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UTILIZATION OF VEGETABLES IN SURPLUS IN PENNSYLVANIA TO MAKE A SHELF STABLE TOMATO SAUCE SUBSTITUTE FOR A NON-PROFIT FOOD PRODUCTION ORGANIZATION

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ABSTRACT

This non-profit organization provides shelf stable sauces and salsas made from vegetables in surplus in Pennsylvania. The goals of this company are to: 1) extend the shelf life of vegetables that typically go to waste due to oversupply or appearance defects, 2) to provide rural areas with an additional job source besides agricultural practices (which are generally seasonal), and 3) to provide nutritional, safe, and satisfying meals to consumers. A tomato sauce substitute was formulated and made in the Penn State Wet Pilot Plant. Food safety regulations and standards are addressed as well as sample HACCP forms. Recommended microbial and sensory analyses are described herein.

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Chapter 1

Introduction

The current world population is 7.2 billion people. By 2050, the UN is projecting the population to increase by 33% to 9.6 billion. Developed nations are unlikely to contribute significantly to this population boom, but some developing nations are growing at a rapid rate with the introduction of efficient technology and sustainable agricultural practices. Another contributing factor is the foreseeable increase in life expectancy. An aging world population will require more support and care from the younger generations and lean heavier on the world economy for supplies and treatments (UN News Center, 2013).

Former Dean of the College of Agricultural Sciences at the Penn State University and current Dean of Food, Agricultural and Environmental Sciences at the Ohio State University, Dr. Bruce McPheron was often quoted as saying, "The world's population is expected to double by 2050. That means we need to produce more food with less land, less people, and less resources." These words were some of the first to shape my new outlook on life when I first started my undergraduate career. I am the new generation coming to save the day. It will soon be my responsibility to feed the world and tend to an older generation that may no longer be able to or could possibly no longer care to fend for itself.

One obvious route to salvation is better breeding and further development of biotechnology to increase food production. While there is still potential for improvement and maximized efficiency in production agriculture, it must also be recognized that there are natural limitations that humans cannot surpass. The gestation cycle of a dairy cow cannot be significantly shortened to increase her number of calves birthed in her lifetime. The number of growing days

from seed to harvest of a corn stalk cannot be lowered to 1/4th the standard cycle to allow for more harvests per growing season. A pepper plant can only support so much weight before the plant buckles and dies. Greater yields cannot be the sole solution for food needs and hunger.

The less common solution is better use of the food already grown. The U.S. Environmental Protection Agency estimates an average of 20-22% of the nation's waste is food. In 2011, that equated to 36 million tons – or 72 billion pounds – of food wasted based on the characterization report of municipal solid waste. The EPA also estimates that 50 million Americans have insufficient means or access to enough food (*Food Waste Basics*, 2013). The Bill Emerson Good Samaritan Food Donation Act of 1996 was enacted in an effort to increase the "donation of food and grocery products to non-profit organizations for the distribution to individuals in need." The Act goes on to state that people or companies donating food in good faith cannot be liable for harm done through mishandling and distribution. By reducing the liabilities, President Clinton made it financially safer to make food donations and reduce food waste as a whole (*Bill Emerson…*, 1996).

The 2007 U.S. Census of Agriculture showed that there was a 15% increase in the value of vegetables, potatoes, and melon sales from 2002 to 2007. As of 2007, the vegetables, potatoes, and melons sector of the fresh produce industry grossed $14.7 billion and accounted for 4.9% of all agricultural products sold in 2007 in the U.S. Nationally, California is by far the largest producer of vegetables, potatoes, and melons with Monterey County seeing more than $1 billion in sales alone. From 2002 to 2007 there was an increase in the number of farms growing vegetables but a decrease in total acreage. While not ranked in the top-10-producing states, Pennsylvania's 9th largest segment of the agricultural industry is attributed to vegetables, potatoes, and melons in terms of total sales (*2007 Census of Ag…*, 2009).

The goal of this thesis is to design a business plan for a non-profit organization that will take vegetables found in surplus in Pennsylvania and convert them into shelf stable sauces and

salsas. The intention of this project is to make a blueprint for future entrepreneurs to start the business with the desire to reduce food waste in Pennsylvania and potentially other areas of the U.S. and the world as well. The non-profit should be able to reduce food waste, increase the jobs, and increase the overall efficiency of food already grown today.

Chapter 2

The Business Model

Introduction

The business model for this tomato sauce substitute was built based on the business model canvas written by Alexander Osterwalder et al. in "How to Describe and Improve Your Business Model to Compete Better." This canvas broke the business plan into easy-to-follow segments and asked the reader detailed questions about the structure and process of the business plan (Osterwalder et al, 2010). The headings of this chapter are labeled based on the model canvas and the questions described in the document are answered therein.

Customer Segment and Market Appeal

Multiple customer segments would be targeted by this business. The first segment to consider is mothers and families. Mothers, in this context, are defined as women who perform the primary grocery shopping task and have toddlers, adolescents, or teenagers to provide for. Their typical concerns are safety of a product, nutritional quality, sensory appeal to family members, and overall cost per unit. They want to feel the product is safe to feed to their family and in some cases healthy based on daily nutritional percentages. At the same time, they have a family to feed and need to be conscious of their spending costs, so overall price will need to be addressed.

Our second segment is people that are actively conscious of the environment. This group can contain all types of members, but will typically be persons between the ages of 21 and 35.

These individuals are willing to pay a slight percentage more for products that they feel are higher quality due to the methods used to produce them or the eco-friendliness of the company selling the product. Words like "recyclable, fair trade, CSAs (community supported agriculture), etc." are commonly used to attract this market segment. Products with minimal environmental impact or positive effects on the ecosystem are popular.

Our third segment is special diet groups. Vegetarians, vegans, and certain food-allergic customers would be interested in this product. Soy-allergic individuals would be excluded from this segment as one of the ingredients contains soy allergens (vegetable oil). Persons who choose to abstain from meat and/or animal bi-products would find these sauces and salsas to be a viable product choice. In many cases, the vegetarian/vegan segment will overlap with the environmentally conscious segment as many people choose to abstain from meat due to the effects of livestock production on the environment.

The main marketing scheme for these products will be to emphasize food waste reduction and nutritional value. The manufacturing goal is to reduce food waste by extending the shelf life of produce to increase the efficiency of the nation's food supply. The company's goal can be expressed to the customer via a description on the label and used to help tell the story of this non-profit.

Value of Product

The primary proposition of these products is a nutritional meal. A key nutritional value to highlight is the presence of bioactive compounds. Bioactive compounds include a large array of compounds that have been found in all types of plants. A well known example is phenols in red wine. Bioactive compounds are defined as extra-nutritional constituents that have been shown to provide health benefits beyond basic nutrition and usually occur in small amounts in plants.

Broccoli and tomatoes are another example of plants high in bioactive compounds. Epidemiological studies have shown that bioactive compounds have protective effects against cardiovascular disease and cancer (Kris-Etherton et al, 2002).

The mothers and families will find value in the safety and cost efficiency of these products as well. The environmentally conscious customers will find value in the reduced food waste. The special diet customers will find value in the conformity of the ingredients to their diet. Few products are marketed that vegetarian/vegan standards as well as allergen-free, so this subgroup of customers will especially find value in this product.

Channels and Customer Relations

Multiple channels will be used to get this product to the customers. It will be transported by trucks to local groceries, regional distributors, and potentially supermarkets like Weis and Walmart. It will be sold in the sauce aisle next to tomato sauce products as it is marketed to be a tomato sauce substitute.

In terms of marketing channels, the product label will have the basic summation of the values being offered (i.e. nutrition, reduced food waste, special diet compatibility, etc.) and tell the story of the product. Advertisements will be implemented through grocery circulars and coupon pages. Offering an initial discount will be good incentive to try this new product and help develop talk among customers. These methods have costs associated with them, but not high costs. Also, these methods do not target the specific customer groups previously detailed, but it will reach a much wider potential customer base in an effort to expand the recognition of the product and possibly expand the customer base beyond those groups previously mentioned.

Technology and social media are also cost efficient methods of customer outreach. A company website would be easy to develop, inexpensive to maintain and manage, and has a much

larger capacity for information than a label or coupon. The company's history, mission, and full product line could be easily displayed on a website. A means of contacting the company – whether by direct e-mail/phone line/messaging or creating a message drop box – could be constructed and make the company more accessible to the customers.

The website can also contain links to the company's social media accounts. Media like Facebook, Twitter, and Instagram are free methods of customer outreach and interact with the customer on his or her personal time. Incentives to follow the company on these sites can be offered in an effort to build a customer following. Posting is free and some of these sites offer the possibility of boosting certain posts for very inexpensive costs. The younger generations especially will be targeted with social media and technological channels as they are typically more active with these forms of communication than older generations are.

The primary customer segment is mothers and families as they have the largest potential budget for food and groceries. They will be likely reached through the grocer circulars, coupon pages, and label details. While younger mothers are attempting to familiarize themselves with social media in an effort to stay up to date with their children, their preferred communication methods will be on product and in print. Younger families, environmentally conscious customers, and special diet groups will likely be better reached through the website and social media platforms. Coupon pages and grocer circulars can also be beneficial marketing to these groups as they might be more inclined to try the product if a discount is offered.

Revenue Streams

The primary source of revenue will be the mothers and families. It is estimated roughly 60% of overall sales will be from this customer segment. They will be paying for the nutritional benefits that this product brings to a meal and possibly to support the reduction of food waste.

The environmentally conscious customer segment will account for 30% of the overall sales and will buy the product firstly for its reduction of food waste and secondly for its nutritional value. The special diet customer segment will comprise the last 10% of the overall sales. This group will value the allergen-free and meat-free properties of the product and potentially the food waste reduction as well.

Resources

The primary value proposition will be providing a nutritious meal to mothers and families. The key resources necessary for delivering this value are brand, people, safe ingredients, and reliable manufacturing equipment. Once a brand is established, it will still require people to evaluate the product's performance to maintain the brand image and integrity. People will be essential for the product's manufacture, distribution, and conveyance to the consumer. Safe ingredients are necessary to better ensure the product is safe for consumption. The reliability of the manufacturing equipment will also play a key role in creating a safe product for consumers. Environmentally conscious consumers and special diets group will also require these key resources to receive the product in a moderate time frame.

Key Activities

The main activity being performed by this company is the manufacture of the pasta sauce. This process includes thermal processing, acidification, and aseptic product filling. This will be the source of the product and the basis for the company's continued success. The glass jars, screw cap lids, and corrugated cardboard boxes will be listed as non-food ingredients and purchased from outside manufacturers. The product will require transportation to reach the

grocery stores and thus all of the targeted consumer groups. HACCP and verification activities will need to be developed and performed specifically for this process at a working facility to ensure the product is being safely made based on the Code of Federal Regulations.

Partner Network

The primary partner will be the produce farmers. They will be providing the majority of the ingredients for the pasta sauce and are therefore the most important. They will be required to maintain predetermined good agricultural practices (GAPs) and ensure the safety of the produce. The farmers will also be responsible for delivering the produce to the manufacturing site.

Another important partner will be the manufacturers of the production lines and the containers for handling and storage. They will ensure the safety of the non-food ingredients and help maintain shelf life and storability of the product. Transportation services are key partners in this network and will be responsible for timely, efficient, and careful distribution of the product to stores and retailers. Retailers will be responsible for the marketing and direct sales of the product to the customer groups. They will be partially responsible for product promotion and fully responsible for product storage and safety outside of the manufacturing plant prior to the consumer's residence. Lastly, third party auditors will be responsible for verifying the safety of the HACCP system as well as the legitimacy of the financial records and processing documentation. Third party auditors will further ensure the safety of the process and the product.

Cost Structure

The most important costs incurred by this business will be the production of the product, the distribution of the product, and the marketing campaign. The production of the product will

account for the majority of the expenses – an estimated 80% - as it includes the purchase of food and non-food ingredients, equipment used for processing, energy needed to run equipment, personnel needed to run equipment, personnel needed to clean and maintain equipment, and storage of the product prior to shipping. Labor costs for employees will likely be the highest percentage of the production costs – potentially 40 to 50% of the total cost.

Product distribution expenses will likely account for 15% of the overall expenses. This will include containers for ease of stacking and shipping, equipment for short-distance transportation (i.e. a pallet fork), equipment for long-distance transportation (i.e. trucks), personnel to operate equipment, and insurance on both the product and the personnel if necessary.

The marketing campaign should account for 5% of the overall expenses. This will include development of the product label, development of the company website, advertisements in grocer circulars, coupon offers in coupon pages, and any additional marketing campaigns considered necessary to promote the product (Osterwalder et al., 2010).

Chapter 3

Product Formulation and Processing

Formulation of Sauce

The sauce recipe was designed based on the recipe Spaghetti Sauce Without Meat from the Penn State Extension *Let's Preserve* series (LaBorde et al., 2014). The revised recipe (listed in Appendix A) was formulated to contain 40% tomatoes, 15% broccoli, 10% cauliflower, 15% zucchini, and 20% peppers. The broccoli, cauliflower, and zucchini were donated by the Pennsylvania Vegetable Growers Association and frozen until they were used for the batch trial. The rest of the ingredients and vegetables needed were purchased from Walmart on North Atherton Street in State College. The vegetables were inspected for any signs of mold or decay as they would be in the manufacturing setting. Vegetables that are received because they are of a lower quality grade based on appearance (i.e. bent cucumbers, oblong peppers, etc.) will still need to be free of mold and decay to be accepted.

The pint jars and lids (without the rings) were both sterilized in boiling water. The pint jars were placed in a five gallon plastic bucket in a six gallon kettle for sterilization. The plastic bucket had holes pre-drilled in the sides and base to allow the water to pass through and reach the jars. The jars were placed upside down in the bucket to allow for proper drainage when the bucket was removed from the kettle. Once sterilized, the jars were removed from the bucket with canning tongs and placed in an oven set to 'warm' to dry the jars and keep them hot. The lids were placed in a small pot and boiled for 20 minutes.

The frozen vegetables (broccoli, cauliflower, and zucchini) were thawed. The tomatoes, broccoli, cauliflower, zucchini, and peppers were chopped in ½ - 1 inch pieces and placed in a

second six gallon kettle and allowed to simmer for 2 hours. The onions, garlic, and celery were chopped into ¼ - ½ inch pieces and sautéed in a small skillet in the vegetable oil until tender. The vegetables and onion medley were pureed in a blender and placed in the first six gallon kettle after it was cleaned and dried. The remaining ingredients (Appendix A) were added to the first kettle and the batch was cooked on medium-high. This temperature was high enough for the batch to boil. The batch was stirred occasionally to keep the sauce from burning on the kettle and facilitate heat distribution. The batch began to splatter sauce as it reached a full boil, so a lid was placed on top of the kettle. The lid was pitched to allow steam to escape but keep the sauce in the kettle.

The pH of the sauce was checked after the first 10 minutes of processing using a calibrated Fisher Scientific Accument Research AR 25 Dual Channel pH/ion meter. The initial pH was 4.74. The batch cooked for 6 hours until it reached approximately 2/3 of the original volume. The pH was considered to be at an equilibrium value because the vegetables were pureed and the sauce was stirred occasionally during cooking. The final batch equated to roughly 8.5L after it was boiled down. The pH was checked again after the batch boiled down and was found to be 4.74. Three teaspoons of citric acid powder was added to lower the pH to below 4.6 to create a shelf-stable acidified product based on CFR regulations requiring acidified foods to have a pH of 4.6 or lower (21CRF114.3). The pH was measured again and found to be 4.36. No specific instructions were given as to the pH equivalent of each teaspoon on the citric acid powder label, so the teaspoons were added one at a time. The sauce was stirred thoroughly allowed to sit for 15 minutes before it was re-evaluated with the pH meter. Upon tasting the sauce after the pH was lowered, an additional ¼ cup of brown sugar was added to reduce the sour, tart flavor of the sauce brought on by the high acidity. After being jarred and allowed to sit for 4 months, the pH was tested again with the same pH meter and found to be 4.651. This does not meet the critical control point of below 4.6 pH (see Appendix B), which means that, in future trials, the formulation will

need to be adjusted to ensure the equilibrium pH stays below 4.6 during the full life of the product.

The jars were removed one at a time from the oven with canning tongs and hot filled with a ¼ inch head space remaining. The desired fill temperature was maintained at 170^{o}F or higher to make sure the product was processed over 165^{o}F based on the critical control point for temperature in the HACCP Plan (see Appendix B). The edges of the jars were wiped clean, the lids were applied to the jars, and the rings were screwed on. Once all of the jars were filled, they were placed in the perforated plastic bucket in second six gallon kettle full and processed in a boiling water bath for 30 minutes. The jars were then removed and set on dry towels. The jars were allowed to set for 24 hours before being moved.

The original Penn State Extension sauce recipe predicted a yield of roughly nine pints for the final sauce product. Due to the vegetables used in the sauce, it yielded 18 pints in all. This may be because the vegetables other than tomatoes could have lower water contents and therefore there was less water to boil off in the final cooking stage.

Product Flow Diagram

The following diagram describes the materials, ingredients, and process steps required to manufacture the sauce.

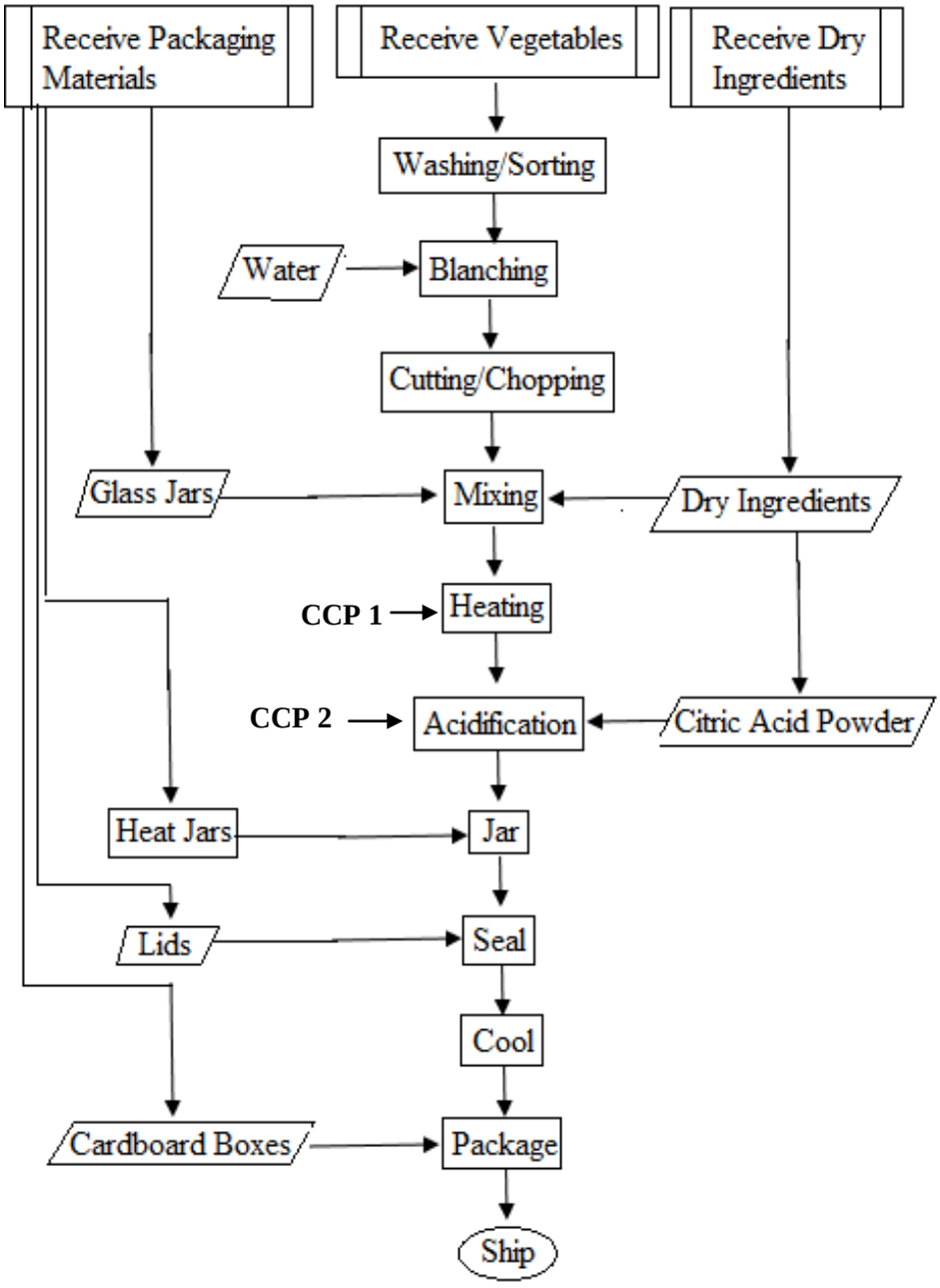

Figure 1 - Product Flow Diagram of Tomato Sauce Substitute

Packaging and Storage

For scale-up production, it is recommended that the product be packaged in one pint glass jars with heat-sealed screw cap lids. A potential local manufacturer of these jars is AB Container

in Enfield, CT. Full product description is listed in Appendix B under the “Ingredient Specifications Sheet”. This will allow for proper heat penetration during thermal processing and oxygen exclusion during storage. The jars should be stored at room temperature (55-75^{o}F).

Chapter 4

Food Safety Regulations

Code of Federal Regulations

In the Code of Federal Regulations, Title 21: Food and Drugs covers most of the legislation and regulations regarding food and food systems. In §114.3: 'Acidified Foods: Definitions', acid food are defined as "foods that have a natural pH of 4.6 or below." It defines acidified foods as "low-acid foods to which acid(s) or acid food(s) are added…[that] have a water activity (aw) greater than 0.85 and have a finished equilibrium pH of 4.6 or below" (21CFR114.3, 2013).

Serving size recommendations are listed in §101.12: 'Reference amounts customarily consumed per eating occasion.' Subsection (b) recommends the serving size for spaghetti sauce products to be 125g whereas the serving size for vegetable sauces or purees is 60g (21CFR101.12, 2013).

The food product itself is not the only subject addressed by the CFR. Good manufacturing practices must be adhered to in order to ensure the safety of the product. In §110.5: 'Current good manufacturing practice," this section states that good manufacturing practices (GMPs) "…shall apply in determining whether a food is adultered (1)…of the act in that the food has been manufactured under such conditions that it is unfit for food; or (2)…of the act in that the food has been prepared, packed, or held under insanitary conditions whereby it may have become contaminated with filth, or whereby it may have been rendered injurious to health." In summary, current good manufacturing practices are practices and processes within a food

manufacturing facility that that do not allow the food product to be adulterated or contaminated, resulting in risks to consumer health (21CFR110.5, 2013).

Food Safety Modernization Act

The Food Safety Modernization Act of 2010 (FSMA) was enacted to amend the Federal Food, Drug, and Cosmetic Act of 1938 (FDCA) in terms of the safety of the nation's food supply. No amendments had been made to the FDCA since 1938 and the profound technological advances in food and food production needed to be legally addressed. In FSMA, §103: 'Hazard analysis and risk-based preventative controls' states that hazard analysis is the duty of the "owner, operator, or agent in charge of a facility." The HACCP system (Hazard Analysis Critical Control Point) was developed to help manufacturers ensure they stay within these regulations and continually produce safe products. While the installation of a HACCP system for acidified canned foods is not legally required under FSMA, the vast majority of food manufacturers have adopted the system as a means of better process control and increased traceability (FSMA, 2010).

A hazard is considered a biological, chemical, or physical property that renders a food product or process unsafe and risks the health of the consumer. The seven steps of a HACCP system are designed to analyze every facet of a food manufacturing process and interpret all and any possible hazards therein. The seven steps of HACCP are listed in Table 1.

Table 1: Seven Steps of a HACCP Plan

Step #	Step Description
1	Conduct a Hazard Analysis
2	Identify Critical Control Points
3	Establish Critical Limits
4	Establish Monitoring Procedures
5	Establish Corrective Actions
6	Establish Verification Procedures
7	Record Keeping Procedures

A critical control point (CCP) is a point at which a hazard can be eliminated or reduced to an acceptable level. Critical limits are established to ensure that a CCP is satisfied within the manufacturing process. The largest proportion of a HACCP plan is good record keeping and verifying that the established procedures and practices are making safe food products. Appendix B contains recommended forms for each step of a HACCP plan. These forms are designed to address every possible aspect of a food processing system and help the manufacturer realize all the potential hazards as well as prepare for establish corrective action procedures and increase product traceability. The forms in Appendix B have been edited to fit the specifications of the production of this tomato sauce substitute.

Chapter 5

Analytical Tests

Microbial

The pathogens that are potentially present on vegetables are *Clostridium botulinum*, *Listeria monocytogenes*, *Escherichia coli* O157:H7 and *Salmonella* spp. due to past reports of outbreaks due to consumption of fresh produce. The cooking step needs to be at least 170^{o}F-175^{o}F for 10 minutes and should be sufficient to kill any vegetative pathogens. The acidification of the product will prevent the germination and growth of pathogenic spore formers (for example, *C. botulinum*) that cannot be killed by high heat. Microbial analyses may be performed to confirm the destruction of vegetative cells in these processes, resulting in a safe product. The initial microbial analysis would be to use 3M Petrifilm™ *E. coli* Plates and 3M Petrifilm™ Coliform Count Plates as they have a quick 24-48 hour processing time and would indicate possible post-processing contamination with fecal pathogens. Three samples should be taken from one jar and diluted 1:5 for plating. If the product was properly manufactured, no coliforms or *E. coli* colonies should be present after 48 hours.

If any colonies do form within the 48 hours, further steps should be taken to identify the bacteria present in the sample. *E. coli* can be identified with the Petrifilm™. The Standard Plate Count methods should be applied to the sample and streaked for isolation (Jay, 2005). If these analyses come back positive, the process should be re-examined to determine the root cause of the problem based on the Corrective Action steps in the HACCP Plan (see Appendix B) and solved to make the process safe for food manufacture again.

Sensory Evaluation

Sensory evaluation is critical for a business of this size. Sensory tests can be used to evaluate preliminary consumer appeal and assess the average consumer's likelihood of purchase. The best possible method to employ is to use an untrained sensory panel and have them grade the product using a Just About Right (JAR) Scale.

JAR Scale combines the attributes of intensity and acceptability in one scale, which minimizes questionnaire length and complexity. It can be used in a triangle test to study how panelists feel about an existing product and compare the measurements of the new product and whether they can detect differences between the three samples provided. It can also be used as a stand-alone analysis in which the product itself is the only sample tasted. This might be a more useful method if there are no products for comparison on the market.

JAR Scales are useful as they do not require a trained panel and can analyze the most important initial consumer attribute: will people buy it. If the product has very distinct flavors but the consumer panel refuses to consider buying it, there is no point in continuing with a product likely to fail. Once the production process is verified and the product is proven safe, sensory analyses can begin (Rothman et al, 2011).

Figure 2 is an example of a sample sensory ballot that could be given to an untrained panel being asked to evaluate this product.

Pasta Sauce Sensory Evaluation

Directions: Rinse your palate with the water provided before evaluating the sample. Allow 30 seconds to pass. After 30 seconds, gather a quarter-sized sample of pasta with sauce and taste sample. Rate the following characteristics of this sample. If necessary, take a second sample to continue evaluating the below described attributes.

Red Color	Texture	'Broccoli' Flavor	Overall Flavor
Much too dark	Much too soft	Much too strong	Much too sour
Too dark	Too soft	Too strong	Too sour
Slightly too dark	Slightly too soft	Slightly too strong	Slightly too sour
Just about right	Just about right	Just about right	Just about right
Slightly to pale	Slightly gritty	Slightly too weak	Slightly too sweet
Too pale	Too gritty	Too weak	Too sweet
Much too pale	Much too gritty	Much too weak	Much too Sweet

Figure 2 - Sample Just-About-Right Sensory Ballot

Unofficial sensory evaluations were conducted using a rough sensory ballot grading the samples with a hedonic scale. The original data was not used because the ballot proved too confusing for the panelists and there were only 12 ballots filled out – not enough to run statistical analyses. Figure 3 shows the original sensory ballot used in the preliminary sensory evaluation. After talking with the panelists and better explaining the tomato sauce substitute as well as the concept behind it, they liked the flavor and the goals of the product. Several panelists mentioned that they could taste the cauliflower and other sulfurous notes, but very few panelists found that characteristic to be unappealing. Larger sensory panels might not be so receptive to the sulfurous notes as this small panel was. This is a challenge that future manufacturers might face as it could lead to sauce reformulation and a reduction in use of cauliflower, broccoli, and other vegetables in the formula. Consumer appeal plays a large role in product popularity and could have a significant impact on the product formulation.

Vegetable Sauce Sensory Ballot

Dislike **Acidity** Like
1 2 3 4 5 6 7 8 9

Dislike **Flavor** Like
1 2 3 4 5 6 7 8 9

Dislike **Texture** Like
1 2 3 4 5 6 7 8 9

Dislike **Color** Like
1 2 3 4 5 6 7 8 9

Dislike **Overall Likeability** Like
1 2 3 4 5 6 7 8 9

Dislike **Likeliness of Purchase** Like
1 2 3 4 5 6 7 8 9

Figure 3 - Original Sensory Ballot

Chapter 6

Conclusions and Closing Remarks

There is still much that needs to be done before this business can come to fruition. Many future challenges can only be addressed once this business is given a solid foundation and problems arise. Some future avenues that will need to be explored are how to maintain year-round operation. Vegetables are seasonal so production needs to be adjusted for the highs and lows of the season as well as what to do in winter when no local vegetables are grown.

It is recommended that the vegetable oil ingredient be changed to use oil that is not produced from soy. Soy is a common allergen and considered a chemical hazard to those with soy allergies. Legislation is currently in progress to increase allergen labeling and using soy-based oil may prove difficult even if the oil comes with a certificate of approval that no soy proteins are present in the oil.

Another pressing issue is that of the products being made. This thesis follows the manufacture and HACCP Plan of only one formulation, but with the intention that it can be the basis for any other sauces created following similar principles. It also has to be considered that vegetable production does not only vary seasonally but also due to weather events. Seldom is a growing season ever perfect, so preparations need to be made for either too many or too few of certain vegetables. There is substantial room for new product development in this regard.

Lastly, this company is intended to be non-profit. With that in mind, any income generated past that which is needed to cover manufacturing expenses and employee salaries should be directed towards charity. The beneficiaries of these proceeds would be ultimately decided by the owner of the company, but it is strongly encouraged that the money goes to the

Pennsylvania Food Banks and/or to other organizations established to reduce hunger. It is also possible that a portion of the products be donated to the Food Bank system to help the fight against hunger.

In conclusion, the potential is there for a business of this nature to make significant changes in the world. The intended markets are receptive to new products and ideas, giving this product high hopes for eventual production. The world as we know it will not survive on increased crop yields alone and must learn to make better use of the food already produced. Increased food efficiency is one of the many keys to reducing food waste and hunger in general.

Appendix A

Revised Spaghetti Sauce Formula

Original Ingredients (LaBorde et al., 2014)	Revised Ingredients
Vegetables • Tomatoes – 30 lb **Seasonings** • 1 cup onions, chopped • 5 cloves garlic, minced • 1 cup celery or green pepper, chopped • 1 lb fresh mushrooms, sliced (optional) • ¼ cup vegetable oil • 2 Tbsp oregano • 4 Tbsp parsley, minced • 2 tsp black pepper • 4 ½ tsp salt • ¼ cup brown sugar	**Vegetables** • Tomatoes (40%) – 12 lb • Broccoli (15%) – 4.5 lb • Cauliflower (10%) – 3 lb • Zucchini (15%) – 4.5 lb • Peppers (20%) – 6 lb **Seasonings** • 1 cup onions, chopped • 5 cloves garlic, minced • 1 cup celery, chopped • ¼ cup vegetable oil • 2 Tbsp oregano • 4 Tbsp parsley, minced • 2 tsp black pepper • 4 ½ tsp salt • ¼ cup brown sugar **Acid** • Citric acid (powdered)

Materials

- 12 one-pint glass wide-mouth Mason jars
- 12 two-piece screw cap lids
- food processor
- 2 large canning kettles
- canning tongs
- knife
- cutting board

- long spoon (wooden preferred)
- hot pads (2, at least)
- canning bucket
- timer
- funnel
- ladle
- measuring cups
- small pot
- small skillet

Procedure

1. Sterilize jars in boiling water bath for 20 minutes. Sterilize lids (not rings) in small pot in boiling water bath for 20 minutes.
2. Wash and chop all vegetables. Add chopped vegetables to large kettle and simmer for 2 hours.
3. Sautee onions, garlic, and celery in vegetable oil until tender.
4. Puree vegetables and onion medley in food processor and add to second large kettle.
5. Add remaining ingredients and cook on medium-high heat until it thickens. Stir occasionally.
6. Check pH of pulp within first 10 minutes. Check pH again once thickened. If pH is below 4.6, add acetic acid.
7. Keep jars hot in oven set to warm.
8. Pour pulp, hot, into hot jars, leavings ¼ inch head space. Carefully wipe edge of jar clean and dry rubber ring of lid with paper towel. Do not touch directly.

9. Process in boiling water bath for 30 minutes. Yield: about 7-9 pints.
10. Let jars set to cool. If lids pop inward, the vacuum seal is intact. If lids do not pop, replace lid and process in boiling water bath for 30 minutes again.
11. Do not move for 24 hours.

Appendix B

Required HACCP Forms

Product Description

1	**Product name(s)**	Vegetable sauce
2	**Process properties (i.e. thermal process, dehydrated, etc)**	Thermal process, hot filled, acidified
3	**Product properties (i.e. Low moisture, frozen, shelf stable)**	Low pH, shelf stable
4	**How is the product to be used (intended use) and who is the intended consumer? (will it be used as an ingredient, will it be cooked, RTE, etc, Will it be sold directly to consumer, to food service, to other companies)**	Direct to general public, to be used as a sauce to be heated and served
5	**Type of packaging (Units per pack, packaging material, etc)**	Glass jar with screw cap lid; pint (16 oz)
6	**Shelf-life**	12 months

7	**Where will the product be sold?** (Retail direct, restaurants, other food companies, etc)	Retail direct
8	**Labeling instructions (looking for those aspects that impact safety)**	Do not use if seal is broken or lid is distended. Refrigerate unused portions after opening.
9	**Special distribution control (Frozen, refrigerated, frozen, thawed, and displayed at refrigeration, etc)**	Use normal shipping and storage conditions.

Incoming Materials

Meat Products / By Products	**Nonmeat Ingredients**	**Processing Aids**
None.	Tomatoes Peppers Broccoli Cauliflower Zucchini Onions Garlic Celery Vegetable Oil Oregano Parsley Black Pepper Salt Brown Sugar Citric Acid Powder	Water
Rework	**Restricted Ingredients**	**Packaging Materials**
None.	(Ingredients that can result in a hazard if not properly added) None.	One pint glass jars Screw cap lids Corrugated cardboard boxes

Ingredient Spec Sheet

INGREDIENT OR INCOMING MATERIAL	INGREDIENT PROPERTIES	SPECIFICATIONS	SUPPLIER
Tomatoes.	Fresh.	Free of rot and/or decay. Keep refrigerated.	Name (Farmer) Address Phone Fax
Peppers.	Fresh.	Free of rot and/or decay. Keep refrigerated.	Name (Farmer) Address Phone Fax
Cauliflower.	Fresh.	Free of rot and/or decay. Keep refrigerated.	Name (Farmer) Address Phone Fax
Zucchini.	Fresh.	Free of rot and/or decay. Keep refrigerated.	Name (Farmer) Address Phone Fax
Onions.	Fresh.	Free of rot and/or decay. Keep refrigerated.	Name (Farmer) Address Phone Fax
Garlic.	Fresh.	Free of rot and/or decay. Keep refrigerated.	Name (Farmer) Address Phone Fax
Celery.	Fresh.	Free of rot and/or decay. Keep refrigerated.	Name (Farmer) Address Phone Fax
Vegetable oil.	Soybean-based oil. 35 lb jugs. Shelf stable.	Per supplier specifications.	Name Address Phone Fax
Oregano.	Treated spice.	Salmonella negative.	Name Address Phone Fax
Parsley.	Treated spice.	Salmonella negative.	Name Address Phone Fax

Black Pepper.	Treated spice.	Salmonella negative.	Name Address Phone Fax
Salt.	Treated spice.	Store at normal conditions.	Name Address Phone Fax
Brown Sugar.	Treated spice.	Per supplier specifications.	Name Address Phone Fax
Citric Acid Powder.	Treated powder.	Per supplier specifications.	Name Address Phone Fax
Water.	Liquid, room temperature.	Potable.	Name Address Phone Fax
Jars.	1 pint (1 oz) volume, wide mouth, glass, round/square, clear, neck finish 70/450, 12 jars/case	Store at normal conditions.	Name: AB Container, Inc. Address: 21Manning Rd, Enfield, CT 06082 Phone: (860) 745-8789 Fax: (860) 745-8791
Lids.	Screw-cap, “G” white metal cap with button, plastisol lined, neck finish 70/450, 950 lids/case	Store at normal conditions.	Name: AB Container, Inc. Address: 21 Manning Rd, Enfield, CT 06082 Phone: (860) 745-8789 Fax: (860) 745-8791
Corrugated Cardboard Boxes.	50 lb maximum weight.	Store at normal conditions.	Name Address Phone Fax

Hazard Analysis

Ingredient or Processing Step	Potential hazards introduced, controlled, or enhanced at this step.	Does this potential hazard need to be addressed in HACCP Plan? (Yes or No)	Why? (Justification for decision made in previous column).	What measures can be applied to prevent, eliminate, or reduce the hazards being addressed in your HACCP Plan?	Is this step a Critical Control Point (CCP)?
Tomatoes.	BIOLOGICAL *Salmonella* spp.	Yes.	Record of past outbreaks.	Heating/cooking step.	No.
	CHEMICAL Pesticide residues	No.	Producer GAPs enforced. Letter of conformation from producer.		No.
	PHYSICAL Rocks, sticks, leaves	No.	Can be harvested in machinery. Sorting/culling step.		No.
Peppers.	BIOLOGICAL *Clostridium botulium*	Yes.	Low acid vegetable. Record of past outbreaks.	Acidification to pH < 4.6.	No.
	CHEMICAL Pesticide residues	No.	Producer GAPs enforced. Letter of conformation from producer.		No.
	PHYSICAL Rocks, sticks, leaves	No.	Can be harvested in machinery. Sorting/culling step.		No.
Cauliflower.	BIOLOGICAL *Clostridium botulinum*	Yes.	Low acid vegetable. Record of previous outbreaks.	Acidification to pH < 4.6.	No.
	CHEMICAL Pesticide residues	No.	Producer GAPs enforced. Letter of conformation from producer.		No.

Cauliflower. (cont.)	PHYSICAL Rocks, sticks, leaves	No.	Can be harvested in machinery. Sorting/culling step.		No.
Zucchini.	BIOLOGICAL *Clostridium botulinum*	Yes.	Low acid vegetable. Record of previous outbreaks.	Acidification to pH < 4.6.	No.
	CHEMICAL Pesticide residues	No.	Producer GAPs enforced. Letter of conformation from producer.		No.
	PHYSICAL Rocks, sticks, leaves	No.	Can be harvested in machinery. Sorting/culling step.		No.
Onions.	BIOLOGICAL *Clostridium botulinum*	Yes.	Low acid vegetable. Record of previous outbreaks.	Acidification to pH < 4.6.	No.
	CHEMICAL Pesticide residues	No.	Producer GAPs enforced. Letter of conformation from producer.		No.
	PHYSICAL Rocks, sticks, leaves	No.	Can be harvested in machinery. Sorting/culling step.		No.
Garlic.	BIOLOGICAL *Clostridium botulinum*	Yes.	Low acid vegetable. Record of previous outbreaks.	Acidification to pH < 4.6.	No.
	CHEMICAL Pesticide residues	No.	Producer GAPs enforced. Letter of conformation from producer.		No.
	PHYSICAL Rocks, sticks, leaves	No.	Can be harvested in machinery. Sorting/culling step.		No.

Celery.	BIOLOGICAL *Clostridium botulinum*	Yes.	Low acid vegetable. Record of previous outbreaks.	Acidification to pH < 4.6.	No.
	CHEMICAL Pesticide residues	No.	Producer GAPs enforced. Letter of conformation from producer.		No.
	PHYSICAL Rocks, sticks, leaves	No.	Can be harvested in machinery. Sorting/culling step.		No.
Vegetable oil.	BIOLOGICAL	No.			No.
	CHEMICAL Allergens	No.	Soybean-based oil, major allergen. Labeled for consumer knowledge.		No.
	CHEMICAL Rancidity	No.	Producer GMPs enforced. Letter of conformation from producer.		No.
	PHYSICAL	No.			No.
Oregano.	BIOLOGICAL *Salmonella* spp.	No.	Record of past outbreaks. Proof of salmonella negative from producer.		No.
	CHEMICAL	No.			No.
	PHYSICAL	No.			No.
Black Pepper.	BIOLOGICAL *Salmonella* spp.	No.	Record of past outbreaks. Proof of salmonella negative from producer.		No.
	CHEMICAL	No.			No.
	PHYSICAL	No.			No.
Salt.	BIOLOGICAL	No.			No.
	CHEMICAL	No.			No.
	PHYSICAL	No.			No.
Brown Sugar.	BIOLOGICAL	No.			No.
	CHEMICAL	No.			No.
	PHYSICAL	No.			No.

Water.	BIOLOGICAL	No.			No.
	CHEMICAL	No.			No.
	PHYSICAL	No.			No.
Glass jars.	BIOLOGICAL	No.			No.
	CHEMICAL	No.			No.
	PHYSICAL Glass shards/shattered glasses	No.	Inspect incoming jars. Remove any broken jars. Wash jars to remove any broken fragments not seen during inspection.		No.
Screw-cap Lids.	BIOLOGICAL	No.			No.
	CHEMICAL	No.			No.
	PHYSICAL	No.			No.
Corrugated Cardboard Boxes.	BIOLOGICAL	No.			No.
	CHEMICAL	No.			No.
	PHYSICAL	No.			No.
Heating Step.	BIOLOGICAL Bacterial contamination	Yes.	Record of past outbreaks.	Heat sauce to 165^{o}F.	Yes. CCP 1
	CHEMICAL	No.			No.
	PHYSICAL	No.			No.
Acidification Step.	BIOLOGICAL *Listeria* spp.	Yes.	Record of past outbreaks, risk of post-heating contamination.	Acidification to pH < 4.6.	Yes. CCP 2
	BIOLOGICAL *Salmonella* spp.	Yes.	Low acid vegetables used. Record of past outbreaks.	Acidification to pH < 4.6.	Yes. CCP 2
	BIOLOGICAL *Clostridium botulinum* spores	Yes.	Low acid vegetables used. Record of past outbreaks.	Acidification to pH < 4.6.	Yes. CCP 2
	CHEMICAL	No.			No.
	PHYSICAL	No.			No.
Packaging Step.	BIOLOGICAL *Listeria* spp.	No.	Record of past outbreaks, limit product's exposure to contamination.		No.

Packaging Step. (cont.)	CHEMICAL	No.			No.
	PHYSICAL	No.			No.

Identifying Critical Limits, Monitoring and Corrective Action

PROCESS STEP CCP 1	CRITICAL LIMIT	MONITORING PROCEDURES	CORRECTIVE ACTION
Heating Step.	Temperature must exceed 165°F.	**What will be measured?** Temperature.	**Identify the cause of the deviation.** Temperature in cold spot of product does not reach 165°F.
		Where will the CL be measured? During cooking.	**What is done to correct the deviation and bring process under control.** Re-cook product.
		How will the CL be measured? Temperature probe.	**What measures are taken to prevent reoccurrence.** Bring product to boil, maintain temperature for 1-2 hours or until significantly boiled down.
		Who will monitor the CL? Line inspector/product manager.	**What is done to prevent product that is injurious to health or adulterated from entering commerce.** Test for bacterial contamination. If not able to re-cook, product is discarded and eliminated.
		How often will the CL be measured? Throughout batch process before added to jars.	

PROCESS STEP CCP 2	CRITICAL LIMIT	MONITORING PROCEDURES	CORRECTIVE ACTION
Acidification.	Product must be at or below pH of 4.6.	**What will be measured?** pH value.	**Identify the cause of the deviation.** pH is too high.
		Where will the CL be measured? During batch processing, before added to jars.	**What is done to correct the deviation and bring process under control.** Add appropriate quantity of citric acid powder to achieve pH < 4.6.
		How will the CL be measured? pH meter.	**What measures are taken to prevent reoccurrence.** Add citric acid powder as necessary.
		Who will monitor the CL? Line inspector/product manager.	
			What is done to prevent product that is injurious to health or adulterated from entering commerce. Reworked if possible. If too contaminated or unsafe, product will be discarded and eliminated.
		How often will the CL be measured? Throughout batch process, before added to jars.	

Verification Record Form

PROCESS STEP CCP 1	VERIFICATION ACTIVITIES	FREQUENCY	RESPONSIBILITY
Heating Step.	Record Temperature of Sauce	Hourly	Production Manager
	Direct Observation	During Production	Line Inspector
	Record Review	Daily	Shift Manager
	Annual Audit	Yearly	Third Party Audit
	Microbial Test	Once per incoming shipment	Production Manager
	RECORDS		
	Calibration Results		
	Production Observations		
	Microbial Results		

PROCESS STEP CCP 2	VERIFICATION ACTIVITIES	FREQUENCY	RESPONSIBILITY
Acidification.	Record pH of Sauce Prior to Filling	Once Per Batch	Production Manager
	Direct Observation	During Production	Line Inspector
	Record Review	Daily	Shift Manager
	Annual Audit	Yearly	Third Party Audit
	Microbial Test	Once per incoming shipment	Production Manager
	Record pH of Final Product 24 Hours After Filling	Once Per Batch	Production Manager
	RECORDS		
	Calibration Results		
	Production Observations		
	Microbial Results		

HACCP Plan Summary

Critical Control Point (CCP 1)	Hazard (s) to be addressed in the HACCP Plan	Critical Limits for Each Control Measure	Monitoring			
			What	**How**	**Frequency**	**Who**
Heating step.	Survival of vegetative pathogens	Temperature at cold spot exceeds 165°F	Temperature below 165°F	Thermo-couple	1x per hour	QA manager; QA intern
Corrective Action	**Verification Activities**	**Record-keeping Procedures**				
Stop production. Reroute exposed product. Adjust heating parameters. Rerun product recorded under temperature. Measure product again.	QA manager to check thermocouple more frequently until at proper level.	Thermo-couple inspection log. Corrective action log. QA verification log.				

Critical Control Point (CCP 2)	Hazard (s) to be addressed in the HACCP Plan	Critical Limits for Each Control Measure	Monitoring			
			What	How	Frequency	Who
Acidification.	Destruction of pathogen spores.	pH must be < 4.6	pH < 4.6	pH meter	1x per batch	QA manager; QA intern
Corrective Action	**Verification Activities**	**Record-keeping Procedures**				
Stop production. Reroute exposed product. Adjust citric acid additions. Rerun product. Measure product pH again.	QA manager to check pH more frequently until below proper level.	pH meter inspection log. Corrective action log. QA verification log.				

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Pennsylvania State University……..……2010-2014
North Schuylkill Jr./Sr. High School……2004-2010

Honors and Awards

Helen Roulin Scholarship (2008, 2010)
National Honors Society (2010)
Ringtown Rotary Scholarship (2010)
Galen Dreibelbis Endowment for Excellence in Agriculture (Fall 2010 - present)
Frank S. & Nina Cobb Grant-In-Aid (Fall 2010 – present)
Penn State Bookstore Scholarship (Fall 2010 – present)
Rudolph Grob Memorial Scholarship (2010, 2011, 2012)
George H. Deike Memorial Scholarship (2010)

Association Memberships/Activities

Ag Advocate (Ag Day Activities Chair, 2012-2013; Ag Day Co-Chair, 2013-2014)
Block & Bridle Club (Scrapbook Chair, 2011-2012; Little I Banquet Chair, 2011-2012)
Food Science Club
Runkle Hall Bible Study (Co-leader, 2012-2014)
American Wine Society
Pennsylvania Farm Bureau (2014)

Professional Experience

Penn State Housing & Food Service…….Jan. 2013-present
Stone Mountain Wine Cellars…….June 2013-Aug. 2013
Food Science Microbiology Lab…….Aug. 2011-Dec. 2012
Schreyer Honors College……..Aug. 2010-May2011
Trinity United Church of Christ……...2006-2010
B&R Farms……2003-July2010

Certification

ServSafe Certified (2013)
HACCP Certified (2014)

Volunteerism

Pennsylvania Vegetable Growers Association
Block & Bridle Blood for Bats Program
Pennsylvania Livestock Association
Schreyer Honors College Day of Service