results of calculation illustrate in what year the cash flow will be in the black but not the breakeven point when accumulated costs will turn black. Breakeven results are included in the following "Breakeven" section.

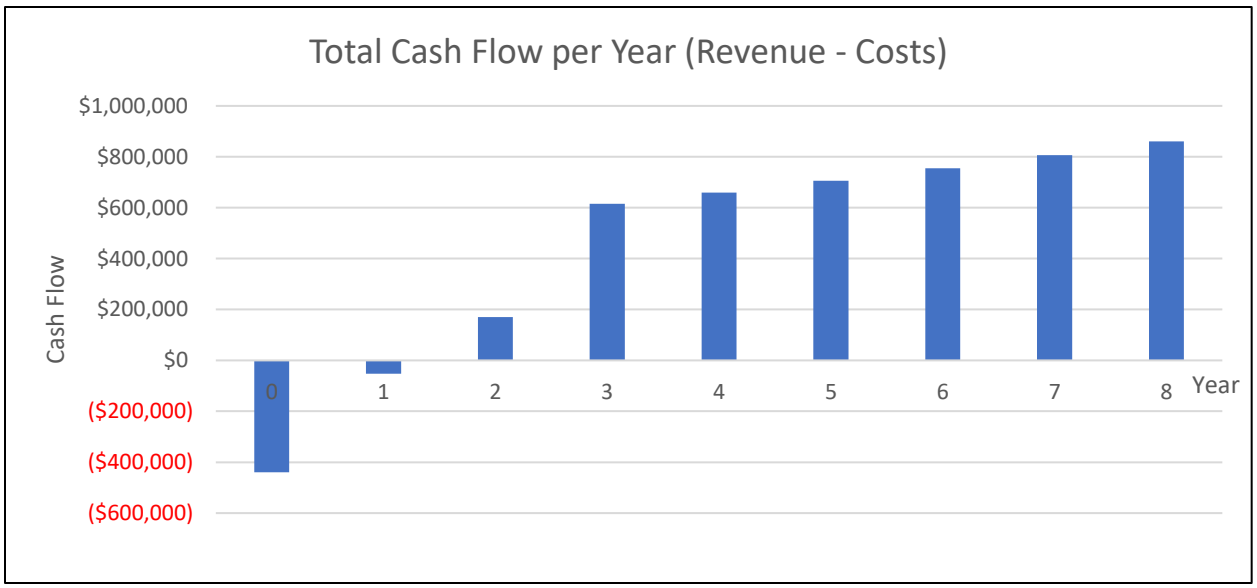


Figure 20 - Total Cash Flow per Year

Breakeven Volume & Payback Period

Breakeven Volume, shown in Figure 21, shows that at for an annual production volume above approximately 20 mil CCF raised crickets (or 39 mil total crickets), the business will be cash flow positive. The Breakeven Volume analysis does not account for startup costs. At the total 39mil annual production capacity, CCF can assess and decide debt pay down strategy. Please note that costs at zero production value include overhead and labor.

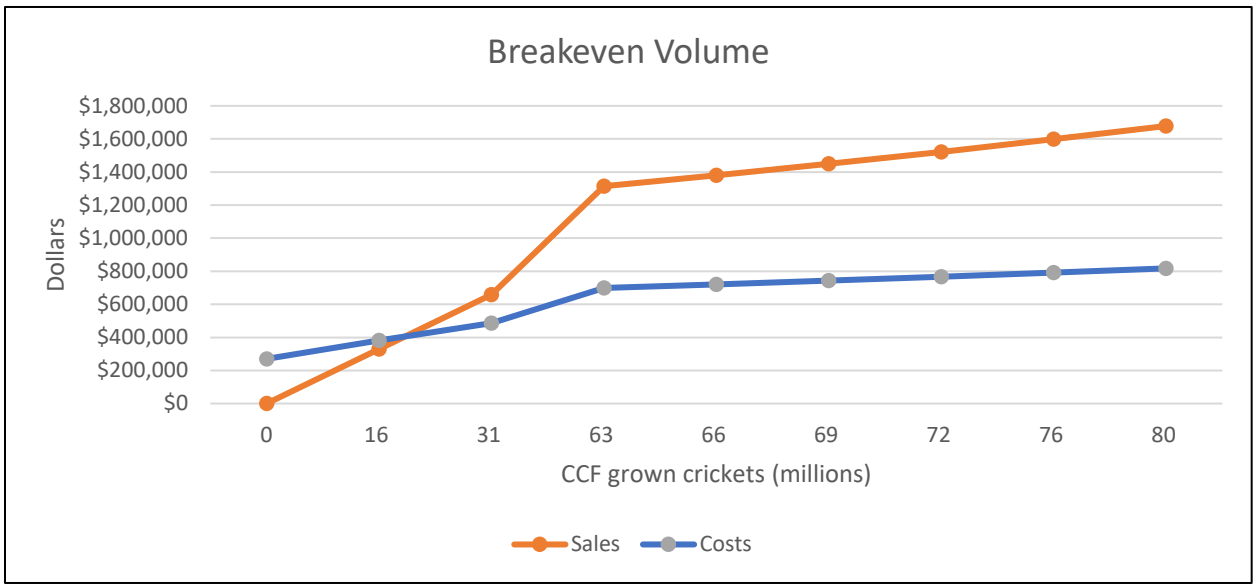


Figure 21 - Breakeven Volume

Payback Period, shown in Figure 22, shows that between year two and three, the business revenue, accounting for startup costs, will become cash flow positive.

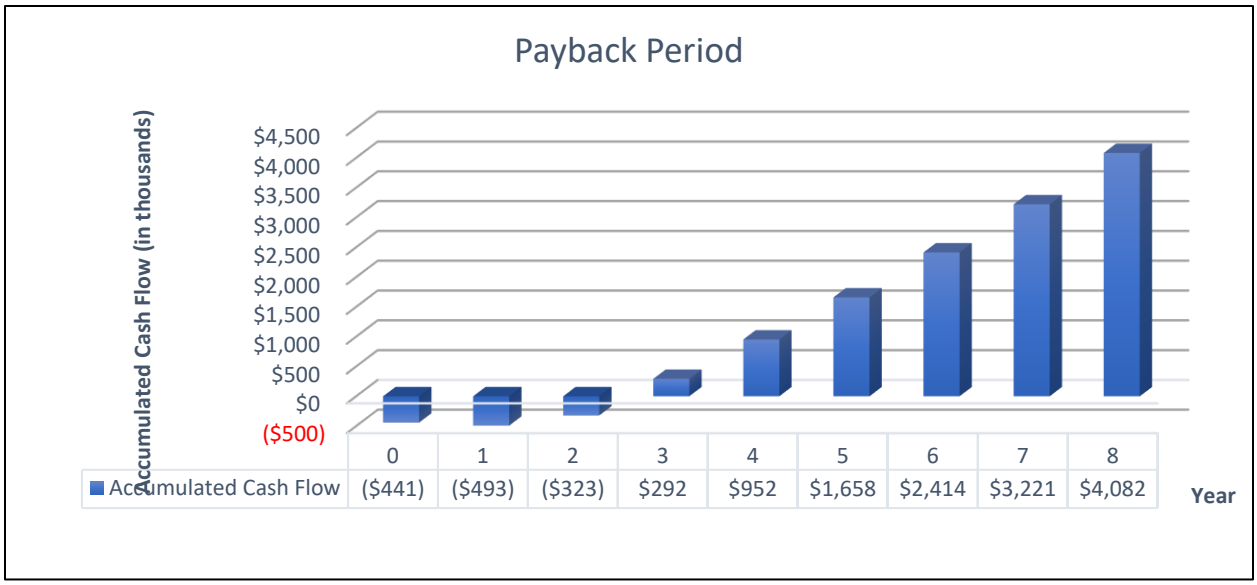


Figure 22 - Payback Period

Cost of Goods Sold

Cost of Goods Sold (COGS) costs for CCF includes purchased goods and labor costs. Labor costs include three fulltime employees and one 1/3 time employee. At this time and due to the limited data, COGS calculation for CCF are based on percent of sales, not per product. Please note future COGS by product calculations will vary as changes in product mix happen. As seen in Figure 23, COGS drops as production ramps to 100% capacity.

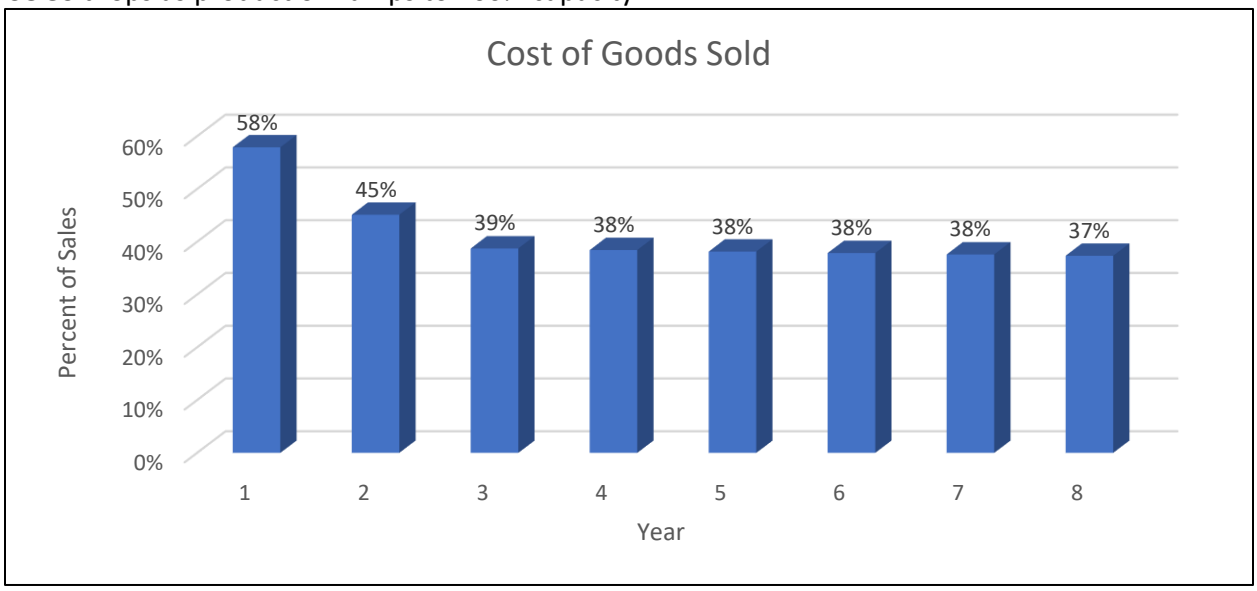


Figure 23 - Cost of Goods Sold

ROI

Using the 25%, 50%, 100% (year 3) plus 5% growth thereafter (years four through eight) model for production, cost and sales, CCF can expect a 61% return on Investment (ROI). If production capacity at year three drops to 50% (63mil crickets), CCF ROI will be 22% - above many companies' ROI threshold. Figure # includes ROI values for different production capacities.

Year 3 Production	
Production Capacity	ROI
100% (126mil crickets)	61%
75% (94 mil crickets)	46%
50% (63 mil crickets)	22%
40% (50 mil crickets)	7%

Summary of Letters of Intent for CCF

CCF has received five non-binding letters of intent to purchase and/ or partner for CCF's cricket products. Quantities range from 100 lbs per month of cricket flour from Six Foods LLC to 3000 lbs per month of FWC with C-fu FOODS INC. Prices vary from none stated to BUGmuscle's interest in buying crickets for $20/kilo (~$9/lbs) for use in nutritional supplements to "lower than $20/lbs" from Six Foods LLC for cricket powder use. A summary of the specifics of these letters can be seen in the table below.

Cost	Letter of Intent States	Contact Name & Company	Purpose of Use	Notes
$20/kilo = $9/lbs or less	"we may well be in favor of purchasing these crickets"	Dianne Guilfoyle - BUGmuscle	Nutritional supplement	
Interested in obtaining a quote	"volumes of 1200lbs, 2000lbs and 3000lbs monthly"	Eli Cadesky – C-fu FOODS Inc	Patent pending food science to extract and restructure insect proteins into versatile food ingredients for B2B	Letter states "Feeds are to be sourced from 'ugly' vegetables, farmer's waste, and other sources."
NA	"collaboration of my laboratory at MSU to measure the fatty acid composition"	Ed Dratz – MSU Professor of Chemistry and BioChem	R&D	
"at a competitive price"	"expect 1000lbs for R&D every year in conjunction with SBIR…after that project 1500lbs/yr with 1.5x growth or possibly more for 5 years"	Kelly Sturek – Bugeater Foods	R&D	Letter contingent on USDA PhII SBIR - checked USDA website and no award posted yet. See PhI here - http://bit.ly/2kz1G7f
lower than $20/lbs	"buy 300lbs of flour to start, with option of as much as 100lbs a month after"	Rose Wang – Six Foods	None stated	

Conclusions and Recommendations

Frass Marketing

The demand of local cannabis and other horticultural fertilizer consumers is unknown. In the event CCF's Frass production exceeds local market needs, a marketing plan to expand regionally seems warranted.

Positive evidence and/or laboratory information related to the value of Frass as a fertilizer over standard nitrogen-phosphorus-potassium (N-P-K) fertilizers for horticultural use should be sought. A better understanding of the benefits provided by Frass fertilizer could be beneficial to price attainment and market expansion.

According to CCF, demand for Frass by local cannabis growers accounts for the majority of current Frass sales. CCF should seek to further exploit and monetize this specific market segment, as well as look for additional Frass markets.

Potential ways to increase Frass value and reach additional markets:

- Grading of Frass based on cricket food source
- Size distribution
- Guaranteed component analysis and/or content
- Packaging

Automation

The potential efficiency gains by development and implementation of automated cricket growth habitat are substantial for CCF. The daily care and feeding of 10 – 20 million crickets using traditional methods would be labor intensive, perhaps prohibitively so.

CCF should make it a priority to assure growth habitat automation technology development has the required resources and strategic focus:

- Are the operational goals for an automated habitat clearly defined?
- Have cost estimates for automation been generated, and sufficient sources of capital secured?
- Have metrics to measure habitat automation efficiency been identified?
- Is a project team with clear roles and responsibilities assembled?
- Is there a project timeline?

Efficiencies to be gained through automation of cricket product processing do have the potential to increase bottom line profitability, but should be considered secondary goals until viable habitat automation is fully implemented.

Data logging has potential value, but becomes almost ancillary in the presence of good habitat automation hardware and software.

Actual costs should be carefully tracked to enhance the accuracy of future economic evaluations.

Production Scheduling and Staffing

The current staffing plans need to be further developed. These plans should include, but not be limited to:

- A comprehensive organizational chart, including reporting structures
- Written job descriptions with clear qualifications, roles and responsibilities
- A listing of required activities for all husbandry, processing, marketing, order fulfillment, maintenance duties
- A written plan to determine task loading, including time studies
- Metrics for measurement of operational efficiencies
- Tools for production forecasting and planning, including periodic reviews to assure production planning methods continue to meet customer requirements.

Production Constraints

Without habitat enclosure automation, daily care and feeding (husbandry) of crickets will likely be the most pressing space and labor force constraint on overall production.

Overall SWOT Analysis & Observations

Strengths	Weaknesses
✓ Good start, pilot facility is operational ✓ Gaining some traction in the market ✓ Good location ✓ Positive indications for Frass market & customers ✓ Committed team ✓ Industry/ research connections in place ✓ Business resource connections strong (Launchpad, SBDC, MMEC, State grant fund programs) ✓ Reasonably well known in insect production community ✓ Benefiting from good publicity ✓ Research connections at MSU/ proximity to university research	○ Lack of clear focus and well-defined strategy ○ Automated habitat bin design/development status is unclear ○ Seeking grant funding for running business, reliance on outside funding ○ Unclear record keeping methods for customer sales and revenue ○ Steep learning curve with respect to business acumen ○ Industry knowledge concentrated in husband/ wife team ○ Unrealistic business operations activities (i.e. customers will pick up products v shipping and packaging for them)
Opportunities	**Threats**
➢ Frass market expansion and price attainment ➢ Reduction in insect husbandry labor costs with automated bin system ➢ Timely pet food industry investments/ capital investments available in the market ➢ Small number of businesses in the industry - opportunity for alliances and acquisition	❖ Soy and bean are a viable protein substitutes ❖ Competitive market space ❖ Market opportunities for bugs (not Frass) outside of local market ❖ Reliance on niche/ fad industry (easy to collapse quickly) ❖ Competitors are ramped up and ahead of CCF ❖ Pricing is outside market expectations ❖ Barrier to entry into human consumption high in Domestic marketplace

End of Final Report November 10, 2017

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