An Eco-Entrepreneurship Project submitted in partial satisfaction of the requirements for the degree of Master of Environmental Science and Management for the Bren School of Environmental Science & Management

by

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FRUIT FORWARD

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The mission of the Bren School of Environmental Science & Management is to produce professionals with unrivaled training in environmental science and management who will devote their unique skills to the diagnosis, assessment, mitigation, prevention, and remedy of the environmental problems of today and the future. A guiding principal of the School is that the analysis of environmental problems requires quantitative training in more than one discipline and an awareness of the physical, biological, social, political, and economic consequences that arise from scientific or technological decisions.

The Eco-Entrepreneurship Project fulfills a core requirement for the Masters of Environmental Science and Management (MESM) Program. The project is a year-long activity in which small teams of students conduct customer discovery research to develop a business model for a new environmental venture, in addition to focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue. This Eco-Entrepreneurship Thesis Project Final Report is authored by MESM students and has been reviewed and approved by:

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ECO-ENTREPRENEURSHIP NEW VENTURE OPPORTUNITY

Fruit Forward will recapture the beneficial properties of wine grape skins and seeds to produce an organic supplement and shelf life-extender for use in cold-pressed fruit and vegetable juices. The short three-day shelf life of cold-pressed juice forces juice producers ("juicers") to press and deliver daily, which incurs high labor and transportation costs and limits business expansion. Juicers eschew existing preservation options because they are known or believed to damage the nutrients in juice, yet sixty percent (60%) of juicers say shelf life is very important to them, and that extending it by even a few extra days would enable increased production efficiency and/or business range expansion. The natural antimicrobial and antioxidant properties of wine grape skins and seeds ("pomace") can solve juicers’ preservation problem by delaying conditions that contribute to food spoilage. Dried and powdered pomace has been shown to extend the shelf life of fish, meat, and dairy products, and can double the shelf life of juice. Furthermore, the preservative molecules in pomace (flavonoids) are known to lower cholesterol and blood pressure and reduce chronic inflammation. Thus, not only can pomace extend the shelf life of cold-pressed juice without damaging nutrients, it supplements the product with healthful, natural antioxidants. Converting winery waste into a value-added product will optimize use of viticulture inputs such as water, fertilizer, and fossil fuels; mitigate greenhouse gas emissions from pomace decomposition; and prevent the groundwater acidification that can occur from pomace leachate. By valorizing winery waste, Fruit Forward will prevent these environmental harms and recover the powerful antioxidants in pomace that would otherwise be lost.

Disclaimer: Any information contained in this document that is not credited to a specific source is either considered common knowledge or has been collected via informational interviewing, in which case the sources must remain anonymous for identity protection.
EXECUTIVE SUMMARY

Fruit Forward has developed a method to transform winery waste into an all-natural, organic supplement and preservative for use in super-premium, cold-pressed fruit and vegetable juices. Many cold-pressed juice producers are unable to expand their businesses due to the short three-day shelf life of their product, but reject current preservation options such as pasteurization or high-pressure processing; these are known or believed to damage critical nutrients in the juice. Wine grape skins and seeds ("pomace") have antimicrobial properties, are rich in healthful antioxidants, and can extend the shelf life of fish, meat, and dairy products. In taste tests, Fruit Forward has shown that pomace can double the shelf life of cold-pressed juice. Our in-depth interviews and survey responses indicate that juicers would value both the shelf life-extending properties and the health benefits of a pomace product. Additionally, a majority of those in our primary target market indicated that they would be willing to use a hypothetical organic shelf life extender, provided it would not harm their juice. Finally, wine grape pomace is abundant and free, and currently poses environmental problems that Fruit Forward can help alleviate.

The state of California produces roughly one million tons of wine grape pomace (WGP) annually, which must be rapidly disposed of for sanitary reasons. Winemakers typically pay to have pomace hauled to a compost or landfill, or it may simply be piled in a nearby field. Pomace piles, or improperly managed composts and landfills containing pomace, produce acidic and phytotoxic leachate that can contaminate groundwater. As pomace decomposes, it releases the potent greenhouse gas, methane, into the atmosphere. By repurposing this material, Fruit Forward will divert winery waste outflows, thereby mitigating greenhouse gas emissions and preventing potential groundwater acidification. Furthermore, valorization of WGP constitutes optimal use of its embedded resources, including water, fertilizer, and fossil fuels.

Recovered pomace can be dried and ground, then added directly to food and beverages as a powder. Alternatively, the most active antioxidant molecules, a class of polyphenols called flavonoids, can be extracted from WGP and used as a liquid concentrate. Whether added in powder or liquid form, the flavonoid molecules from WGP act to inhibit lipid oxidation and microbial growth, the two main components of food spoilage. In addition, the antioxidant capacity of flavonoids confers multiple health benefits, such as lowering cholesterol, reducing blood pressure levels, and minimizing chronic inflammation. Use of WGP is particularly well-suited to the cold-pressed juice industry, since it can extend juice shelf-life without nutrient damage, and is also likely to enhance product value due to the known health benefits of wine grapes and flavonoids.

Distinct from traditional blended fruit juices and smoothies, cold-pressed juice is made with a specialized hydraulic press that completely separates fruit and vegetable liquid from the fibrous pulp. Without pulp in the finished product, it can take several pounds of produce to
create a single 16 oz. bottle of juice. Freshness and nutrient content are prioritized above all else, and great care is taken to avoid exposure to nutrient-damaging heat during production. The short shelf life of fresh juice means that it must be sold within three days of production or else treated to prevent spoilage. Preservation options include pasteurization - rarely employed since it uses heat to inactivate pathogens - and a newer technology known as high-pressure processing (HPP). As the name suggests, HPP destroys microbes in food by applying extremely high pressure and does not introduce heat. The effect of HPP on nutrients is thought to be minimal, though this issue is hotly debated in the cold-pressed juice industry. HPP is also extremely expensive and must be performed on juice after it is bottled, often at an offsite location. A few larger juice companies have opted for HPP and the extra 30-45 days of shelf life it offers. However, many smaller companies mistrust and/or cannot afford HPP, and see no need for this level of preservation.

Fruit Forward has interviewed or surveyed over three dozen juicers, many of whom stated a desire for just the “few extra days” of shelf life. This would eliminate the need to press and deliver every day, enabling them to expand product distribution and decrease labor costs. Powdered or extracted WGP flavonoids can give juicers these extra days; Fruit Forward has shown that powdered Pinot Noir and Chardonnay pomace double the shelf life of a green juice blend, using taste as the primary metric. Current commercial sales of WGP-derived products include: dried, powdered pomace in capsule form, marketed as a nutraceutical; dried, powdered pomace sold as a flour; and crystallized, water soluble pomace extract marketed as a food ingredient. To date, no business has differentiated pomace as a food preservative despite numerous scientific articles demonstrating its efficacy in shelf-life extension. We will be the first to offer a concentrated, organic food preservative from this unique and valuable material.

Next steps for Fruit Forward include outsourced quantitative testing of cold-pressed juice shelf life extension via powdered pomace or concentrated flavonoid extracts. We will also work directly with two local juicers in order to assess our product’s effect on juice in terms of flavor, texture, and appearance.

Fruit Forward sees this as a viable, profitable business opportunity that will successfully reduce waste, optimize resources, facilitate good nutrition, and mitigate contributions to climate change. There is a current boom in the sales of health and wellness products. Within that, the cold-pressed juice industry is growing so quickly it has been likened to an “entrepreneurial gold-rush”. We anticipate reaching and retaining customers through advertising in trade journals, such as Beverage Industry Magazine, and by introducing our product at natural food conventions like Natural Expo West. Combined with an increasing consumer focus on nutrition and natural ingredients, Fruit Forward believes the use of pomace as an antioxidant-rich natural preservative for cold-pressed juice is a timely, attractive, and durable opportunity.
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ENVIRONMENTAL PROBLEM-SOLUTION ANALYSIS

Environmental Objective

Fruit Forward initially set out to address the overwhelming global issue of organic waste. In 2012, forty percent (40%) of all food produced in the United States was thrown away, an estimated $165 billion in losses, making organic waste the largest contribution to municipal solid waste in the country. Although reduction is always the number one strategy for mitigating organic waste issues, repurposing traditional waste byproducts offers many benefits to the environment and society. By repurposing wine grape pomace via waste valorization, secondary effects of landfilled waste can be reduced and value can be added.

Environmental Problem

Wine Grape Pomace

The state of California is the world's fourth largest producer of wine, growing and consuming roughly four (4) million tons of wine grapes annually. This is converted into approximately one (1) million tons of pomace produced during harvest and production. On a global scale, pomace production totals close to 15 million metric tons. The time-sensitive nature of wine grape pomace (WGP) production makes its disposal especially challenging for winemakers and waste disposal companies, who may compost, landfill, or simply pile WGP on nearby land. In every case, pomace decomposition releases the potent greenhouse gas methane into the atmosphere, thereby contributing to global warming. Some studies have suggested that methane emissions of wine grape pomace can be as high as 104 mL per gram of raw matter. When expressed as CO₂ equivalency, this translates to more than a tonne of CO₂ equivalent emissions per tonne of pomace. In addition, pomace creates ecotoxic, acidic runoff that may contaminate soil and groundwater, which can easily occur any time there is no barrier between soil and WGP, regardless of whether the pomace is composted, piled, or landfilled.

Returning WGP directly to cropland as a source of fertilizer is not a solution to the pomace problem, as its low pH (3.8) and high concentration of polyphenols (2.6 g/kg) render it phytotoxic to the surrounding ecosystem. Because pomace is also nitrogen-poor, its addition to soil can actually result in nitrogen depletion. Furthermore, leaching and runoff from unlined WGP piles can contribute to eutrophication by increasing soil potassium, biological oxygen demand (BOD), and total suspended solids (TSS, typically sugars in this case).

These deleterious effects on the environment carry consequences for ecosystems as well. Lempereur et al (2014) have shown that both composting and spreading (e.g. on soils) have a negative impact on ecosystem quality, as expressed by the potential disappeared fraction...
PDF represents the fraction of species with a high probability of no occurrence in a region, due to the negative effects of acidification and eutrophication.

Finally, piles of pomace and mismanaged compost are a sheer nuisance. WGP has a strong odor that intensifies rapidly and attracts insects, while pomace compost piles - especially when swarming with flies - are an unattractive eyesore.

Synthetic Preservatives
Wine grape pomace can preserve foods by preventing lipid oxidation and microbial growth, both of which cause the off odors and flavors associated with spoilage. The preservative effects of WGP are mediated by a powerful class of antioxidant compounds known as polyphenols. Wine grapes have hundreds of different polyphenolic chemicals, including resveratrol and various flavonoid-type molecules, known for their health benefits.

Recent interest in applying natural, plant-based antioxidants as preservatives has been spurred by the realization that widely-used synthetic phenolic antioxidant (SPA) preservatives are persistent, ecotoxic, and potentially harmful to human health. The most common synthetic phenolic preservatives are BHA (butylated hydroxyanisole) and BHT (butylated hydroxytoluene). SPAs have been employed as preservatives in the food industry for at least seventy years, and are also used in cosmetics, rubber, plastics, and packing materials. These chemicals are toxic to laboratory animals at high doses and have been classified as possible human carcinogens. There is also evidence they disrupt hormone function, and BHT has been classified by the European Commission on Endocrine Disruption as a Category 1 priority substance. Although both BHA and BHT have been tested for human safety at the low concentrations in which they are applied, their ubiquity, combined with the persistence and newly understood ecotoxicity of these chemicals and their derivatives call for reevaluation of their use. Studies in China have detected synthetic phenolic antioxidants and their major metabolites in municipal sewage sludge in China, as well as in raw wastewater and river waters. In the UK, 100% of groundwater samples examined (N=106) tested positive for the presence of BHT. Because SPAs and SPA derivatives have the potential to bioaccumulate and are toxic to some aquatic species, their presence in ground and surface waters is especially concerning. Finally, a recent analysis of SPA metabolites in household dust revealed that BHT could be detected in 99.5% of samples (339 samples collected from 12 countries). In short, recent studies show that these harmful synthetic chemicals are widespread, and the quest for natural, effective alternatives is on. Though SPAs are not used in cold-pressed juice, the food and cosmetic industries could present a future opportunity for Fruit Forward to displace SPAs, thereby benefitting the environment and promoting human health.

Finally, it should be emphasized that phenolic antioxidants from grape seeds and skins, in contrast to SPAs, are believed safe for human consumption even at elevated levels. At least two pomace processing companies have detailed the results of eight human clinical trials...
and more than two dozen animal studies in their successful applications for GRAS status from the FDA. In humans, sustained daily doses of grape seed extract up to 100 mg per kg body weight per day (roughly 5-10 g/day for people between 100 and 200 lbs) for up to 12 weeks showed no harmful effects (and instead conferred beneficial effects, such as lowering blood pressure). In animal studies, both grape seed and grape skin extracts administered for extended periods of time at up to 6% of the total diet likewise showed no adverse effects.\textsuperscript{23,24} The bioaccumulation of grape polyphenols in tissue has not been actively investigated, but due to the natural presence of polyphenols in the human diet (i.e. tea, chocolate, fruits and vegetables), it seems unlikely that either we or our microbiome have not yet evolved to utilize these molecules.

**Environmental Policy Analysis**

*Organic Waste*

Organic waste has potential for several sustainable fates, including conversion to energy, nutrients (composting), and sources of human nutrition. Local and state governments have begun to recognize this, and are beginning to crack down on organic waste streams directed to landfills. Furthermore, the decomposition of organic matter in landfills is responsible for significant greenhouse gas emissions, constituting 18\% of U.S. methane emissions in 2012.\textsuperscript{25,26} The city of Seattle provides one example of new policy around the issue of organic waste. As of January 1, 2015, residents and commercial establishments of Seattle will be required to compost or use a waste recycling service.\textsuperscript{25} Non-compliance will result in fines or public shaming in the form of tagging.

Another, highly relevant example comes from California itself. Businesses in the state have begun to face regulation of their organic waste as California AB 1826 comes into effect. As of April 1, 2016, any commercial entity generating more than eight (8) cubic yards of organic waste per week must now recycle that waste.\textsuperscript{27} This limit will be further reduced to four (4) cubic yards as of January 1, 2017. According to our calculations, a small winery generating less than 5,000 cases per year will not be affected by AB 1826, though larger wineries will certainly be motivated to find acceptable means of pomace disposal under this new law. California is moving toward more sustainable waste management, and Fruit Forward will be part of the solution.

**Environmental Solution**

Winemakers and other businesses have undertaken several approaches to dispose of hazardous pomace waste. Utilizing pomace for compost is a popular solution but requires an industrial composting facility with the capability to monitor and manage nitrogen and oxygen content to keep the necessary microbial processes going. Some winemaking companies have also begun to convert pomace into products with more value than compost, such as a neutral liquor made from secondary fermentation, a “flour” for
nutritional enhancement of baked goods, and a healthful added ingredient marketed to the food industry. These latter uses are examples of a process known as waste valorization, which can be defined as “the process of converting waste materials into more useful products including chemicals, materials, and fuels.” Waste valorization is a better alternative to composting or secondary fermentation because it makes use of the hundreds of complex and varied plant secondary metabolites, which are nearly impossible to synthesize in the laboratory.

Waste valorization in the case of food manufacturing has attracted attention in recent years as we have come to recognize the unacceptably high volume of food waste in the United States. Thirty-nine percent (39%) of food losses occur during manufacture (as compared to 42% produced by households). Combined with America’s increasingly tighter regulations on organic waste and the municipal trend toward Zero Waste policies, food manufacturing facilities - including wineries - are being challenged to rethink the fate of their by-products. By repurposing WGP as a preservative, Fruit Forward will mitigate greenhouse gas emissions from pomace decomposition and prevent potential groundwater acidification from pomace leachate. Furthermore, valorization of WGP will make optimal use of its embedded resources: water, fertilizer, and fossil fuels. Finally, we believe Fruit Forward’s utilization of pomace waste to be a superior example of waste valorization, since it not only recovers the healthful plant polyphenols from grape skins and seeds, but also puts them to use as a natural preservative that can slow or prevent further food waste.

BUSINESS MODEL ENVIRONMENT

Industry Definition
Fruit Forward expects to enter the global food preservative industry by offering a natural alternative to traditional shelf life extenders. According to a market report, titled “Food Preservatives Market - Global Industry Analysis, Size, Share, Growth, Trends, and Forecast, 2014 – 2020,” the global preservative market was valued at approximately $2 billion in 2013 and is projected to grow to almost $2.6 billion by 2020. Further market trend analyses state that the beverage sector commands 25.5% of this industry, and this will define the initial market scope of Fruit Forward.

Within the food preservation industry, Fruit Forward is addressing the cold-pressed juice market with a WGP product. This type of beverage production utilizes a hydraulic press to squeeze juice rather than traditional centrifugal juicing that introduces heat and allegedly compromises the nutritional content of the product. This is a rapidly expanding industry with many small businesses contributing to a large market size. Sales of bottled super-premium fruit and veggie juices totaled $2.3 billion in 2014, and are up 58% since 2004, according to Beverage Marketing, a research and consulting firm.
Los Angeles is the primary business hub of this industry in the United States, with some calling it the “land of a thousand juice bars” because it’s “nearly impossible to walk a block without stumbling upon a new juice spot.” Considering the proximity of Santa Barbara to Los Angeles, Fruit Forward is well-positioned to address the needs and demands of this growing industry.

Key Trends

Market Trends

“Health is going mainstream. As consumers around the globe search for better, healthier and smarter solutions that fit their lifestyle and specific needs, the motivation for manufacturers and retailers to foster strategies for a healthier world is powerful,” states a global health and wellness report published by Nielsen Holdings, an American global performance management company. A shift in consumer attitudes toward taking personal responsibility for individual health has translated into substantial growth of the health-and-wellness market. According to data from Euromonitor International, the global sales reached approximately $774 billion for 2014, with retail value sales of health-and-wellness products grossing more than $160 billion in the United States alone. Functional foods, or foods that have a positive effect on health beyond basic nutrition, are projected to continue to increase in popularity (Figure 1). Fruit Forward will capitalize on this trend with a timely entrance to market.


Concurrent with the health and wellness market trends, the demand for cold-pressed juice is also rising: "Absolutely no bubble—we have completed an in-depth analysis, and cold-pressed juice is a solid trend, not a fad," said Liquiteria CEO Mark Wood. It is believed by producers that cold-pressed juice increases the rate of nutrient absorption in the gut,
possibly allowing much larger quantities of uptake than if you were to eat the fruits and vegetables whole.\textsuperscript{41,42} Organic juice has become more available to the public, be it in cafés, restaurants, grocery stores, supermarkets or juice bars. Consumer demographics have also broadened, making it accessible to a larger consumer base.\textsuperscript{40} Investments in the juice industry have increased since 2004-2005, when the sales of fresh juices and healthy beverages began to outgrow those of soft drinks and other less healthy beverage products.\textsuperscript{40} Public awareness of the unhealthiness of soft drinks has played a key role in this trend, and premium juice is predicted to conquer America the way premium coffee has, stirring an entrepreneurial gold rush.\textsuperscript{43}

\textit{Technology Trends}

Pasteurization and high-pressure processing (HPP) are currently the main techniques used for actively preserving premium fruit and vegetable juice blends. Pasteurization uses heat treatment to kill off pathogenic bacteria and other microbes that contribute to food spoilage\textsuperscript{44} while HPP is a non-thermal preservation alternative that employs a high-level of isostatic pressure to inactivate bacteria, viruses, yeasts, molds, and parasites.\textsuperscript{45} Pulsed electric field (PEF) technology is a new technique emerging in the European juice market that could become a viable option in the United States, but no domestic juice companies currently using this method have been identified.\textsuperscript{46}

Pasteurization is generally regarded by cold-pressed juicers and consumers as an unfavorable preservation technique, because it is known to decrease nutrient content by degrading vitamins B1, B2, B12, C, E, and folate.\textsuperscript{47} Furthermore, some juicers believe that there are beneficial bacteria present in cold-pressed juice and do not wish to employ a preservation technique that destroys pathogens and probiotic microbes alike.

Studies have also shown that while consumers appreciate the “environmental friendliness” and increased “naturalness” of HPP and PEF, they were concerned about the high price, lack of information about the technologies, and a general skepticism surrounding these processes.\textsuperscript{48} However, other technologies, like organic production, are warmly welcomed by many consumers.\textsuperscript{48}

\textit{Regulatory Trends}

The main regulatory issue concerning the cold-pressed juice industry is the US Food & Drug Administration’s (FDA) regulation mandating bacterial reduction to sell juice wholesale.\textsuperscript{42} This regulation requires a five (5) log reduction in pathogens before distributing through a wholesale supply chain. For cold-pressed juice companies who want to market their product as “raw,” this regulation prevents them from entering wholesale distribution and significantly limits the growth of their business. Fruit Forward does not intend to meet the requirements of this regulation, but instead offer an alternative that can achieve the preservation and business expansion goals of our customers without third-party involvement. Said another way, our intention is to extend shelf life without making any
claims on pathogen reduction. Although there is a good deal of evidence that pomace can kill bacterial pathogens as well as food spoilage microbes,\textsuperscript{12,49,50,51} Fruit Forward does not intend to make this claim for its product, and will focus instead on shelf life extension in terms of taste and odor preservation.

Current regulation by the FDA also requires unpasteurized cold-pressed juices to bear a label that states they are “unsafe” for infants, pregnant women, and elderly people.\textsuperscript{52,53,54} The industry is working towards lifting this labelling requirement, which may lead to the FDA reducing the rigidity of their regulations. This would ultimately be beneficial for Fruit Forward in the long term.

\textit{Societal & Cultural Trends}

According to the 2015 Nielsen global health and wellness report, “roughly seventy-five percent (75\%) of global respondents believe they ‘are what they eat’ and nearly eighty percent (80\%) are actively using foods to forestall health issues and medical conditions, such as obesity, diabetes, high cholesterol and hypertension. Successful manufacturers and retailers will innovate and provide products that incorporate easy and convenient health solutions.”\textsuperscript{36} The increasing interest in health benefits, along with the demand for fewer chemical preservatives, is known as “green consumerism”. This trend emerged in the beginning of the 1990s with the rise in consumer demand for antimicrobial compounds that were natural, not toxic for humans, environmentally safe, inexpensive, and easily found on sale.\textsuperscript{55}

Juice is the third most popular breakfast item after coffee and cereal.\textsuperscript{40} Cold-pressed juice has drastically increased in popularity as consumers are seeking fresh, natural, and minimally processed foods that also promote good health.\textsuperscript{36} For individuals on a “detox” mission, a five-to-ten day juice cleanse is a very popular option. The juices are all-natural, cold-pressed, and are increasingly seen as a lifestyle change when consistently incorporated into the daily diet.\textsuperscript{56} According to the Nielsen report, thirty-three percent (33\%) of global respondents also say that organic products are very important and that they are willing to pay a premium for them.\textsuperscript{36}

\textit{Market Forces}

\textit{Market Issues}

The main issues within the cold-pressed juice market revolve around the decision of whether or not to use preservation, and disagreement over whether or not preservation techniques like HPP are harmful to the juice product. Plaintiffs of recent lawsuits against corporations using HPP while simultaneously labeling their juices as “raw” have made allegations such as, “the juice products are not 'raw'. The effects of HPP on the Juice Products are identical to those of traditional pasteurization—inactivated enzymes, inactivated probiotics, altered physical properties of the product, and denatured proteins,
among other undesirable qualities. As a result of Defendant's use of HPP, its Juice Products are nothing more than run-of-the-mill, processed juices, and fail to provide the same nutrients, enzymes, and vitamins that the products have prior to being subjected to HPP.”

Although the lawsuits have since been dismissed, they raise an important issue about consumer perception and the value of cold-pressed juice. Part of its appeal is that it is fresh and natural - two things that are threatened by the use of preservation techniques.

High-pressure processing also requires extensive energy consumption to effectively inactivate microbes by “squeezing” them with a pressure of greater magnitude than that found in the Mariana Trench, making this process quite expensive. One cold-pressed juice business owner estimated an HPP cost of approximately $0.30 per bottle of juice, before any transportation or distribution costs.

**Market Segments**

Fruit Forward will focus primarily on the cold-pressed juice market segment that presses their juice ahead of sale, rather than only to order, as this group would have the greatest need for an organic preservative. Furthermore, due to the controversy surrounding pasteurization and high-pressure processing of juice, the market segment that does not want to undergo such processing represents a substantial and important subdivision that Fruit Forward will target. Table 1 shows Fruit Forward’s positioning among juice preservation methods and includes examples of brands and segments that are not intended to be initial customers, due to their current use of other methods. However, it should be noted that these segments still represent potential future customers, as they might be interested in our product’s antioxidant content and potential health benefits.

**Table 1: Fruit Forward positioning among juice preservation methods.** *Note that the microbial reduction in juice is still being confirmed for Fruit Forward’s product (See Appendix V) and that this will not be an emphasized as part of our value proposition. For health benefits of WGP, see see Minimum Viable Product section.*

<table>
<thead>
<tr>
<th>Preservation Method</th>
<th>Pasteurization</th>
<th>HPP</th>
<th>Fruit Forward</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shelf Life</td>
<td>90 d</td>
<td>30-45 d</td>
<td>7 d</td>
<td>3 d</td>
</tr>
<tr>
<td>Microbial Reduction</td>
<td>&gt;99%</td>
<td>&gt;99%</td>
<td>90%*</td>
<td>0%</td>
</tr>
<tr>
<td>Nutrient Effects</td>
<td>Most damage: Enzyme denaturation; Vitamin degradation</td>
<td>Less than pasteurization, but disputed</td>
<td>No damage; boosts antioxidant content and offers health benefits</td>
<td>--</td>
</tr>
<tr>
<td>Cost per Bottle</td>
<td>Most affordable option</td>
<td>$0.30 + Transportation and Distribution</td>
<td>$0.13</td>
<td>--</td>
</tr>
<tr>
<td>Existing Example</td>
<td>Naked Juice, Odwalla</td>
<td>Suja, Blueprint</td>
<td>--</td>
<td>Most local retailers</td>
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Needs and Demands
Based on customer interviews and survey data, the number one pain point identified by cold-pressed juicers is the need for a longer product shelf life. This extended shelf life will provide many benefits, including the ability to ship products to customers farther away, reduced delivery frequency and costs (a five or seven day juice cleanse may require multiple deliveries without preservation), and reduced labor costs, since juicers typically press every night under current conditions. As stated by the account executive of a local cold-pressed juice company, “extending shelf life is the catalyst to success in this business.” Cold-pressed juicers have also expressed a desire to increase the antioxidant content of their product as consumer sales tend to respond well to this “buzzword”. Fruit Forward’s product made from wine grape pomace will directly address both of these demands, and furthermore may be of value in certain future market segments solely for its antioxidant content.

Switching Costs
Minimal switching costs are anticipated for potential customers, other than optimizing the use of Fruit Forward’s product as part of an in-line cold-pressed juicing process. No current business exists that Fruit Forward will directly compete with in the cold-pressed juice market, so branding and brand loyalty will not be an issue. It is expected that the majority of customers will not be using a preservative method prior to using Fruit Forward’s product and therefore will not have to attend to the disruption of business or voiding of contracts. For only those customers choosing to switch from another preservation technique to Fruit Forward’s product, it is possible that a brief disruption of business may occur. In comparison, a juice company that decides to adopt a preservation technique that results in a five (5) log reduction in pathogens, such as pasteurization or HPP, would incur high switching costs due to a change in the manufacturing and processing of their product.

Market Analysis

Total Available Market Size
Based on the 2013 estimated value of the global food preservative market and the assumption that beverage additives account for 25.5% of the total industry, Fruit Forward is estimating a total available market size of $510 million. However, if the proposed industry trajectory is true, this valuation could increase to more than $650 million by 2020.

Served Addressable Market
The LA Times reports that the cold-pressed juice market is valued at approximately $100 million annually, with more than two-thirds of the sales revenue acquired by independent brands (not wholesale). According to the Pressed Organic Juice Directory, there are approximately 4,400 store locations within the United States that sell cold-pressed juice (Figure 2); these stores represent the served addressable market for Fruit Forward.
However, it is unclear whether or not this directory reports exclusively organic cold-pressed juice retailers, so it is possible that this served addressable market size is underestimated.\textsuperscript{59}

![Figure 2: Pressed Juice Companies in the United States, 2015. Source: Pressed Organic Juice Directory.](image)

**Market Divisions**

Within the cold-pressed juice market, there is a sharp division between businesses in relation to preservation practices. Some companies in this market use HPP or other preservation techniques to conform to FDA regulations for wholesale distribution.\textsuperscript{49} However, juicers who strongly dislike HPP and pasteurization view these companies as “juice hoarders,” attesting that they are not focused on health education or proper nutrition, are infiltrating the market solely for the purpose of making a profit, and are stealing customers away from local “mom and pop” juice bars. While these claims are unsubstantiated as of yet, it is clear that anti-HPP juicers believe in the potency of a truly fresh product and feel the public is being duped by HPPing wholesalers whose juice is thirty days out from production. Basic knowledge of biochemistry and chemical stability - or even just common sense - tell us that a month old product is unlikely to contain the same nutrient content as a fresh one, and thus we agree with these juicers to some extent. Businesses seeking wholesale distribution would not be included Fruit Forward’s target market, as our WGP product is unlikely to meet the FDA requirements. However, it is possible a WGP product could be used by these businesses for its other beneficial nutritional properties e.g. antioxidants.

The Fruit Forward team has also discovered a dichotomy of cold-pressed juice bar owners regarding their reasons for entering the market. During informational interviewing, one juicer noted that he got into the cold-pressed industry, because a friend recommended it as a good business opportunity. Fruit Forward refers to this kind of juicer as a “Businessperson,” or someone who is more concerned with building a successful company and is only as interested in product integrity as their customers are. Other juice bar owners ardently believe in the nutritional value and health promoting properties of their product.
and want to share that with their customers. They have entered the cold-pressed juice market based on their conviction that “it’s about what you put in your body,” and are therefore classified as “Juice Enthusiasts”. Distinction between Businesspeople and Juice Enthusiasts may be an important factor in determining how Fruit Forward markets its product to the cold-pressed juice industry.

**Target Market**

Within the served addressable market (SAM), Fruit Forward is mostly interested in customers that press some or all of their juice ahead of sale. Juice companies that only prepare juice as per order will not have a high demand for an organic preservative and therefore would not be included in the target market (TM). Data collected by the Cold-Pressed Juicer Survey (See Appendix II) estimates that ninety-one percent (91%) of the SAM would be captured in this segment, or approximately 4,000 juice store locations.

Figure 3: Fruit Forward Market Size. Total Available Market (TAM, teal) represents the market value for the global food preservative industry, specifically for beverages. Served Addressable Market (SAM, light blue) consists of all cold-pressed juice retail locations in the United States. The Target Market (TM, red) captures juice store locations that press their product ahead of sale and are also unwilling or unable to use high-pressure processing. Sources: Transparency Market Research, Pressed Organic Juice Directory, Cold-Pressed Juicer Survey data.

Fruit Forward’s serviceable obtainable market, or target market (TM), will capture the subdivision of cold-pressed juiceries that presses ahead of sale and is also not willing or able to use high-pressure processing or other preservation technologies. These companies will have the greatest preservation pain point for Fruit Forward to alleviate and are estimated to comprise sixty-seven percent (67%) of those juicers who press ahead of sale, or roughly 2,700 potential customers (Figure 3). Businesses that are already willing and eager to implement an in-line, natural solution to augment the shelf life of their product will be potential early adopters. Fruit Forward has already identified and developed relationships
with several business locations within Santa Barbara that fit this description, and the team is eager to begin networking with cold-pressed juicers in larger metropolitan areas such as Los Angeles, San Francisco, and New York City.

Competitive Analysis

Competitors

There are no direct competitors currently marketing their products to the cold-pressed juice industry as an organic preservative; therefore the intensity of rivalry is very low. However, there are several companies making products using grape skins and seeds that could potentially push into the competitive market space if Fruit Forward’s business model proves successful and profitable.

1. **Polyphenolics** – A division of Constellation Brands, Inc., an international producer and marketer of alcoholic beverages and located in Madera, California, Polyphenolics produces a grape seed extract using a patented hot water extraction method. This product is intended for use as an ingredient in nutraceutical formulations and its health benefits are heavily promoted. As a subsidiary of Constellation Brands, Polyphenolics has access to large amounts of capital and lab analysis capacity for product optimization. However, they do not use fermented grapes in their manufacturing, suggesting that they may have high supply chain costs.

2. **San Joaquin Valley Concentrates (SJVC)** – Located in Fresno, SJVC is a sister company of E&J Gallo Winery and a supplier of grape juice concentrates, natural dyes, and grape seed extract to the food and beverage industry. Also using pre-fermentation grape seeds and a warm water extraction process, they manufacture a product called ActiVin™ for use as an ingredient in nutraceuticals, beverages, teas, oatmeals, and cereals. SJVC does not directly advertise ActiVin™ as a food preservative, but the company website mentions that it has the potential to be used as a “natural preservative in meat by limiting oxidation.”

3. **Naturex** – Naturex is a publicly traded French company and is considered the “global leader in specialty plant-based natural ingredients.” Operating at an industrial scale, Naturex markets natural ingredients across a wide variety of industries, including food, nutraceuticals, pharmaceuticals, and cosmetics. Although they have developed an antioxidant rosemary extract with the suggested potential to be used as a food preservative, it is unlikely that they would be interested in the specific needs and demands of Fruit Forward’s target market.

4. **GRAP’SUD** – This company is also operating out of France and manufactures grape and olive byproducts tailored to the specific requirements of the nutraceutical, food,
agriculture and agro-industry, alcohol and spirits, and oenology markets.\cite{66} Even with a product portfolio that boasts a suite of grape juice concentrates, grape extracts and natural colorings, this company does not appear to be marketing the preservative properties of grape polyphenols. They have an independent supply chain, but all of the relationships they have developed are with French winemakers.

5. **WholeVine** – A sister company of Jackson Family Wines in Sonoma County, WholeVine is committed to “helping the fine wine industry reduce its environmental footprint by generating new uses for vineyard byproducts.”\cite{67} Their products include oils, cookies, and flour made from repurposed wine grape skins and seeds. WholeVine would likely incur the highest switching costs as a new entrant, since it appears their research on varietal grape polyphenols primarily focuses on the characterization of compounds that contribute to color.

A competitive analysis reveals how Fruit Forward’s unique value proposition differentiates from that of other potential competitors (Figure 4). All of the addressed businesses market the use of natural ingredients and the antioxidant health benefits of their products, but not very many are exploring the preservative potential of their products. While a few companies source their inputs from repurposed biowaste, only Naturex and Grap’sud employ an independent supply chain. To date, none of these potential competitors have optimized their production process to achieve organic certification.

![Figure 4. Fruit Forward Competitive Analysis. Major competitors include processors of wine grape pomace such as Polyphenolics, San Joaquin Valley Concentrates (SJVC), Grap’Sud, and Whole Vine, as well as Naturex, manufacturer of an all-natural antioxidant preservative derived from rosemary plants. Asterisks (*) represent foreign companies.](image)

Naturex is the only company with sizable brand recognition due to its commercial presence, but this is not a common household name. However, WholeVine has been successfully expanding its sphere of influence with its direct-to-consumer (B2C) business model.

**New Entrants**
Fruit Forward will need to secure proprietary information to alleviate the threat of new entrants into the competitive space. Patents for the proposed organic extraction process and
the specific application of its WGP products in cold-pressed juice will ensure that intellectual property is maintained. A diversified portfolio of products, both in powder and liquid forms, that has been optimized for different juice blends will also make it more difficult for competitors to replicate Fruit Forward’s value to juicers.

Organic certification may also prove to be a substantial barrier to entry into the market. Competing businesses would be required to re-design their extraction processes, which could lead to high switching costs, particularly for industrial manufacturers that have streamlined their production and hold massive capital investments in production equipment e.g. Naturex.

**Substitute Products & Services**

WGP products sold by other companies could act as direct substitutes for Fruit Forward’s proposed product design. However, these products are not organically-certified or specifically formulated for the preservation of cold-pressed juice, which may reduce customer incentive to switch. Item substitutes for Fruit Forward’s products and services could also include other natural food ingredients that can be added to cold-pressed juice to extend its shelf-life; at this time, no such product is in use for juice. However, a rosemary extract produced and sold by Naturex is currently marketed as a food preservative, and depending on taste, might potentially be used in fruit and vegetable juices.

It should also be noted that vitamin C, vitamin E, and citric acid can all be employed as antioxidant food preservatives. While the latter is primarily used to prevent oxidation of pigments (i.e. to prevent browning), the former two work to slow the development of off odors and flavors by inhibiting the lipid oxidation that leads to food spoilage - much like wine grape pomace. Vitamins C and E inhibit oxidation by scavenging free radicals, as does wine grape pomace. However, pomace also inhibits oxidation by preventing the initial formation of free radicals, thus attacking the problem from both sides. Furthermore, because it contains a mixture of hundreds of different, synergistic polyphenolic compounds, wine grape pomace far outperforms single antioxidant molecules such as vitamins C and E in terms of antioxidant capacity. For these reasons, Fruit Forward does not perceive these to be substitute products.

A variety of substitute services are available in the form of thermal or physical preservation techniques (Table 2). Historically, pasteurization has been a common method of preserving juice without the use of fermentation. However, in the spirit of current cultural trends, it has been rejected by cold-pressed juicers due to the negative effects of high temperature, such as protein denaturation and the inactivation of beneficial bacteria, which tend to reduce the juice quality and freshness. A more popular choice of substitute service is high-pressure processing (HPP), particularly with businesses looking to break into the wholesale market segment. This process is energy intensive and consequently expensive, costing approximately $0.20-0.30 per pound of product, or per 16 oz. bottle of juice. Additionally, the effects of HPP vary drastically by treatment type and sample ingredients; therefore, every juice blend would
need to be analyzed individually for optimal shelf-life extension, further increasing costs. While Fruit Forward would also plan to optimize product performance for different blends, this process would require far less energy and expense. Other existing preservation techniques include pulsed electric field (PEF) and ultraviolet (UV) methods, but these have limited customer use due to unfamiliarity and/or limited efficacy across all juice products.

<table>
<thead>
<tr>
<th>Table 2. Current Options for Juice Preservation.</th>
<th>Comparison of available thermal (pasteurization), physical (UV, PEF, and HPP), and chemical (BHA) techniques for juice preservation by cost, energy use, nutrient degradation, capacity to yield a 5 log bacterial reduction, major pros, and major cons.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category</strong></td>
<td><strong>Method</strong></td>
</tr>
<tr>
<td>Thermal</td>
<td>Pasteurization</td>
</tr>
<tr>
<td>Physical</td>
<td>UV (ultraviolet)</td>
</tr>
<tr>
<td>Physical</td>
<td>PEF (pulsed electric field)</td>
</tr>
<tr>
<td>Physical</td>
<td>HPP (high pressure processing)</td>
</tr>
<tr>
<td>Synthetic Antioxidants (Chemical)</td>
<td>BHA/BHT (butylated hydroxyanisole/ butylated hydroxytoluene)</td>
</tr>
</tbody>
</table>

There is also the possible substitution of certain chemical preservatives, such as BHT and BHA. These are synthetic antioxidants that function similarly to the polyphenolic compounds found in WGP. However, as previously discussed, these particular chemicals are classified as ecotoxic, carcinogenic, and even illegal in some countries, rendering them poor and even improbable substitute products. Other potential synthetic chemicals will also present their own safety concerns. Conversely, the polyphenolic chemicals in WGP are not expected to accompany health risks since these are the same organic compounds found in commonly eaten table grapes. However, further health risk assessment should be conducted prior to market launch. Competitive positioning of Fruit Forward’s organic preservative proposition indicates that a shelf-life extension product made from WGP is more affordable and eco-friendly than available substitute products and services (Figure 5).
Figure 5: Substitute Products & Services. Fruit Forward’s competitive advantage over substitute products like synthetic phenolic antioxidant preservatives (e.g. BHT), and physical preservation methods like high-pressure processing (HPP).

**Suppliers & Other Value Chain Partners**

Fruit Forward will establish its operations between wineries (suppliers) and cold-pressed juice companies (customers). Fruit Forward’s main supply, organic wine grape pomace, is typically considered a waste product by winemakers (key partners) and as such is a very inexpensive feedstock; many wineries actually pay to have it removed from their property. Furthermore, WGP is produced in bulk in the wine industry during harvest, the most hectic part of viticulture. One local winemaker estimated that he works “as much as 100 hours a week” during grape harvest and that dealing with vast quantities of WGP is the last thing he wants to worry about. Therefore, supply costs and availability are not considered substantial hurdles to business operations. The bargaining power of these suppliers also is not expected to be significant since Fruit Forward is providing them a service by removing this waste and also has the capacity to diversity supply source, if necessary, thereby creating competition between potential suppliers.

Once a sale has been made, Fruit Forward will enter into the cold-pressed juice supply chain concurrent with the fresh produce ingredients. Entering at this point is unique compared to other preservation techniques, like pasteurization and HPP, which occur after the juice is produced, typically at an off-site location. This in-line process application of a WGP-derived organic preservative means juice producers will not have to succumb their product to an additional (often third-party) processing step, which will increase convenience, decrease costs, and maintain maximum product freshness to be enjoyed by the end consumer.

It is also important to note that an additional value chain partner may be needed downstream of Fruit Forward’s operations. Any fibrous waste potentially generated by the
polyphenolic liquid extraction process will be redirected to biomaterials producers for reuse, ensuring a closed loop system.

Stakeholders
Fruit Forward has a variety of stakeholders across a plethora of industries. The most evident are winemakers and vineyard owners, who will benefit immensely from convenient and free waste disposal. Similarly, waste treatment plants may also benefit from this waste valorization as industry expert interviews revealed that winery waste is extremely difficult to treat. Producers of cold-pressed juice, as the primary customer base, will have the greatest stake in the production of an organic preservative. Consequently, Fruit Forward’s customers’ customers, cold-pressed juice consumers, will have a stake in this product as their preference will ultimately shape the demand parameters of juice bar products. In other words, the opinions of the consumer will dictate the actions and behaviors of cold-pressed juice producers. Leaders in the natural foods and food preservatives industries will also have a great deal of interest and potential gain following the launch of the company. Additionally, the U.S Food and Drug Administration (FDA) and other policymakers will be involved in Fruit Forward’s operations as the product will both need to be monitored for human consumption and provide a healthy alternative to traditional chemical food preservatives.

Competitive Advantage
Considering the holistic benefits of our multi-faceted value proposition, Fruit Forward encompasses six (6) main points of product differentiation and business advantage.

1. **Proprietary extraction technique and market application** - Fruit Forward would secure intellectual capital by filing a patent for the unique cold water extraction process used to capture WGP polyphenols. After consulting with an intellectual property attorney, it was discovered that our specific market application for WGP-derived products is also patentable.

2. **Organic certification** - As previously discussed, Fruit Forward would be the first company to bring a certified organic WGP extract to market, creating a barrier to entry for businesses that have not optimized production to meet the specific certification criteria. This certification will also act as a signal of value and trustworthiness to potential customers that Fruit Forward has not formed personal relationships with, contributing to brand reputation. Furthermore, an organically-derived shelf-life extender has the potential to revolutionize the food preservative industry.

3. **Low switching costs for customers** - This increases the convenience for customers and mitigates the competitive threat of substitute products and services.
4. **Increased health benefits compared to substitute products** - Fruit Forward has a competitive advantage in its ability to both preserve juice and boost its health benefits (see Minimum Viable Product section), a significant perk in a social climate with increasing demand for functional foods.

5. **Ideal domestic positioning** - Fruit Forward is strategically located between the prosperous wine country of Santa Barbara County and the cold-pressed juice hotspot, the city of Los Angeles. This drastically simplifies customer acquisition, feedstock supply, and product distribution. Conversely, some of Fruit Forward’s most imminent competitors cater to foreign markets, such as France, which limits personal relationships with domestic customers.

6. **Exclusive relationships with organic vineyards** - Fruit Forward is one of the few players in the competitive space to employ a supply chain that is independent of a parent company. This has allowed for the development of personal relationships with a variety of organic vineyards, therefore enabling a diverse portfolio of supply chain partners and decreasing the possibility of price leveraging by suppliers. Combining these relationships with our extensive research of the cold-pressed juice market, Fruit Forward has strategically placed itself in the optimal position to capitalize on this timely, attractive, and durable business opportunity.

**CUSTOMER DISCOVERY**

Customer Discovery Timeline

- **Fall 2014:**
  - Fruit Forward rules out a Business to Consumer (B2C) model for a WGP preservative.
  - Fruit Forward discovers a potential Business to Business (B2B) model for a WGP preservative when a local juice business reveals they are actively searching for ways to extend product shelf life.

- **Winter 2015:**
  - In-depth interviews (N=14) with more cold-pressed juice producers show that product loss due to spoilage is not a major problem, but indicate that many juicers are limited by short shelf life and would like product to last longer.

- **Spring 2015:**
  - Continued in-depth interviews (N=4) reveal that not all juicers want extended shelf life (some believe product is valuable only when fresh); this subset
prizes nutrients and antioxidants above all else, and would be interested in supplementing antioxidant content.

- **Fall 2015:**
  - Online survey responses (N=25) support segmentation of the juicer market, and indicate willingness to pay (WTP) of both segments for an organic preservative that “could double your product’s shelf life and increase the health benefits.”

- TOTAL (N = 82): 57 interviews, 25 survey responses

**NOTE:** All interviews conducted by Fruit Forward in the course of this project are summarized in Appendix IV.

**Customer Problem Hypotheses**

The realization that wine grape pomace (WGP) could work as a food preservative led us to explore potential customers. We started with consumers.

**Hypothesis 1: Consumers would value a WGP product that could extend produce shelf life.**

**Research Methodology and Objectives**

Fruit Forward conducted 17 interviews in person with local farmers’ market shoppers or via email with friends and family, with the goal of assessing consumer interest in a shelf life extending spray or wash intended for produce (See Appendix II, Consumer Survey).

**Results**

1) When asked “if there was an all-natural food wash or spray that could extend the shelf life of your fruits and vegetables without the use of chemicals or traditional food preservatives, would you use it?” consumers indicated skepticism. Even though they were specifically told “all-natural” and “without the use of chemicals,” they were reluctant to put anything directly on their food.

**Lessons Learned**

Overcoming the hurdle of skepticism would take a great deal of consumer education (that would need to be based on existing and as-yet-to-be-conducted research), and for this reason a Business-to-Consumer (B2C) model is not likely to work well for Fruit Forward. The B2C model was ruled out just before we discovered the preservation problem of a local cold-pressed juice producer (“juicer”), which led us to our second hypothesis.

**Hypothesis 2: Juicers lose a lot of product due to short shelf life.**

**Research Methodology and Objectives**
Fruit Forward conducted 19 one-on-one interviews in person and over the phone, with the goal of collecting basic information about the cold-pressed juice industry and testing whether the customer pain point we had discovered was shared by other juicers. Specifically, we wished to know:

- How many juicers press juice ahead of sale?
- What are the actual and ideal numbers for product shelf life?
- How much juice is lost to spoilage in an average week?
- How do juicers keep their product fresh?
- What are the biggest problems facing cold-pressed juice businesses and what do they wish they could change?

**Results**

1) We quickly realized that some “juice bars” grind/blend fruit and vegetable juices to order rather than ahead of sale. Juice made on the spot is distinct from premium “cold-pressed” juice made on an industrial juice press, and it appeared that only companies that press juice ahead of sale might struggle with shelf life. Thus, we learned that some juice and smoothie bars serve only made-to-order juice and are thus not potential customers. We also found and interviewed seven (7) local juicers who press ahead of sale and would be potential customers.

2) For juicers who press ahead of sale, the typically reported product shelf life was three (3) days. Most juicers said they would like product to last a few extra days, indicating a seven (7) day shelf life would ease their production constraints and allow them to expand their business range.

   - “Just a few more days of shelf life would allow us to expand to the Bay Area.”
   - “Seven to ten days would enable us to increase our distribution.”
   - “Cleaning that machine takes a lot of time, and when we have to make each blend every night it is a LOT of labor. With a three-day shelf life, we need to be delivering [to businesses] daily.”
   - “We press for eight hours a day and then deliver immediately - it’s a lot of effort.”

3) We were surprised to learn that not much juice product is lost to spoilage. Juicer profit margins are tight due to the high cost of input materials (produce), so they keep a close watch over production and sales numbers to minimize loss.

4) Refrigeration and prevention of oxygen exposure, i.e. dispensing and storing juice in sealed bottles, were the only means of preservation juicers reported. We also learned that there are different degrees of product preservation, with wholesale distribution requiring the most rigorous. Specifically, the FDA requires a 5-log reduction in microbial content of fresh juice, typically contains ~100,000 microbes per milliliter, depending on the batch and the acidity of the juice blend, according to
our independent research. Most juicers we spoke to were not interested in wholesaling their product and were not looking for this kind of extreme treatment. Although multiple preservation methods are available (see Table 1), juice producers are reluctant to jeopardize the integrity of their product, and those we spoke to have chosen to keep business small, pressing and delivery juice daily to customers or retail locations rather than utilize pasteurization or high pressure processing (HPP). Importantly, juicers looking to wholesale their juice are not potential Fruit Forward customers since WGP, despite its antimicrobial properties, cannot reduce microbial counts to the degree needed.

5) When asked what they most wished to change about the juice business, interviewees named consumer awareness of input costs, as well as product shelf life.

- “[I would like to change] customer education in understanding the real cost of food - like why organic produce is expensive but a bag of Fritos is cheap, and why the fresh produce is worth it.”
- “Extending shelf life is the catalyst to success in this business.”

These quotes reveal that extending product shelf life by even a few days would save juicers time and money by enabling them to press less often and deliver less frequently.

Lessons Learned
A major takeaway from our initial round of juicer interviews was that preventing food waste is not going to be a big part of our ecological benefit or value proposition, since juicers are careful not to make more product than they can sell before it spoils. However, we also found that juicers do seem to struggle with short shelf life, which forces inefficient production schedules and limits juice business size and range. Having verified that shelf life is a big issue for juicers, we next wanted to explore how much value a juice business would find in Fruit Forward’s potential product.

Around this point in our customer discovery, we discovered, based on taste only, that we could double the shelf life of a leafy green juice blend by treating it with a competitor’s pomace “flour” (see Appendix V: Research Results). Our next hypothesis was geared toward a product with this capability.

Hypothesis 3: There are many juicers who are not interested in HPP but would value shelf-life doubling.

Research Methodology and Objectives
Fruit Forward conducted 19 one-on-one interviews in person and over the phone to explore juicer valuation of shelf life doubling, as well as their attitudes toward a newly popular
preservation option: high-pressure processing (HPP). (Note that hypotheses 2 and 3 were addressed simultaneously.) In the spring quarter of 2015, we began using an approved interview script with specific questions (see Appendix III), such as:

- What are some of the most challenging problems for your business?
- Do you prepare juice ahead of time to sell later?
- What are your current methods for keeping your juice fresh?
- Have you considered other methods? If not, why?
- What is your opinion of high-pressure processing (HPP)?
- What is your juice’s current shelf life? What would be the ideal shelf life if you had the ability to extend it? What would this do for your business?
- If there were an additive made from all natural agricultural products that could extend the shelf life of your juice, do you think you would consider using it in your product? What would be your main concerns about it, if any? Would this additive need to be organic?
- Assuming it could double your current shelf life, how much do you think you might be willing to pay for this product (per bottle)?

**Results**

1) The decision to use HPP has been divisive in the cold-pressed juice industry. Many juicers indicated distrust of this method, while others stated they would purchase and use HPP equipment if they could afford it, or would consider buying time on a time-shared facility (“toll processing”). Although there is no doubt HPP is far superior to pasteurization at maintaining nutrient integrity (Table 1), whether it truly leaves all nutritional components of juice intact is still hotly debated. In addition, HPP kills the majority of microbes in juice. Since these may be beneficial for digestive health, many juicers are skeptical of using high-pressure processing.

- “I would not consider HPP, because it would compromise the nutritional value. Plus, by the time the juice reaches the shelf, it’s already three days old after transportation to and from the processing facility.”
- “I don’t know about HPP... it kills the good bacteria too!”
- “HPP is like losing a finger instead of a hand [pasteurization] - you’re still losing something!”

2) Many juicers were interested in our product as we described it to them, as long as it did not “harm” the juice or cause loss of nutrients, with some emphasizing the desire for a natural preservative. Others were adamant about not wanting to extend juice shelf life, believing juice is best fresh and that nutritional benefits are rapidly lost with time. However, as we talked with these juicers further, we came to learn they might be interested in an organic source of added antioxidants for their products.
○ “[I am] interested in keeping the product fresh, not in extending shelf life.”

3) Fruit Forward learned that a 95% organically-sourced product can still be labeled as organic, and thus offering an organic preservative is not essential for juicer marketing purposes. Nevertheless, juicers indicated a preference for organic ingredients wherever possible.

4) Willingness to pay (WTP) values from several local juicers were promising, with one reporting $0.50 per bottle of juice served, and another $0.20 per bottle. In addition, one company disclosed their monthly production capacity as 10,000 bottles a month, enabling preliminary calculations on monthly revenue per cold-pressed juicer.

Lessons Learned
Fruit Forward was surprised to find that some juicers have no desire for extending shelf life, and even more surprised to find that these juicers might still be interested in our product as a natural, organic source of antioxidants. To gain more quantitative information about juicer interest in our product, potential market segmentation, and WTP, we designed and administered an online survey.

Hypothesis 4: Juicers would value shelf-life doubling, and/or antioxidants in their juice, with a WTP of approximately $0.20-0.50 per bottle of cold-pressed juice.

Research Methodology and Objectives
A survey for cold-pressed juicers (N=25) (see Appendix II, Cold-Pressed Juicer Survey) was designed using the online tool, Survey Monkey, and a request for survey response was submitted to over 120 juice businesses we discovered via internet searches, LinkedIn, Groupon, and the Pressed Organic Juice Directory. 59 Juicers were asked:

- Do you prepare juice ahead of sale?
- What is your opinion of HPP?
- Would you consider yourself more of a “Businessperson” or “Juice Enthusiast”?
- Are antioxidants important to you or your customers?
- Please rank the value of:
  - Increased antioxidant content in product
  - Extended product shelf life
  - Increased fiber, vitamins, and minerals in their product
- Would you consider using an organic preservative in your cold-pressed juice if it could double your product’s shelf life and increase the health benefits??
- What would you be willing to pay, per bottle, for such a preservative?

Results
1) Online research and the results from our survey enabled Fruit Forward to estimate our Total Available Market (TAM), Served Addressable Market (SAM) and Target Market (TM). Because we have no current plans to pursue international markets, we defined the SAM to be all juice bars in the United States (approximately 4400).\textsuperscript{59} Based on our survey numbers, Fruit Forward’s TM - juicers who press ahead of sale (91% of SAM) and are also not interested in HPP (67% of 91%) – is approximately 2,700 juice retail location, or potential target customers (see Figure 3).

2) Within Fruit Forward’s Target Market, 58% self-identified as Businesspeople, and 42% as Juice Enthusiasts. 92% of juicers reported that antioxidants were important to them or their customers.

3) Around one-third of Juice Enthusiasts ranked antioxidant content of highest importance to their business, while 80% of Businesspeople ranked shelf life highest (Figure 6).

4) The interest in a preservative was stronger for Businesspeople than for Juice Enthusiasts, with more than half (60%) of the Businesspeople indicating “yes” they would consider using an organic preservative in their product, and 29% of Juice Enthusiasts indicating they would “maybe” consider it (Figure 7). Of all respondents interested in an organic preservative, the mean WTP was $0.20 per bottle, with a maximum of $0.50 per bottle served. The mean WTP for the TM came to $0.13 per bottle (Note: For comparison, the cost of HPP toll processing is ~$0.30 per bottle, before transportation and distribution costs.)

5) Comments on HPP:
   ○ “We believe valuable nutrients are lost and taste is compromised in the HPP process.”
   ○ “Customers should be made well aware that they’re not buying fresh juice. I’ve seen a lot of misleading marketing around this process.”
   ○ “Probiotic-based extending of the shelf life would be better for us as a brand.”
   ○ “HPP juice that is on the market tastes how our juice tastes after it has gone bad.”

6) Comments on using an organic preservative:
   ○ “Absolutely! It would reduce costs significantly and increase quality.”
   ○ “Yes, as long as it is 100% organic and natural!”
   ○ “If it was not a form of pasteurization, we would definitely use it.”
   ○ “As long as heat treatment isn’t used, I would definitely consider an option that would reduce the risk of harmful bacteria from the juice product.”
Lessons Learned

Fruit Forward’s target market appears to be segmented by our product’s multi-faceted value proposition. We discovered that what we had previously considered a nice perk - the health benefits of WGP antioxidants - is in fact important to almost all survey respondents. Although shelf life was indeed the top priority for the entire target market (67%) as well as each market segment within that, almost one-third of Juice Enthusiasts ranked antioxidant content as more valuable to their business than shelf life or nutrients! In contrast, none of the Businesspeople ranked antioxidant content above shelf life or nutrients.
Our survey results indicate a roughly 60/40 split between Businesspeople and Juice Enthusiasts in our target market, with the Businesspeople expressing the most interest in our product as it was described to them: “an organic preservative [that] could double your product’s shelf life and increase the health benefits.” When described as a preservative, in spite of the words “organic” and “health benefits,” our product was of little interest to Juice Enthusiasts, with 71% saying they would not use it and the remainder stating they were unsure. However, this same market segment places an extraordinary value on the antioxidants in their product. We believe that these customers would be very interested in WGP as a natural, healthful antioxidant supplement, particularly because it could be described on their product label as “organic grape skins and seeds”. It should also be noted that the majority (57%) of the Juice Enthusiast segment ranked “extended product shelf” life highest among several cold-pressed juice attributes. For this reason, we believe that at least a subset of this segment would be interested in the preservative aspect of WGP in addition to its healthful properties.

Customer Profile
Our in-depth interviews and survey results enabled us to derive Fruit Forward’s customer profile, Jane Appleseed (Figure 8). Jane represents Fruit Forward’s typical target market customer, and might be either a Businessperson or a Juice Enthusiast. Based on the different values prioritized by each of these segments, Fruit Forward will market to them separately, prioritizing Businesspeople, who we see as our primary customers (Table 3). Juicers interviewed who represent each market segment are further described below.

![Jane Appleseed](image)

**Figure 8. Fruit Forward’s Customer Archetype (TM):** A cold-pressed juice producer who makes product ahead of sale but does not want to use HPP for preservation.

1. **The Businessperson** - This juice bar owner has lots of experience as a business executive and got into the cold-pressed juice industry after a friend recommended it as a promising business opportunity. Following a discussion of Fruit Forward’s vision,
he stated that he would be “open to it if it was beneficial to consumers and appealed to [them].”

2. **The Juice Enthusiast** - This juice bar owner is extremely concerned with the integrity of his cold-pressed juice and is skeptical of “creative marketing gimmicks that don’t actually help heal people.” While he agrees that it is difficult “to run a business with a product so shelf life unstable,” he is more interested in Fruit Forward’s product for its added antioxidant health benefits and would require it to be organic to align with his core value of “100% organic” ingredients.

<table>
<thead>
<tr>
<th>Segment</th>
<th>Value</th>
<th>Market WGP as...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Businesspeople (primary customer)</td>
<td>Shelf Life</td>
<td>Preservative</td>
</tr>
<tr>
<td>Juice Enthusiasts (secondary customer)</td>
<td>Antioxidants</td>
<td>Supplement</td>
</tr>
</tbody>
</table>

**PROPOSED BUSINESS MODEL**

**Customer Segments**
In interviews, six cold pressed juicers told Fruit Forward that a longer shelf life would enable them to expand their businesses, and that they would value a shelf life doubling from three to six (3-6) days. Sixty-seven percent (67%) of 25 surveyed juicers ranked shelf life as the most important added benefit to their product, when compared to increased nutrients or antioxidants. Thus, we conclude that cold-pressed juicers share the same pain point of short product shelf life, preventing them from maximizing production and distribution efficiency. Fruit Forward’s initial assumption that juicers experience heavy losses due to spoilage was not justified, but this did not lead to a major pivot as the majority of juicers still reported that they desire extended shelf life.

Early interviews suggested that existing juice preservation options are not acceptable to a segment of juicers, because they are expensive and/or are thought to damage the juice product. In fact, we found that the main issue with HPP is that it is widely mistrusted by cold-pressed juicers. As one juicer told us, “we believe valuable nutrients are lost and taste is compromised in the HPP process.” It was also assumed that all juicers would be interested in making their product last as long as possible, which we found is not the case with almost half our target market - a segment we dubbed “Juice Enthusiasts”. In fact, there was a specific tradeoff balance between product stability and quality that needed to be maintained. Our customer research led us to focus first on the other segment of our target market - the “Businesspeople”. This subgroup will be our primary customers and early adopters of a WGP product.
Value Proposition
Dried and powdered WGP can double the shelf life of cold-pressed juice, from three to six (3-6) days (see MVP Section and Appendix V) via potent antioxidants. Three extra days of shelf life will enable juicers to run their businesses more efficiently by eliminating the need to press and deliver every day, saving them both money and labor. Our product(s) are cheaper than HPP and can be used in-line, meaning juicers can avoid paying for transportation to and from an HPP facility and losing control of their cold-pressed juice in this process. Our product will be natural, organic, and sustainable, qualities that appeal to the core values of archetypical juice drinkers. The natural flavonoids and antioxidants present in WGP will also appeal to juice consumers due to their well-publicized health benefits. Thus, Fruit Forward’s powdered WGP product, as well as the flavonoid extract under development, offer a unique combination of efficiency improvements and product differentiation benefits, enabling juicers to advertise their preservative as a healthful and sustainable addition to the juice.

Key Partners and Key Activities
Through informational interviewing of nine local winemakers (key partners), Fruit Forward discovered they will happily give us their organic pomace and that they produce more than enough to meet our supply needs. We also learned that pomace is generated within a condensed and very busy time of year (harvest), and that we will need a quiet, non-disruptive means of removing pomace whenever it is ready for pickup. Fruit Forward’s key activities will include collection of organic WGP from wineries and transport by truck to a processing facility where it can be frozen and stored. Next we will begin processing pomace into our product and packaging it for shipment.

Key Resources
Fruit Forward will require a reliable means of collecting and storing the significant volumes of WGP produced by each of our partner wineries, such as a truck and the macro bins used to transport wine grapes and WGP. Other equipment required to carry out our key activities will be a large storage freezer, a lyophilizer (commonly known as a freeze dryer), commercial scale grinders and sifters, and a large scale version of our flavonoid extraction apparatus. This latter resource will enable production of a liquid preservative product. All of this equipment was tested in a small scale pilot (see Appendix V), where we confirmed it will be needed as a key resource.

Channels and Customer Relationships
Channels to our customer segments will include personal sales and website orders with outsourced shipping. Fruit Forward will also explore using a distributor. For customer relationships, we envision the company following a personal assistance, business-to-business (B2B) model. Although time consuming, we believe it is necessary to build our
specific customer base, and this has served as the model thus far for our interactions with two potential early adopters.

Revenue Streams
Revenue will flow from juice drinkers to juicers to us, and some expenses will include the cost of collection, storage, processing, and packaging. Based on our customer discovery and hypothesis validation so far, we believe this model represents a scalable, profitable business (Figure 9).

![Figure 9: Fruit Forward Proposed Business Model.](image)

Fruit Forward will generate revenue through the production and sale of two different WGP products: a powder, consisting of dried and finely ground pomace, and a liquid extract of WGP flavonoids. The latter may alternatively be transformed into a concentrate for increased transportation efficiency and product stabilization. Assuming a 1% concentration of WGP to cold-pressed juice, which has proven effective at preventing juice spoilage (Appendix V), it is estimated that one kilogram of product can preserve approximately 213 bottles of juice. A target market mean willingness-to-pay of $0.13 per bottle implies that one (1) kilogram of powdered product, or the flavonoid content equivalent of one kilogram of powdered product in liquid/concentrate form, will go to market for $28. These predicted prices assume equivalent efficacy between powder and liquid products, and are therefore expected to be of equal value to consumers. However, further customer research should be conducted to see whether a liquid WGP product would hold additional value to consumers over a powdered product and yield a higher WTP.

Cost Structure
Fruit Forward will incur a plethora of costs based on the current business model, including but not limited to: pomace transportation, processing and quality analysis equipment,
energy consumed in manufacturing, research and development, and general SG&A expenses. Feedstocks are predicted to be acquired free of charge due to the WGP waste valorization component of the business model. Looking at per unit processing, the variable cost of goods sold (COGS) is estimated to be about $4.29 per kilogram of product (Table 4, see Appendix VII for justification). It should be noted that packaging will also contribute to the COGS; however, these costs cannot be appropriately estimated until the development of a minimum viable product is complete. Additionally, certain resource velocity drivers could potentially decrease COGS as production approaches economies of scale. This could predominantly be achieved through the purchase of better equipment for bulk processing, such as a commercial scale lyophilizer, grinder, sifter, storage facility, and extraction apparatus.

Table 4: Variable Costs of Goods Sold. Estimated costs for transportation, lyophilization (freeze-drying), polyphenolic extraction, and shipping.

<table>
<thead>
<tr>
<th>VARIABLE COSTS</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
<td>$0.09</td>
</tr>
<tr>
<td>Lyophilization</td>
<td>$2.84</td>
</tr>
<tr>
<td>Extraction</td>
<td>$0.08</td>
</tr>
<tr>
<td>Shipping</td>
<td>$1.28</td>
</tr>
<tr>
<td><strong>Total COGS</strong></td>
<td><strong>$4.29</strong></td>
</tr>
</tbody>
</table>

Operational fixed costs include utilities, rent, insurance and salaries and wages. While these costs are difficult to predict and subject to relevant industry rates at time of launch, total SG&A costs are estimated at $3,265 per month (Appendix VII).

Due to the scientific nature of Fruit Forward’s operations, the majority of start-up costs will be allocated to the purchase of equipment for processing, storage, transportation, and everyday business activities (Table 5). A minimum total capital investment of approximately $109,000 will need to be raised in the first round to cover these expenditures.

Table 5: Estimated startup costs. Includes all equipment required for transportation, processing, extraction, storage, and business-as-usual expenses. *After consulting an intellectual property attorney, a product will cost $9,000 to file and patent, plus an additional $7,000 for legal processing costs.
### STARTUP COSTS

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freezer</td>
<td>$4,000</td>
</tr>
<tr>
<td>Freeze dryer</td>
<td>$11,000</td>
</tr>
<tr>
<td>Vacuum Pump</td>
<td>$8,000</td>
</tr>
<tr>
<td>Milling equipment</td>
<td>$5,000</td>
</tr>
<tr>
<td>Extraction equipment</td>
<td>$2,000</td>
</tr>
<tr>
<td>Lab equipment</td>
<td>$10,000</td>
</tr>
<tr>
<td>Spectrophotometer UV/VIS</td>
<td>$5,000</td>
</tr>
<tr>
<td>F-150 light duty truck</td>
<td>$30,000</td>
</tr>
<tr>
<td>Macro bin</td>
<td>$300</td>
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<tr>
<td>Refrigerator</td>
<td>$2,000</td>
</tr>
<tr>
<td>Furniture</td>
<td>$10,000</td>
</tr>
<tr>
<td>Computers &amp; Printer</td>
<td>$5,000</td>
</tr>
<tr>
<td>Intellectual Property*</td>
<td>$16,000</td>
</tr>
<tr>
<td><strong>Total Startup Costs</strong></td>
<td><strong>$108,300</strong></td>
</tr>
</tbody>
</table>

**Gross Margin Analysis**

If the COGS are truly equal to $4.29 per kilogram of product, the gross profit of one kilogram sold at $28 would amount to approximately $23.71. This means that the gross margin, or percent of revenue that can be used to cover operating costs, debts, and liabilities, is roughly 85%.

Based on the reported production rate of 10,000 bottle of cold-pressed juice per month, collected from informational interviewing, every customer would require 47kg, or equivalent, of Fruit Forward’s product each month to serve 100% of their production. This yields a gross profit of $1,113 per customer per month!

**Sales Forecast**

**Key Macro Assumptions**

“A growing global middle class will continue to expand the consumer base for spa and wellness industries.” Assuming that the demand for healthy, natural products continues to increase, Fruit Forward expects to acquire customers through involvement in sales event triggers such as natural ingredients expos, conferences, and trade shows. Our potential European competitors, Naturex and Grap’sud, have increased their public exposure through exhibits at Vitafoods Europe, a global nutraceutical event, and the Food ingredients (Fi) Europe & Natural ingredients (Ni) Conference. Following their lead, Fruit Forward will table at domestic trade shows first, such as the Natural Products Expo West, to increase
public outreach and customer acquisition, and will consider future international sales events as our business grows.\textsuperscript{74}

Fruit Forward does not foresee any industry sales cycle implications. However, our supply source is directly dependent on the timing of the wine grape harvesting season. At the end of every summer, a large quantity of WGP is produced over a relatively short period of time; therefore, we will address this supply cycle by freezing pomace for prolonged storage until we are ready to process it to meet customer demands.

\textit{Key Specific Assumptions}

1. \textbf{Sales growth} - Fruit Forward will launch following the commitment of ten (10) potential customers at launch, representing just 0.4\% of target market, and expects to acquire more business at a rate of 2 new customers per month for Years 1, 2, and 3. Additionally, it is estimated that sales to existing customers will continue to grow by 2\% each year to reflect the projected annual growth of the juice and smoothie bars industry.\textsuperscript{75}

2. \textbf{Product type sales} - Based on the current needs and demands of the target market (TM), it is assumed that sales will consist of 80\% WGP liquid extract or concentrate to 20\% WGP powder product.

3. \textbf{Sensitivity analysis} - Compared to a base case of business as usual, a variety of conditions could potentially affect the revenue forecast, such as incurred costs for pomace supply if wineries demand a profit, incurred costs for the disposal of fibrous waste to biomaterials producers following polyphenolic extraction, or increased sales resulting from the employment of a sales team, to name a few. These should all be considered when conducting a comprehensive financial analysis. However, the most sensitive factor contributing to sales revenue is the price point of the products themselves. A sales revenue forecast example is given below comparing two scenarios with different product price points (Table 6). The low scenario represents a TM mean willingness-to-pay of $0.13 per bottle of juice served, or $28 per kilogram of powdered product or kilogram equivalent of liquid and/or concentrated WGP extract. The high scenario represents a served addressable market (SAM) mean willingness-to-pay of $0.20 per bottle of juice served, or $43 per kilogram or kilogram equivalent of product.
Table 6: Sales Revenue Forecast. Revenue forecast for low scenario ($28 per kg, or kg eq., of product) and high scenario ($43 per kg, or kg eq., of product). See Appendix VII for financial justifications.

<table>
<thead>
<tr>
<th>Fruit Forward Sales Revenue Forecast</th>
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<tbody>
<tr>
<td><strong>Low Scenario</strong></td>
</tr>
<tr>
<td>Year</td>
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</table>

Staffing Plan

In addition to the current team members, Fruit Forward will expect to bring on additional staff to fill the following positions: organic chemist, food scientist consultant, sales representative, and part-time accountant. The full-time organic chemist will be hired near the time of launch and the food scientist consultant and sales representative will be brought on at the beginning of the second and third year, respectively (Table 7). We will be attempting to hire a part-time accountant at the end of year three. Prior to this, we expect to outsource a Certified Public Accountant.

Table 7: Help Wanted. Position titles and types to be filled following the launch of the business and their respective salaries and time of employment (in respect to launch).

<table>
<thead>
<tr>
<th>Position</th>
<th>Job Type</th>
<th>Month Hired</th>
<th>Potential Salary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic Chemist</td>
<td>Full-Time</td>
<td>1</td>
<td>$50,000</td>
</tr>
<tr>
<td>Food Scientist</td>
<td>Consultant</td>
<td>13</td>
<td>$100/hr</td>
</tr>
<tr>
<td>Sales</td>
<td>Full-Time</td>
<td>25</td>
<td>$30,000 + Comm.</td>
</tr>
<tr>
<td>Accountant</td>
<td>Part-Time</td>
<td>36</td>
<td>$60/hr</td>
</tr>
</tbody>
</table>
The organic chemist would be recruited from a graduate program, ideally following the completion of their degree, and would be offered 10-15% ownership of the company. All full-time employees would receive benefits equivalent to 25% of their salary. The sales representative, and any subsequent employees hired to assist their team, would also receive a commission of which the percentage is yet to be determined.

**MINIMUM VIABLE PRODUCT**

Wine grape pomace can be dried (with or without heat), powdered, and added directly to foods as a preservative. Alternatively, flavonoids and other polyphenolic antioxidants can be extracted from WGP using a combination of organic solvents, heat, and agitation. A newer method of extraction requires only cold water and low voltage electricity. To identify a minimum viable product for testing, Fruit Forward has experimented with three forms of WGP: 1) commercial pomace powders made using heat, 2) our own pomace powder made in the absence of heat, and 3) our own cold water-extracts. Each of these contains grape flavonoids and other polyphenols that act as antioxidants to preserve juice and confer human health benefits. Juice preservation results from two key functions of WGP antioxidants: antimicrobial activity and prevention of lipid oxidation.

**Scientific Background**

_Antimicrobial Effects of WGP_

Microbes are just about everywhere, including our food. In the case of juice, bacteria and yeast from the surfaces of fruits and vegetables end up in the final product, typically at concentrations of over a million per bottle, depending on the acidity of the juice (more acidic juices have fewer microbes due to their low pH) (Appendix V). The vast majority of these organisms are not harmful to humans (and may even be helpful), but their growth over time causes changes in the appearance, odor, and flavor of juice, rendering it unpalatable. On rare occasions juice may be contaminated with pathogenic organisms such as the bacterial species _Listeria monocytogenes, Salmonella enterica_, and _Escherichia coli O157:H7._

The risk of contamination, combined with the requisite time frame for shipping and retailing, have led the U.S. Food and Drug Administration to mandate a 5 log (or 99.999%) reduction in pathogens for any juice product that is sold wholesale. It is for this reason that fresh cold-pressed juice is usually sold by juicers themselves from dedicated storefronts (juice bars), or shipped directly to consumers from juice production facilities. Any cold-pressed juice found in grocery stores has been preserved - most often by pasteurization or HPP - in order to meet the FDA standard. Suja and BluePrint are examples of popular cold-pressed juice brands sold wholesale. Products from older juice brands like Odwalla and
Naked Juice are likewise preserved, but these have been made using blenders/food processors (not juice presses) and therefore do not qualify as cold-pressed.

Whether or not juicers are interested in wholesale channels, product spoilage is a problem due to the off flavors and odors that develop in untreated juice after just 3–4 days, some of which are caused by microbial growth. Wine grape pomace can inhibit the growth of pathogenic and spoilage microbes.\textsuperscript{12,78,79} At lower concentrations powdered pomace or pomace extracts simply halt the growth of microbes, though at higher concentrations microbes are killed, most likely through disruption of their membranes.\textsuperscript{78} Specific foods for which WGP has been shown to work as a preservative include fish,\textsuperscript{79,80} chicken,\textsuperscript{81} pork,\textsuperscript{82} beef,\textsuperscript{82} yogurt, and salad dressing,\textsuperscript{9} and pomace has been successfully used in the form of a powder, extract, and even as part of a chitosan film.\textsuperscript{9,10} Typically, evaluation of food spoilage includes assessment of both microbial growth inhibition and lipid oxidation.

\textit{Lipid Antioxidant Effects of WGP}

Oxidation of lipids in foods is a major factor in spoilage, causing deterioration of color, flavor, texture, and nutritional quality.\textsuperscript{12} Lipid oxidation may occur after exposure to oxygen, light, heat, or ionizing radiation, all of which create lipid free radicals (the “initiation” stage).\textsuperscript{18} Lipid free radicals cause a chain reaction, creating more and more radicals until the reaction is terminated by formation of a non-radical product (the “propagation” and “termination” stages). Antioxidants protect food quality by breaking the lipid radical chain reaction. They react with free radicals to terminate propagation before damage is done.\textsuperscript{18}

Phenolic compounds are particularly efficient at breaking free radical chain reactions, and for this reason they are employed as preservatives in food.\textsuperscript{18,78} The most common phenolic antioxidant preservatives are the synthetic chemicals BHA (Butylated hydroxyanisole) and BHT (Butylated hydroxytoluene).\textsuperscript{13} They are used in many types of food (human and animal), as well as in cosmetics, packing materials, rubber, and plastics,\textsuperscript{17} and are also frequently used in packaging (e.g. cereal box liners), where they are effective as food preservatives due to their ability to migrate from packaging into the contained foods.\textsuperscript{18}

As discussed previously, the safety of synthetic phenolic antioxidants (SPAs) has been questioned, and researchers have been exploring the idea of plant-based antioxidants as natural preservatives. Antioxidant-rich substances such as green tea, rosemary, oregano, pomegranate, and grape are all being explored as sources of natural preservatives. Of these, WGP is especially effective, since it is believed to inhibit lipid oxidation in several ways beyond breaking the lipid radical chain reaction.\textsuperscript{78} Like their synthetic counterparts, plant-based antioxidants are also phenols, but plant phenols are far more complex and diverse. Due to the multiple phenol “subunits” that combine to make larger molecules, plant phenols are usually called polyphenols. Polyphenols can be broken into many subclasses (Figure 10), with the most varied and active classes falling into the flavonoid
category.\textsuperscript{83} Flavonoids have received much attention in the media over recent years, as a growing body of scientific evidence supports their health benefits.\textsuperscript{84,85,86} 

![Figure 10: Chemical classes of polyphenols. Source: Fitter Food.](image)

**Health Benefits of WGP**

Beyond its potential as a food preservative, a plethora of academic and clinical studies suggest WGP can improve human health by slowing the onset of diabetes,\textsuperscript{87} preventing high blood pressure,\textsuperscript{88} lowering blood sugar,\textsuperscript{88} reducing chronic inflammation,\textsuperscript{89} lowering cholesterol, and altering the gut microbiome toward a more beneficial mix of microbes.\textsuperscript{89} Recent buzz about the healthful effects of flavonoids and the red wines that contain them will enhance the appeal of Fruit Forward’s WGP products.\textsuperscript{90} Both juicers and their customers will find value in the health benefits of a pomace preservative, which will enable an unprecedented form of differentiation: their products will be healthful because of, not in spite of, the preservatives in them. We anticipate that our MVP will work as a preservative and add value to any food in which it is used, making it a so-called “functional food” - a food that has a positive effect on health beyond basic nutrition (see Figure 1 and related text for a sense of this growing market).

**Prototype Development: Powdered Product**

Using a commercial WGP powder (marketed as a flour), Fruit Forward has shown that Pinot Noir and Chardonnay pomace can double the shelf life of cold-pressed juice, based on taste (Appendix V). Following this, we undertook a pilot project in order to produce our own powdered product and attempt to create a liquid flavonoid extract. Those experiments are summarized here and described in more detail in Appendix V.
In December of 2015, a freeze-dried (“lyophilized”) and powdered prototype was made using Pinot Noir pomace from a local winery (see Appendix V). The powder consisted of fine (<63 µm) particles, was red-brown in color, smelled faintly of fermented grapes, and tasted slightly tangy. Powder was stored in a sealed plastic bag at room temperature.

In January of 2016 the powder was tested in a California Juice Company green juice blend (Big Sur), at a 1% mass-to-volume concentration (Appendix V). Though lyophilized and powdered WGP has never been tested for preservation of juice, to the best of our knowledge, a 1% Pinot Noir pomace concentration has been shown to preserve taste and prevent lipid oxidation in foods such as yogurt and salad dressing. While we did not systematically assess juice taste in this experiment, treated and untreated juice samples were observed visually for a period of 19 days at 4°C incubation, after which juice was examined for microbial counts. Juice was also tasted to assess sensory qualities at Day 7. Pomace powder lent a slightly tangy flavor and gritty texture to the juice, but was not unpleasant.

By Day 5, untreated juice contained bubbles consistent with fermentation, while pomace-treated juice did not (Appendix V). This difference was evident throughout the course of the experiment. Due to this observation, we diluted and plated juice from one control and one treated sample on two types of microbial growth media, with the goal of comparing microbial Colony Forming Units (CFU) between samples. CFU counts for control samples were more than ten-fold higher than those of pomace-treated samples (Appendix V). This suggests our powdered product has antimicrobial activity, in keeping with reports in the scientific literature. We interpret this as evidence of overall chemical integrity and antioxidant activity of our prototype. Future experiments will quantify antioxidant activity in free radical scavenging assays, and optimize the current production method.

**Powdered Prototype Lessons Learned**

While pomace-treated juice was not unappealing in appearance, it did look different from untreated juice, with a purple-brown pomace layer evident (see Appendix V). Furthermore, based on sensory evaluation at Day 7, as well as previous experimentation using a competitor’s product, we have found that addition of pomace has texture impacts on juice and causes a slight change in taste, adding a tangy note. One of the biggest problems powdered pomace poses is lack of solubility, which would keep juicers from adding it to whole batches of product at once. In discussions with our external advisors at California Juice Company, we decided these were all potentially problematic, and turned our attention to making a water-soluble polyphenolic extract for use in juice. As for Fruit Forward’s first prototype, we strongly believe there are numerous market opportunities for powdered WGP and we intend to explore these in the future. This idea is well-supported by the growing consumer demand for natural products and “clean labels,” as well as the forecasted growth of the functional foods market (Figure 1).
Prototype Development: Liquid Extract

Using freeze-dried Pinot Noir pomace from development of the powdered prototype, we performed three separate flavonoid extractions in December 2015 and January 2016, in order to optimize conditions and methodology (Appendix V). Although experiments were successful and much progress was made, the resulting flavonoid extracts were quite dilute, containing flavonoids but at low concentrations. A juice experiment performed using Extract 2 did not show any obvious shelf life extension, based on taste. The next step for Fruit Forward’s liquid extract will be concentration of flavonoid extracts via lyophilization (freeze-dry), followed by retesting in juice.

Juice Testing Details

To this point, juice shelf life extension has been assessed by taste alone. Fruit Forward next plans to utilize more sophisticated measures of spoilage, such as quantified microbial growth and lipid oxidation. For the sake of simplicity and expediency, we will outsource these assays to EuroFins (Eurofins Nutrition Analysis Center, Des Moines, IA), a reputable company that provides contract laboratory services to academic and industry researchers.

Minimum Viable Product Timeline

April 2016:
- Select outsourced assays to quantify juice spoilage
- Communicate with juicer advisors to prepare for experiment

May 2016:
- Estimate cold water extraction efficiency to optimize extraction methodology
- Repeat extraction, assess total phenolics (Total Phenolic Content (TPC) assay, already established in-house), and concentrate the extract
- Send juice samples to Eurofins for testing
  - Compare various concentrations of polyphenolic extract for preservation of juice using at least 2 different assays
  - Test powdered prototype for preservation as well

June 2016:
- Use new extraction and efficacy numbers to estimate start-up costs more precisely
- Work with advisors and one other local juice company to assess use of MVP in their juice products
ENVIRONMENTAL BENEFITS

Fruit Forward’s mission is well aligned with the values and goals of the Bren School’s Eco-Entrepreneurship Program due to the following three environmental benefits of our endeavor: 1) greenhouse gas mitigation, 2) resource optimization through waste valorization, and 3) food preservation. Beyond these direct impacts, our venture will be part of a larger industrial ecology movement toward minimizing waste and harnessing industrial effluents for use as inputs in other processes.\(^{91}\)

**Greenhouse Gas Mitigation**

Fruit Forward has the ability to make a contribution to the mitigation of greenhouse gas (GHG) emissions by upcycling WGP and turning it into an all-natural food preservative. When methane gas is released from organic matter into the atmosphere, it drastically influences climate change conditions. Methane is a highly potent GHG with a global warming potential (GWP) twenty-five (25) times that of carbon dioxide.\(^{92}\) Based on the methane potentials of red and white WGP, quantities of winery waste at a scale of hundreds of tonnes could have a severe negative impact on atmospheric conditions based on predicted methane emissions and the corresponding carbon dioxide equivalent of GWP (Table 8).\(^{93}\)

**Table 8: Potential Climate Change Impacts of Wine Grape Pomace.** Methane potential (mL/g), methane emissions (kg/tonne), and carbon dioxide equivalent emissions (kg/tonne) of WGP, for both red and white varietals. All values given under standard temperature and pressure.

<table>
<thead>
<tr>
<th>Pomace Type</th>
<th>CH(_4) Potential (mL/g)</th>
<th>CH(_4) Emissions (kg/tonne, STP)</th>
<th>CO(_2e) Emissions (kg/tonne, STP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressed Red</td>
<td>81</td>
<td>55.06</td>
<td>1376.50</td>
</tr>
<tr>
<td>Pressed White</td>
<td>85</td>
<td>57.77</td>
<td>1444.25</td>
</tr>
</tbody>
</table>

Every tonne of WGP diverted from a landfill or mismanaged compost pile has the potential to prevent 55-58 kg of methane, or 1.4 tonnes of carbon dioxide equivalent, from escaping into the atmosphere.\(^8\) Some higher methane potential estimates suggest that as much as 1.8 tonnes of CO\(_2\) equivalent could be mitigated per tonne of repurposed WGP.\(^{94}\) The impacts of these emissions on climate change are substantial, with global WGP currently contributing 20 million tonnes of carbon dioxide equivalent per year from its anaerobic decomposition.

**Resource Optimization**

As noted above, wine grapes require a vast amount of nutrients. Using our assumption of 1.59 tonnes of WGP generated per hectare, we can calculate the approximate resource investment that goes into each tonne of pomace as a percentage of the total resources used in wine grape production (Table 9).
Table 9: Wine grape pomace resource utilization. Resource consumption, per tonne of pomace, by the fertilization and maintenance required for the production of WGP: nitrogen (kg), phosphorus (kg), potassium (kg), lime (kg), and diesel fuel (L). Resources used for land conversion or preparation are not included.

<table>
<thead>
<tr>
<th>N-fertilizer (kg/t)</th>
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<td>181.57</td>
<td>37.19</td>
</tr>
</tbody>
</table>

Aside from the eutrophication consequences of excessive fertilizer use, a major cause for concern in this scenario is diesel fuel consumption. Diesel is used to power all sorts of agricultural equipment and is a necessary resource for wine grape production. However, based on these calculations, approximately 37 liters of diesel fuel per hectare of land is wasted when WGP is not upcycled in some way. This is a blatant misuse of fossil fuels and subsequent GHG emissions, and poses a very serious issue when brought to scale.

Energy conservation is also an important factor in the valorization of waste streams. Again, using our assumption of 1.59 tonnes of wet pomace generated per hectare, we can calculate the expected energy contained in WGP. Based on the conservative estimate of 32,246 MJ per hectare of total energy input for organic vineyards, it is predicted that approximately 20,281 MJ is embedded in each tonne of WGP. This represents a significant amount of energy that would otherwise be lost to decomposition in a compost pile or landfill.

Finally, grapes, like any other crop, require water, which in most cases means irrigation. The average crop water used for small, young grape vines in a Washington study from 1985 to 1986 was approximately 146mm per year. Mature plants from 1987 to 1990 were reported to consume 417mm per year. Due to high variability of water uptake by plants, further research is needed to fully quantify the potential water optimization proposed by Fruit Forward’s waste valorization business model.

Food Preservation

Although cold-pressed juice manufacturers keep tight control over production and inventory, they regularly lose juice to spoilage because of its short shelf life. A typical bottle of juice contains roughly 2 pounds of produce, which represents approximately 569 kcal of embedded energy for crop production alone. According to preliminary results from Fruit Forward’s juicer survey, their average weekly juice loss is 8.5 bottles per week, which represents a bare minimum of 4837 kcal embedded energy that is wasted. When juice production and transport are also considered, the amount of energy Fruit Forward could conserve by preventing food waste becomes even greater.
MOVING FORWARD

Next Steps
Much hinges on the quality of Fruit Forward’s concentrated flavonoid extract. Beyond efficacy, important characteristics of this product will be solubility, stability, a neutral or inoffensive flavor and color, and low cost of manufacture. Alternative forms of polyphenol extraction are also available to try, and will be considered if necessary, although these methods rely on organic solvents such as ethanol or methanol and are not ideal. Aside from changing extraction methods, another potential Fruit Forward pivot would be renewed focus on powdered pomace, for applications in cold-pressed juice or potentially other markets. Whether in powder or liquid form, a pomace-based preservative may well have value in the broader natural foods market, the food packaging industry, or the personal care product (PCP) industry.

Potential Future Markets

1. **Natural foods** - To explore the natural foods market, Fruit Forward will need to identify a customer pain point by determining which food products have the shortest shelf life, and then must assess the potential usefulness of a WGP-derived preservative in this context. For our water soluble flavonoid extract, there are potentially very broad applications in foods, and this product will surely get attention as a food ingredient (beyond juice) at some of the conventions we are already planning to attend as part of juicer demand creation, such as Natural Expo West. The logical next step would be to investigate the preservative potential of a WGP product in foods with higher fat content, such as the meat industry, as these markets would have more value to gain from a product that delays lipid oxidation.

2. **Food packaging** - As mentioned previously, WGP effectively preserves food even when embedded into a cellulose (natural) film. Although currently beyond the scope of our project, future efforts for Fruit Forward will include exploration of WGP powder uses in food packaging.

3. **Organic personal care products** - The organic PCP market holds the most immediate promise for Fruit Forward. Like the juice market, it is rapidly growing (valued at $8.4 billion in 2013 and projected to reach $15.7 billion by 2020), and is growth limited due to shelf life.\(^9\)\(^9\) As stated by the research firm Transparency Market Research: “...the shorter shelf life of organic personal care products is a critical factor expected to limit the growth of the global organic personal care products market in the next few years.”\(^9\)\(^1\) Furthermore, there is potential for use of both powder and liquid WGP products in PCPs, increasing the options for application of a pomace preservative. At this time, research of this market is in its infancy.
When appropriate, Fruit Forward will begin exploration of these potential future markets with informational interviews of industry experts and business owners. Natural foods, natural food packaging, and organic PCP businesses are likely to be tied by the same set of core values, with customers who care about ingredients and strive to avoid synthetic chemicals. This may make them easier to access once we have begun developing relationships, assuming interviewees will refer us to others.

CONCLUSION

In the course of this project, Fruit Forward has discovered a unique opportunity to solve two problems simultaneously. The environmental problems posed by wine grape pomace can be addressed by diverting and valorizing pomace into a useful commodity: a natural organic preservative that can extend the shelf life of cold-pressed juice, saving juice businesses time and money. Although several competitors exist in the WGP processing space, as of yet none of them are producing an organic product. More importantly, none are marketing pomace as a preservative, instead focusing on its healthful effects and/or its usefulness as a baking flour. Our product will double juice shelf life while adding appealing and healthful antioxidants. Fruit Forward’s interview and survey data show that juicers would value a WGP-derived product and that their willingness to pay, combined with the continuing strong growth of this market, is high enough to make this a profitable venture. The cold-pressed juice industry is currently a $100 million market in the United States and going strong. Research shows that consumers have begun to pay increased attention to their health, seeking out natural, nutrient rich foods and avoiding synthetic chemicals. Part of this trend includes a preference for functional foods, which offer consumers health benefits beyond basic nutrition. A WGP product will be perfectly on trend in this regard, due to the proven anti-inflammatory and positive cardiovascular effects of its abundant flavonoid molecules. In the future, Fruit Forward could capitalize on the functional foods trend by expanding to the natural foods market. Beyond foods, our product has potential to replace synthetic preservatives in food packaging or personal care products, addressing consumer concerns and preventing continued environmental contamination from SPAs (synthetic phenolic antioxidants) such as BHA and BHT.

Through customer interviews, Fruit Forward discovered and validated that juicers struggle with short shelf life, suffering inefficient production and distribution as a result. However, we also found that juicers in our target market are segmented by their interest in extending shelf life. While many juicers admitted that extending shelf life by even a few extra days would enable increased production efficiency and/or business range expansion, not all of them sought this opportunity. We have described these two market segments as Businesspeople and Juice Enthusiasts. Of juicers who self-identified as Businesspeople, 60% said they would be interested in using our product. This segment will be Fruit Forward’s primary customer. Importantly, adding WGP to juice will not only preserve but also enhance the product by providing healthful antioxidants. Thus, Fruit Forward will be saving its
customers money and helping them differentiate their products. Finally, while not necessarily interested in shelf life extension, Juice Enthusiasts may well value a WGP product strictly as an antioxidant supplement for their juices. For this reason, Juice Enthusiasts will be Fruit Forward’s secondary customer.

In preliminary and pilot project experiments, Fruit Forward has developed two WGP products: a fine powder and a liquid flavonoid extract. Future work will determine which of these is best suited for our customers, though our immediate focus is on improving and concentrating the extract, which we believe has more potential due to its solubility. Subsequent to this, we aim to further validate the product’s preservative qualities using quantitative scientific assays.

In conclusion, Fruit Forward has seen an opportunity to solve a customer problem while conferring the environmental benefits of pomace removal, which include GHG mitigation, viticulture resource optimization, groundwater protection, and waste valorization. The latter is becoming an increasingly salient part of our worldview, as the global population grows and resources dwindle. Even as we strive to reduce it, the world is starting to realize the potential of organic waste, which can be harnessed for energy or materials production, or at the least recycled (composted) in order to recover its basic nutrients. Wine grape pomace is a particularly valuable resource, given its extremely high concentration of powerful antioxidants. Fruit Forward will be a part of the solution by recapturing the beneficial properties of wine grape skins and seeds that would otherwise be lost, bringing a much-needed natural, organic, and healthful preservative to our customers.
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APPENDIX I: Technical Literature Review

TECHNICAL LITERATURE REVIEW

A new way forward.

Submitted by:
Summer Broeckx-Smith & Jessica Sexton
Fall 2015

Bren School of Environmental Science & Management
University of California, Santa Barbara
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INTRODUCTION

Fruit Forward is a new venture opportunity that aims to create an all-natural food preservative by repurposing a traditional winery waste, known as grape pomace. Consisting of seeds, stems, and skins, wine grape pomace (WGP) is a byproduct of the winemaking process and is rich in fiber, antioxidants, and other nutrients.\textsuperscript{1} WGP has been shown to delay the onset of food spoilage due to inherent active compounds, called polyphenolics, and their antioxidizing and antimicrobial activities.\textsuperscript{2,3,4} Fruit Forward plans to capitalize on these properties of WGP by creating a minimally processed, dried, powdered version of WGP, and/or a water-soluble WGP extract, for use as a natural preservative and potential health supplement.

Our product will be marketed to cold-pressed juice producers as a way to naturally extend their product’s shelf life while maintaining maximum freshness and nutrient composition. Many small juice bar owners are unable to expand their businesses due to the short shelf life of cold-pressed juice and therefore incur high labor and transportation costs from the need to press and deliver product daily. These businesses may not possess the capital to invest in current juice preservation methods, such as high-pressure processing (HPP) or pasteurization, or may be concerned that these options may not maintain the nutritional quality of their product. With the use of our WGP product, juicers can extend the shelf life of their cold-pressed juice, expand product distribution and decrease labor costs, while also adding a natural and healthful ingredient likely to appeal to their customers.

Currently, the state of California is the fourth largest producer of wine in the world, using roughly four (4) million tons of grapes annually.\textsuperscript{5} Winemakers invest copious amounts of resources in their vineyards in order to cultivate high quality wine grapes.\textsuperscript{6} During the winemaking process, vast quantities of resource-intensive WGP are produced in a short time-frame, and this abundant agricultural waste can be difficult to dispose of.\textsuperscript{7} Despite its classification as an organic waste, WGP does not compost easily and the composting process can be expensive.\textsuperscript{8} Thus many wineries do not compost their WGP, and instead pay to have it hauled and composted elsewhere, or disposed of in landfills, where its decomposition releases methane, a potent greenhouse gas, into the atmosphere.\textsuperscript{9}

Using WGP destined for a landfill as a natural preservative and health supplement will divert a conventional waste stream while providing cold-pressed juice consumers with additional health benefits of antioxidants and other nutrients. This form of repurposing, known as waste valorization, will decrease winery waste outflows, conserve the resources embedded in wine grapes, and mitigate greenhouse gas emissions from landfills.
RESOURCE UTILIZATION IN THE WINEMAKING INDUSTRY

Viticulture is a resource-intensive agricultural art form, requiring very specific amounts of nutrients to produce high-quality wine grapes. Fertilizing and maintenance of vineyards requires a variety of resources, such as energy, nitrogen, phosphorus, potassium, lime, and diesel fuel, to name a few (Table I1).  

Table I1: Resource utilization of wine grape production. Resource consumption per hectare required for fertilizing and maintenance of vineyards: nitrogen (kg), phosphorus (kg), potassium (kg), lime (kg), and diesel fuel (L). Resources used for land conversion or preparation are not included. Source: Point et al, 2012.

<table>
<thead>
<tr>
<th>N-fertilizer (kg/ha)</th>
<th>P-fertilizer (kg/ha)</th>
<th>K-fertilizer (kg/ha)</th>
<th>Lime (kg/ha)</th>
<th>Diesel (L/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>92.88</td>
<td>70.83</td>
<td>161.86</td>
<td>1154.75</td>
<td>236.51</td>
</tr>
</tbody>
</table>

A conservative yield estimate approximates 6.37 tonnes of wine grapes per one (1) hectare of land, while a study of viticulture in a Mediterranean climate - similar to California’s - indicates vineyard yields can be as high as 14.72 tonnes of grapes per hectare.

This same study found that total energy input per conventional vineyard hectare was about 43,880 MJ while the energy input for organic viticulture was about 32,246 MJ per hectare. This includes energy embedded in fertilizers and pesticides, as well as energy used for crop maintenance, harvesting and irrigation.

The WGP produced in the winemaking process represents approximately 25% of the total cultivated biomass, a significant portion of the grapes’ embedded resources (Figure I1). Based on the conservative yield estimate, WGP yield would then be about 1.59 tonnes per hectare, and this must either be upcycled, to capture any value, or downcycled into compost or landfill disposal.

Figure I1: The Vine Cycle of Wine Production. The vine cycle of organic matter flows in the winemaking process. WGP is considered a potential loss and can either be upcycled or downcycled. Source: Brinton & York, 2003.
Discarded WGP contains valuable nutrients, including potassium, calcium and nitrogen, and although composting pomace is challenging, it can be achieved with the proper mixing of pomace and manure or other high pH, nitrogen rich materials. Maintaining the correct ratio of WGP to manure is critical, as is frequent turning of the compost piles. Due to its acidic nature, WGP needs to be mixed with equal parts manure for effective composition, a ratio that is unsustainable for most vineyards, especially those that do not have livestock on site. The frequency of turning required for pomace compost is greater than other organic wastes, making WGP compost more expensive than most other biomaterials. According to Brinton and York, “twice-weekly mechanized turning [of WGP compost] for 16 weeks costs a total of $41.23 per ton, compared to $6.75 per ton for the same manure turned with a bucket loader every two weeks.” Because WGP is produced rapidly over a short period of time, composting facilities, which often operate under the authority of solid waste and environmental agencies, may not easily handle all of a region’s pomace. In response to this, some composting facilities have come to charge “tipping” fees to dispose of WGP, and have thus become “glorified dumps”.

ENVIRONMENTAL HAZARDS OF WINE GRAPE POMACE

With approximately fifteen (15) million metric tons of winery waste produced globally every year, the question of disposal is not a trivial one. Its low pH (3.8) and high concentration of polyphenols (2.6 g/kg) make WGP phytotoxic and unsuitable for direct application to cropland. Furthermore, nitrogen levels in WGP are inadequate to support its microbial degradation; thus, addition of pomace to soil actually results in nitrogen immobilization of that soil, which decreases soil fertility. Conditioning of WGP through composting can ameliorate the phytotoxicity and improve nitrogen and micronutrient content, though even composted pomace lacks adequate nitrogen levels for crops, and those that receive it still require supplemental nitrogen fertilization.

Rather than compost grape pomace, many wineries will pay to have it hauled away to landfills, or simply pile it in a remote corner of their property to let it decompose naturally. Unfortunately, the seasonal nature of wine production means these piles accumulate rapidly in a short time, allowing little abiotic degradation. Biotic (microbial) degradation also proceeds slowly due to the acidic nature and high lignin content (from seed and stem constituents) of pomace. In fact, intact grape seeds can often be seen in pomace and compost piles years later.

Unturned compost, pomace piles, and landfilled pomace are all eventually decomposed via anaerobic digestion, which results in generation of methane, a potent greenhouse gas. It is estimated that the methane potential of red and white grape pomace is approximately 81 mL methane per gram of raw matter and 85 mL methane per gram of raw matter, respectively. However, some studies have suggested that methane emissions of WGP can
be as high as 104mL per gram of raw matter. Further environmental hazards of stockpiled, composted, and landfilled pomace result from leaching and runoff. These include alteration of soil composition and contamination of surface and groundwater.

In addition to the nitrogen immobilization of soils exposed to pomace, leaching, runoff, and direct discharge from pomace piles can cause increases in soil potassium, decreases in pH, and can harm surface waters due to the accumulation of BOD (biological oxygen demand) and TSS (total suspended solids, typically sugars in this case). Similarly leaching or runoff into surface and/or groundwater can increase acidity and add oxygen-depleting nutrients (nitrogen, phosphorus, and BOD). Soil and water pollution can easily occur any time there is no barrier between soil and WGP, whether composted, piled, or landfilled.

These deleterious effects on the environment carry consequences for ecosystems as well. Lempereur et al (2014) have shown that both the composting and the spreading of WGP on soils have a negative impact on ecosystem quality, as expressed by the potential disappeared fraction (PDF). PDF represents the fraction of species with a high probability of no occurrence in a region, due to the negative effects of acidification and eutrophication. Finally, piles of pomace and mismanaged compost are a sheer nuisance. WGP has a strong odor that rapidly worsens and attracts insects, and pomace compost piles - especially when swarming with flies - are an eyesore.

**ENVIRONMENTAL BENEFITS OF FRUIT FORWARD**

*Greenhouse Gas Emissions Mitigation*

Fruit Forward has the ability to make a significant contribution to the mitigation of greenhouse gas (GHG) emissions by upcycling WGP and turning it into an all-natural food preservative. When methane gas is released from organic matter into the atmosphere, it drastically influences climate change conditions. Methane is a highly potent GHG with a global warming potential (GWP) 25 times that of carbon dioxide. Based on the methane potentials of red and white WGP, quantities of winery waste at a scale of hundreds of tonnes could have a severe negative impact on atmospheric conditions based on predicted methane emissions and the corresponding carbon dioxide equivalent of GWP (Table I2).

**Table I2: Potential Climate Change Impacts of Wine Grape Pomace.** Methane potential (mL/g), methane emissions (kg/tonne), and carbon dioxide equivalent emissions (kg/tonne) of WGP, for both red and white varietals. All values given under standard temperature and pressure.

<table>
<thead>
<tr>
<th>Pomace Type</th>
<th>CH₄ Potential (mL/g)</th>
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Every tonne of WGP diverted from a landfill or mismanaged compost pile has the potential to prevent 55-58 kg of methane, or 1377-1444 kg of carbon dioxide equivalent, from
escaping into the atmosphere. High methane potential estimates have even suggested that as much as 71 kg of methane (1773 kg CO\textsubscript{2} eq.) could be mitigated per tonne of repurposed WGP. The impacts of these emissions on climate change are significant when considering the scale of the winemaking industry.

Resource Optimization

As noted above, wine grapes require a vast amount of nutrients. Using our assumption of 1.59 tonnes of WGP generated per hectare, we can calculate the approximate resource investment that goes into each tonne of pomace as a percentage of the total resources used in wine grape production (Table I3).

<table>
<thead>
<tr>
<th>N-fertilizer (kg/t)</th>
<th>P-fertilizer (kg/t)</th>
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CONCLUSION

Fifteen (15) million tonnes of wine grape pomace are produced every year around the world. The generation of this organic waste results in a predicted total of 846 million kg methane emissions, a substantial contribution to global warming potential and climate change, as well the threat of significant environmental hazards to soils and ground and surface waters. These hazards include acidification, introduction of ecotoxic compounds, and changes in nutrient composition that include nitrogen immobilization, elevated potassium concentrations, and accumulation of BOD and TSS.

Fruit Forward plans to valorize this agricultural byproduct by extracting its abundant phenolic compounds for applications in human nutrition and food preservation. Each tonne of pomace we process will theoretically mitigate the global warming potential of 1400 kg CO\textsubscript{2} equivalent and conserve 20,281 MJ embedded energy, as well as upcycle a plethora of resources that were required for wine grape production. Furthermore diversion of pomace from piles, compost, and landfills will keep soil and water free of its acidic, phytotoxic, and oxygen-depleting effects.

By repurposing wine grape pomace and harnessing its value, Fruit Forward can have a sizable, quantifiable, beneficial impact on the environment as we aim to reduce waste, upcycle resources, and facilitate good nutrition, all while making a profit in the process.

REFERENCES


APPENDIX II: Survey Design

Consumer Survey

1. Do you ever shop at a farmers' market, weather permitting? If so, what is your reason for going there?

2. Do you currently have any issues with produce going bad before you get a chance to eat it? If so, have you been looking for something to help prevent this food waste?

3. What is your current method at home for preventing produce from going bad? Are there any problems with that method or reasons you would prefer not to use it?

4. If there was an all-natural food wash or spray that could extend the shelf life of your fruits and vegetables without the use of chemicals or traditional food preservatives, would you use it? If it were available for purchase in grocery stores, how much would you be willing to pay for it?

Cold-Pressed Juicer Survey

[Thank you for agreeing to participate in this study. The questions we will ask you today are intended to explore food waste and preservation techniques in the cold-pressed juice industry. The research that we obtain here will help with the development of our Eco-Entrepreneurship Master's Thesis Project at the Bren School of Environmental Science & Management at the University of California, Santa Barbara.

The study should take approximately 3 minutes to complete. There are no risks associated with this survey, and no personal or sensitive information will be collected. We will have exclusive access to the notes taken based on this questionnaire. Your participation is voluntary and may be terminated at any time.

If you have any questions or concerns regarding this survey or would like to withdraw your responses, please email sbroeckx-smith@gmail.com or call Summer Broeckx-Smith at (518) 428-0233. If you have any concerns about the intentions or procedures used in this study, you can email the University of California, Santa Barbara's research ethics committee at warren@research.ucsb.edu.

Thank you again! Your participation is greatly appreciated!

Sincerely,
Summer Broeckx-Smith and Jessica Sexton
Bren School of Environmental Science and Management
University of California, Santa Barbara]
1. Do you prepare your cold-pressed juice ahead of time?
   ○ Ahead of time.
   ○ Only to order.
   ○ Both.

2. Approximately how much juice do you currently throw out each week due to spoilage?

3. What is the current shelf life of your cold-pressed juice, in days?

4. What would be the ideal shelf life, in days, if you had the ability to extend it?

5. What is your opinion of HPP (high-pressure processing)?
   ○ Love it! I am using it or would use it if it were available.
   ○ Hate it! I would never consider using HPP.
   ○ Don’t know.
   Please briefly explain your answer.

6. Are antioxidants important to you or your customers?
   ○ Yes!
   ○ Not really.

7. Rank the following based on the value it could add to your company (1-3, with 1 the most valuable and 3 the least valuable):
   ○ Increased antioxidant content in product.
   ○ Extended product shelf life.
   ○ Increased fiber, vitamins, and minerals in product.

8. Would you consider yourself more of a businessperson or a juice enthusiast?
   ○ Businessperson.
   ○ Juice enthusiast.

9. Would you consider using an organic preservative in your cold-pressed juice if it could double your product’s shelf life and increase the health benefits?
   ○ Yes.
   ○ No.
   Please briefly explain your answer, including concerns, if any.

10. If yes, how much would you be willing to pay for this product, per bottle of juice?
APPENDIX III: Juicer Interview Script

Fruit Forward Interview Questions for Juicers Version 1.1 April 9, 2015

Opening statement: We are Master’s students at the UCSB Bren School of Environmental Science and Management, conducting research on food waste and preservation techniques in the juice industry. We would like to interview you about your product shelf life.

Thank you for offering to participate in this interview. The discussion we will have with you today is intended to explore food waste and preservation techniques in the juice industry. The research that we obtain here will help with the development of our Eco-Entrepreneurship Project at the Bren School of UC Santa Barbara.

The interview should take approximately 15 minutes to complete. There are no risks associated with this interview, and no personal or sensitive information will be collected. We will have exclusive access to the notes taken based on this discussion. Your participation is voluntary and may be terminated at any time.

If you have any questions or concerns regarding this survey or would like to withdraw your responses, please email sbroekx-smith@gmail.com or call Summer Broeckx-Smith at (518) 428-0233. If you have any concerns about the intentions or procedures used in this interview, you can email UC Santa Barbara’s research ethics committee at warren@research.ucsb.edu.

Your participation is greatly appreciated.

Sincerely,

Summer Broeckx-Smith, Jessica Sexton, and Sean Parker
Bren School of Environmental Science and Management
University of California, Santa Barbara

Can you tell us a few things about your products and business?

● What are some of the most challenging problems for your business?
● What is the number one thing you wish were different about the juice industry?
● Do you prepare juice ahead of time to sell later?
● If so, do you press/prepare it onsite?
● What are your current methods for keeping your juice fresh?
● Have you considered other methods? If not, why?
● What is your opinion of high-pressure processing (HPP)?
● How much juice do you have to throw out in a week due to spoilage?
● What is your juice’s current shelf life? What would be the ideal shelf life if you had the ability to extend it? What would this do for your business?
● If there were an additive made from all natural agricultural products that could extend the shelf life of your juice, do you think you would consider using it in your product? What would be your main concerns about it, if any? Would this additive need to be organic?
● What range of shelf-life extension would be required for you to bother using such an additive?
● Assuming it could double your current shelf life, how much do you think you might be willing to pay for this product (per bottle)?
● How do your customers respond to nutritional quality such as antioxidants, fiber, etc.?
● Any other comments?
**APPENDIX IV: Summary of Interviews**

Table IV1: Summary of Customer, Consumer, Winemaker, and Industry Expert Interviews. 19 juice (5 smoothie, 14 cold-pressed), 9 winemakers, 2 pomace processors, 7 experts, 3 IP consultants (IP currently listed as “experts”), 17 consumers.

<table>
<thead>
<tr>
<th>Type</th>
<th>Number (N=57 total interviews)</th>
<th>Key Insights</th>
</tr>
</thead>
</table>
| Cold-pressed juice producers| 14                              | Most do not currently preserve juice - product has 3 day shelf life.  
   ~ Half of those who don’t preserve say they are very interested in new method of preservation, as long as it doesn’t damage the juice. |
| Smoothie and juice Bars      | 5                               | Juice consumers are concerned with health and natural ingredients, tend to prefer juice and smoothie add-ins they recognize, i.e. would choose turmeric over “antioxidant” supplement. |
| Industry experts            | 10                              | Winemakers pay to have pomace hauled offsite to compost or landfill.  
   Pomace does not compost easily - must be properly mixed with nitrogen-rich waste and turned regularly. |
| Pomace processor            | 2                               | The cost of pomace is a liability to wineries – $16/ton to remove.  
   Many options for WGP: food supplement, natural food dye, nutriceutical, fermentable material for making spirits, cosmetic ingredient.  
   Pomace (dried & powdered) is currently being tested at USDA for studies on metabolic diseases |
| Wineries                    | 9                               | Most pay to have pomace hauled away. Disposing of it is a headache for them during the busy harvest time - it attracts insects and birds, containers leak acidic residue.  
   Winemakers are happy to give it to Fruit Forward.  
   Many vineyards grow grapes organically but are not certified - there is a growing trend toward organic cultivation. |
| Consumers                   | 17                              | Want natural products.  
   Skeptical about any kind of “preservative”. |
APPENDIX V: Research Results

PRELIMINARY CHARACTERIZATION OF COLD-PRESSED JUICE

Early experiments to characterize cold-pressed juice focused on microbial content and pH of three juice varieties obtained from our external advisors Geoff Crosby and Bill Sharp at California Juice Company. Microbial counts were performed using a standard bacteriological growth medium (Table V1). Because the leafy green Big Sur blend is a popular blend that also spoils quickly, it was chosen as a model juice for future experiments.

Table V1. pH and microbial content of three cold-pressed juice blends. Juices were obtained 1 day after pressing, serially diluted, and spread on Luria Bertani agar plates to obtain colony counts. Plates were incubated at 37 degrees C for 1 day.

<table>
<thead>
<tr>
<th>Juice Blend</th>
<th>Ingredients</th>
<th>pH</th>
<th>Colony Forming Units/ml juice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mavericks</td>
<td>Kale, spinach, cucumber, parsley, ginger</td>
<td>6.2</td>
<td>4 x 10^6</td>
</tr>
<tr>
<td>Big Sur</td>
<td>Kale, spinach, apple, cucumber, celery, ginger, parsley, lemon</td>
<td>4.3</td>
<td>1.2 x 10^6</td>
</tr>
<tr>
<td>Alcatraz</td>
<td>Lemon, ginger, apple cider vinegar, echinacea, cayenne</td>
<td>2.6</td>
<td>4.0 x 10^2</td>
</tr>
</tbody>
</table>

EXPERIMENTAL DETAILS - JUICE EXPERIMENT WITH POMACE “FLOUR”

To understand how WGP might affect cold-pressed juice, we obtained and tested commercial Pinot Noir and Chardonnay skin or seed pomace powders from a source that markets these as specialty flours (WholeVine Products, Santa Rosa, CA). In winter quarter of 2015, the Pinot Noir powders were tested in Big Sur juice at 1 day post production. For testing, ½ teaspoon of powder (skins, seeds, or a mix of both) was added to a full (12 fluid oz) bottle of juice, which was then capped and stored at 4 degrees Celsius. An additional condition of 1 full teaspoon of mixed skins and seeds (½ t each) was also tested. Bottles were mixed and opened for blind tasting after 3 and 7 days. Table V2 shows that addition of Pinot Noir skin pomace to Big Sur altered the taste slightly, but also prevented the juice from tasting sour after 3 and 7 days. Control juice was described as “fairly sour” and given sourness scores of 4.5 or 6, while treated juice was described as “slightly tart, not sour”, and given sourness scores of 1 or 2.
Table V2. Results of blind taste test: commercial Pinot Noir pomace powder in California Juice Company Big Sur Blend. Two tasters provided comments on days 3 and 7. Tasters also rated juice sourness on a scale of 1-10 (1 being not so sour and 10 being extremely sour) on day 3.

<table>
<thead>
<tr>
<th>Day 0</th>
<th>Control</th>
<th>½ t Grape Skin (2.8%)</th>
<th>½ t Grape Seed (3.4%)</th>
<th>¼ t Skin, ¼ t Seed (3.1%)</th>
<th>½ t Skin, ½ t Seed (6.2%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taste</td>
<td>-</td>
<td>A little more tart, not identifiably grape</td>
<td>No noticeable difference from Control</td>
<td>No noticeable difference from Control</td>
<td>A little more tart, not identifiably grape</td>
</tr>
<tr>
<td>Color</td>
<td>-</td>
<td>Slightly darker green</td>
<td>Slightly darker green</td>
<td>Slightly darker green</td>
<td>Darker green</td>
</tr>
<tr>
<td>Texture</td>
<td>-</td>
<td>No noticeable difference</td>
<td>No noticeable difference</td>
<td>No noticeable difference</td>
<td>Slight grainy texture</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Day 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taste</td>
</tr>
<tr>
<td>Color</td>
</tr>
<tr>
<td>Sourness (1-10)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Day 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taste</td>
</tr>
<tr>
<td>Color</td>
</tr>
</tbody>
</table>

After observing successful preservation of Big Sur by Pinot Noir pomace, we wished to experiment with the Chardonnay pomace. One thought was that white grape pomace would have less color than red grape pomace and thus the pomace would be less evident in juice. During Spring quarter of 2015, Chardonnay skin and seed powders were tested in a fresh juice blend, “All Greens”, obtained from a local juice bar (Lazy Acres, Santa Barbara, CA). All Greens was used in place of Big Sur (not available at the time) as it has similar ingredients and pH. In this experiment, Chardonnay skin and seed powders were tested separately and compared to untreated controls. In addition, a Baobab powder control was set up. Like pomace, Baobab powder lowers the pH of juice slightly. This control was used to test whether the preservation effects of pomace were simply due to pH changes. Samples were set up in sanitized ½ oz (133 ml) glass jars with sealing lids, using ~50 ml juice in each and ¼ or ½ teaspoon of powders (see Table V3), and incubated at 4 degrees Celsius for one week. Juices were tasted (unblinded) after 3, 5, and 7 days (Table V3).
<table>
<thead>
<tr>
<th>Day 3</th>
<th>Control A</th>
<th>Control B</th>
<th>Grape Skin ¼ t (1.4% w/v)</th>
<th>Grape Skin ½ t (2.8% w/v)</th>
<th>Grape Seed ½ t (3.4% w/v)</th>
<th>Baobab ¼ t (2.8% w/v)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taste</td>
<td>Bitter (but not spoiled yet)</td>
<td>Bitter (but not spoiled yet)</td>
<td>Less bitter than control</td>
<td>-</td>
<td>Less bitter than control, more sour than grape skin sample</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>5.1</td>
<td>5.0</td>
<td>4.5</td>
<td>4.5</td>
<td>5.1</td>
<td>4.0</td>
</tr>
<tr>
<td>Color</td>
<td>Green</td>
<td>Green</td>
<td>Green brownish</td>
<td>Green brownish</td>
<td>Green with brown, clumpy matter</td>
<td>Green with white layer</td>
</tr>
<tr>
<td>Texture</td>
<td>None</td>
<td>None</td>
<td>Slightly chewy/grainy</td>
<td>-</td>
<td>-</td>
<td>No graininess</td>
</tr>
<tr>
<td>Day 5</td>
<td>Bitter/sour, had to spit out</td>
<td>Bitter/sour, had to spit out</td>
<td>Not bitter or sour: drinkable</td>
<td>Not bitter or sour: drinkable</td>
<td>Drinkable, but does not taste as good as skin supplemented samples</td>
<td>More bitter/sour than controls</td>
</tr>
<tr>
<td>pH</td>
<td>5.1</td>
<td>5.1</td>
<td>4.4</td>
<td>4.5</td>
<td>5.1</td>
<td>4.0</td>
</tr>
<tr>
<td>Texture</td>
<td>None</td>
<td>None</td>
<td>Slightly chewy/grainy</td>
<td>Slightly chewy/grainy</td>
<td>Quite chewy/grainy</td>
<td>No graininess</td>
</tr>
<tr>
<td>Day 7</td>
<td>Foul smell, bitter taste, undrinkable</td>
<td>Foul smell, bitter taste, undrinkable</td>
<td>Tasted fine, seemed drinkable</td>
<td>Tasted fine, seemed drinkable</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>pH</td>
<td>5.1</td>
<td>5.1</td>
<td>4.4</td>
<td>4.5</td>
<td>5.0</td>
<td>4.0</td>
</tr>
</tbody>
</table>

Like Pinot Noir pomace, Chardonnay pomace was effective in extending the shelf life of juice based on taste. Baobab powder was not effective, in spite of its low pH. However, both Pinot Noir and Chardonnay powders altered the taste and appearance of juice. Taste changes were pleasant and totally acceptable, while appearance changes were more problematic. Pinot Noir powder creates a dark purple layer in the juice (see Figure V3) that may or may not bother consumers. Chardonnay powder appears brown when added to green juice, and is not appealing at all. Seed powder was especially unappealing due to its tendency to clump, and the texture of the seeds was also grittier.

In an attempt to make a finer powder that would not be as obvious in juice, we turned to drying, grinding, and sifting our own Pinot Noir pomace. We also planned to attempt extracting the active flavonoid molecules from pomace using a new, cold water procedure.
OVERVIEW OF PRODUCTION PROCESSES

To produce WGP powder and extract from scratch, we followed the processes diagrammed in Figure V1, using frozen Pinot Noir pomace obtained from the Foley winery in September 2015. Experimental details are described below.

![Image: Process flow diagram](image)

**Figure V1.** Top panel: process flow for powdered product only. Photographs of each step are shown. Bottom panel: complete process flow including water extraction of polyphenolics and creation of a concentrated, water-soluble product.

EXPERIMENTAL DETAILS - POWDERED POMACE

Ten (10) 1 gallon freezer bags of wine grape pomace (Pinot Noir, Syrah, Grenache, and Gamay Noir - all containing grape skins, seeds, and some stems) were obtained from three different wineries, and stored in air-tight plastic containers at -20 degrees C. Almost all pomace types were organically grown. A typical bag weighed between 1.5 and 1.7 kg.
To remove water from the frozen pomace without introducing heat, which can damage flavonoids and other polyphenolics, lyophilization (or “freeze-dry”) was performed. Approximately 900 g Pinot Noir pomace was lyophilized for 36 h (LabConco FreeZone 4.5 lyophilizer, Apeel Sciences, Santa Barbara, CA). Lyophilization was completed on October 23rd, 2015. The dry weight of pomace was found to be 272 g, or roughly 30% of the wet weight. Dried pomace was stored at -20 degrees Celsius.

Next (December 2nd, 2015), 50 g dried pomace was further processed by grinding in a standard coffee grinder (Fig. V1, top panel), then sifting for 5h through a series of mesh sieves to obtain particles of various sizes (Table V4 and Fig. V2). Approximately 14% of the material was lost in this process (stuck to the sieves, spilled on the lab bench, etc). Because much of the powdered pomace was very coarse, it was determined that future grinding should be done on a more effective piece of equipment, and/or be done more thoroughly.

<table>
<thead>
<tr>
<th>Particle Size (µm)</th>
<th>Mass Obtained (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;500</td>
<td>20.0</td>
</tr>
<tr>
<td>250-500</td>
<td>16.7</td>
</tr>
<tr>
<td>125-250</td>
<td>4.5</td>
</tr>
<tr>
<td>63-125</td>
<td>1.1</td>
</tr>
<tr>
<td>&lt;63</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Figure V2. Left panel: pomace particles ranging in size from >500 (top) to <63 (bottom) µm. Right panel: close up image of pomace particles <63 µm.
Fruit Forward’s Pinot Noir pomace powder (skins and seeds and some stems too) was tested in Big Sur juice on January 21st, 2016. 100 ml juice was added to Pyrex glass bottles (100 ml volume) containing 0 g (samples 1 and 5) or 1.0 g (samples 2 and 3) of pomace powder. A 5th bottle was set up using 1.0 g of commercial Pinot Noir skins (0.5 g) + Pinot Noir seeds (0.5 g) (sample 4). Bottles were photographed at this point (day 0), then incubated at 4 degrees Celsius.

After 5 days bottles were photographed again. At this time bubbles were observed in the control bottles (#s 1 and 5) as well as in the bottle containing commercial pomace powder (# 4), whereas no bubbles could be seen in the Fruit Forward-treated juice bottles (#s 2 and 3) (Fig. V3). The juice was not sampled for taste. At Day 19 juice was serially diluted in sterile water and plated to assess any differences in microbial growth between samples. Five dilutions (10^2 - 10^5) from one control bottle (# 1) and one test bottle (# 2) were plated on potato dextrose agar (PDA) or Pseudomonas isolation agar (PIA), and plates were incubated at room temperature for 2 days.

![Figure V3. Top panel: samples at Day 0. From left to right: samples 1 and 5 (controls), samples 2 and 3 (Fruit Forward Pinot Noir pomace powder (1%), and sample 4 (commercial Pinot Noir pomace powder (1%)). Note the obvious layer of purple powder in the test samples. Bottom panel: samples at Day 5. Note the presence of bubbles in control samples and the commercial sample.](image)

Images of Pseudomonas isolation agar (PIA) plates are shown in Figure V4, with microbial CFU counts summarized in Table V5. A greater than ten-fold reduction in microbial growth
was seen in the pomace powder-treated sample as compared to the control, which is in keeping with reported findings on the antimicrobial properties of WGP.

![Figure V4. *Pseudomonas* isolation agar (PIA) plates showing microbial colony forming units (cfu) from untreated (left panel) and Fruit Forward Pinot Noir pomace-treated (right panel) juice. Juice was diluted and plated at Day 19, after incubation at 4 degrees Celsius.](image)

**Table V5.** Total colony forming units in Big Sur juice after 19 days, in the presence or absence of Fruit Forward’s powdered Pinot Noir pomace (1%). Diluted samples were plated on *Pseudomonas* isolation agar (PIA) or Potato Dextrose agar (PDA).

<table>
<thead>
<tr>
<th>Plate Type</th>
<th>Sample</th>
<th>Number of colonies counted, dilution</th>
<th>CFU/ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>PDA</td>
<td>Control (sample 1)</td>
<td>$14, 10^4$</td>
<td>$1.4 \times 10^7$</td>
</tr>
<tr>
<td>PDA</td>
<td>Treated (sample 2)</td>
<td>$57, 10^3$</td>
<td>$5.7 \times 10^6$</td>
</tr>
<tr>
<td>PIA</td>
<td>Control (sample 1)</td>
<td>$46, 10^3$</td>
<td>$4.6 \times 10^6$</td>
</tr>
<tr>
<td>PIA</td>
<td>Treated (sample 2)</td>
<td>$24, 10^2$</td>
<td>$2.4 \times 10^5$</td>
</tr>
</tbody>
</table>

Based on our experiments, we felt confident in the potential for WGP (both commercial and our own) as a juice shelf life extender. However, the texture and appearance of WGP powder in juice indicated a likely need for a water-soluble or liquid pomace extract.

**EXPERIMENTAL DETAILS - LIQUID EXTRACT**

To make a WGP preservative that would be easier for juicers to use and generally more versatile than an insoluble powder, we chose to follow a novel protocol that enables extraction of tannins and flavonoids using nothing but cold water and low voltage electricity.¹ Figure V5 illustrates the extraction apparatus we constructed for this purpose.

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and Figure V6 shows bottles of (separately extracted) tannins and flavonoids. To date, three extraction attempts have been made, the details of which are recorded in Table V6.

**Figure V5.** Left panel: electrodes and pomace packet containing whole skins and seeds; Right panel: extraction set up, with electrode and pomace “sandwich” immersed in sterile water. Leads are attached to electrodes and a magnetic stir bar and plate were used to aid in extraction.

**Figure V6.** Second cold water extraction of tannins and flavonoids from lyophilized Pinot Noir pomace.
Table V6. Parameters and efficacy of pilot preliminary polyphenolic cold water extractions. Extractions were performed in large (Extraction 1) or small (Extractions 2 and 3) containers, with comparably sized electrodes, volumes of water, and amounts of pomace. Phenolic content of extracts was measured in two ways: simple absorbance at 280 nm or Folin-Ciocalteu assay, and was compared in both cases to a gallic acid standard curve. Total phenolic acid content (TPC) is expressed as Gallic Acid Equivalents (GAE). Efficiency estimates are based on an assumption of 68 mg total phenolic compounds per gram of dry pomace.\(^2\) Flavonoids and tannins were assumed to comprise 100% of the phenolics in pomace. For Extraction 2, efficiency has been calculated using TPC values from both assays.

<table>
<thead>
<tr>
<th>Extraction # (date)</th>
<th>Pomace mass, state</th>
<th>Electrode size</th>
<th>Volume H2O used</th>
<th>Start, End Temperature (degrees C)</th>
<th>A280 (GAE)</th>
<th>TPC (GAE)</th>
<th>Estimated efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extraction 1 (12/11/2015)</td>
<td>19.6 g, powdered</td>
<td>Large (3.5x3.5&quot;)</td>
<td>650 ml</td>
<td>ND</td>
<td>19.7 µg/ml</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Extraction 2 (01/18/2016)</td>
<td>8.8 g, whole</td>
<td>Small (2.5x2.5&quot;)</td>
<td>T: 225 ml F: 225 ml</td>
<td>T: 21.4-22.6 F: 21.4-22.4</td>
<td>12.1 µg/ml 2.6 µg/ml</td>
<td>0.6 µg/ml 1.5 µg/ml</td>
<td>0.08% (TPC) 0.56% (A280)</td>
</tr>
<tr>
<td>Extraction 3 (01/26/2016)</td>
<td>7.9 g, powdered</td>
<td>Small (2.5x2.5&quot;)</td>
<td>T: 225 ml F: 225 ml</td>
<td>T: 20.6-21.0 F: 20.7-20.3</td>
<td>ND</td>
<td>0.5 µg/ml 2.2 µg/ml</td>
<td>0.12% (TPC)</td>
</tr>
</tbody>
</table>

Tannin and Flavonoid extracts from Extraction 2 were tested in 2 day old juice from California Juice Company. 15 ml water, 15 ml tannin extract, 15 ml flavonoid extract, or 7.5 ml of each were added to 45 ml 2 day old Big Sur juice blend in sanitized 60 ml bottles and incubated at 4 degrees C. After 5 and 19 days, juice was tasted and scored (Table V7). (At the time of this experiment, neither the efficiency nor the total phenolic content (TPC) of these extracts were known. Instead, the volumes to be used in juice were based on an assumption of 100% extraction efficiency, such that 1 g of pomace would equal 25.5 ml of tannin or flavonoid extract. For 60 ml bottles, we would use 0.6 g pomace powder for a 1% final concentration. Thus, we used 15 ml extract in each 60 ml bottle of juice.)

This experiment was run in conjunction with the Fruit Forward pomace powder experiment described above. Unlike with the powdered WGP experiment (done in partially full 100 ml bottles), the appearance of samples in this experiment (done in completely full 60 ml bottles) did not change over the first 5 days; no bubbles could be seen in any samples, possibly due to the more complete exclusion of oxygen by minimal head space in the 60 ml bottles.

Table V7. Results of liquid extract juice experiment; taste test. Samples were scored in a blind taste test on a scale of 1 (fresh) to 5 (fully spoiled), on Days 5 (7 day old juice) and 19 (21 day old juice). Scores for each replicate are reported, along with the average score. ND = not done.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Day 5 Score: replicates a, b, c (ave)</th>
<th>Day 19 Score: a, b, c (ave)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>4, 1, 1 (2.0)</td>
<td>4, 4, ND (4.0)</td>
</tr>
<tr>
<td>Tannins (amount)</td>
<td>2, 3, 2 (2.3)</td>
<td>5, 4, ND (4.5)</td>
</tr>
<tr>
<td>Flavonoids (amount)</td>
<td>2, 4, 3 (3.7)</td>
<td>4, 4, ND (4.0)</td>
</tr>
<tr>
<td>Tannins + Flavonoids (amount)</td>
<td>4, 3, 2 (3.0)</td>
<td>3, 3, ND (3.0)</td>
</tr>
</tbody>
</table>

Samples were tasted at Day 5 with the assumption that untreated juice would be soured. Unfortunately, the control samples did not taste spoiled at this point and preservation by our liquid extract could not be assessed. Samples were tasted again on Day 19, whereupon juice containing the tannin + flavonoid extracts reportedly tasted slightly better than others (Table V7).

After discovering the total phenolic concentration and extraction efficiency of our liquid extracts (see Table V6), we realized our extraction procedure must be optimized, and/or that the flavonoid and tannin extracts must be concentrated in order to get TPC values close to those of powdered pomace. These will be Fruit Forward’s next steps.
APPENDIX VI: Business Model Canvases

**Iteration 1 Canvas**

<table>
<thead>
<tr>
<th>Key Partners</th>
<th>Key Activities</th>
<th>Value Propositions</th>
<th>Cost Relationships</th>
<th>Cost Segments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic Wholes</td>
<td>Production - obtaining and transporting pomegranate</td>
<td>Extending shelf life</td>
<td>Personal assistance model</td>
<td>Cold pressed juice makers</td>
</tr>
<tr>
<td></td>
<td>Production - processing and storing pomegranate</td>
<td>Lower cost and greater ease of use than HPP</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Production - packaging of dried pomegranate</td>
<td>Increased flavor and other nutrients</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Key Resources**

<table>
<thead>
<tr>
<th>Key Resources</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Patent Sieves</td>
<td>Testing</td>
</tr>
<tr>
<td>Freezer dryer and dehydrator</td>
<td>Testing</td>
</tr>
<tr>
<td>Storage for frozen pomegranate</td>
<td>Testing</td>
</tr>
<tr>
<td>Means of storing pomegranate</td>
<td>Testing</td>
</tr>
</tbody>
</table>

**Cost Structure**

- Employees and company operations
- Transportation of juice
- Sales & Marketing
- Processing Costs (Equipment and Energy)

**Revenue Streams**

- Juice Maximum WTP = $6.20-6.90 per bottle

**Iteration 2 Canvas**

<table>
<thead>
<tr>
<th>Key Partners</th>
<th>Key Activities</th>
<th>Value Propositions</th>
<th>Cost Relationships</th>
<th>Cost Segments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic Wholes</td>
<td>Production - obtaining and transporting pomegranate</td>
<td>Extending shelf life</td>
<td>Personal assistance model</td>
<td>Personal care product (PCP) manufacturers</td>
</tr>
<tr>
<td></td>
<td>Production - freezing and processing pomegranate</td>
<td>Lower cost and greater ease of use than HPP</td>
<td>Cold pressed juice - business type</td>
<td>Testing</td>
</tr>
<tr>
<td></td>
<td>Production - packaging of dried pomegranate</td>
<td>Increased flavor and other nutrients</td>
<td>Cold pressed juice - retail type</td>
<td>Testing</td>
</tr>
</tbody>
</table>

**Key Resources**

<table>
<thead>
<tr>
<th>Key Resources</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Freezer dryer or dehydrator, mortars and pestles</td>
<td>Testing</td>
</tr>
<tr>
<td>Cold water-activated apparatus</td>
<td>Testing</td>
</tr>
<tr>
<td>Storage for frozen pomegranate</td>
<td>Testing</td>
</tr>
</tbody>
</table>

**Cost Structure**

- Employees and company operations
- Transportation of juice
- Sales & Marketing
- Processing Costs (Equipment and Energy)

**Revenue Streams**

- Juice Maximum WTP = $6.20-6.90 per bottle

Testing
Iteration 3 Canvas

**Key Partners**
- Organic Wineries

**Key Activities**
- Collection
- Transportation
- Storage
- Processing
- Packaging

**Value Proposition**
- Shelf life extension
- Cheaper than HPP
- In-line process
- Nutrients
- Antioxidants
- Organic
- Sustainable

**Customer Relationships**
- Personal Assistance Model (B2B)

**Customer Segments**
- Cold-pressed juicers
- Juice drinkers

**Channels**
- Direct delivery
- Personal sales
- Website
- Distributor

**Key Resources**
- Freeze dryer
- Extraction equipment
- Refrigerator
- Freezer (storage)

**Cost Structure**
- SG&A expenses
- Pomace transportation
- Processing equipment
- Energy consumption
- R&D

**Revenue Streams**
- Willingness to pay, $0.20-0.50
  - Mean = $0.26 per bottle
APPENDIX VII: Financial Justification

### Transportation Costs

<table>
<thead>
<tr>
<th>Cost of Fuel</th>
<th>$2.55/gal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Distance per Trip</td>
<td>84 miles</td>
</tr>
<tr>
<td>2015 F-150 Fuel Efficiency</td>
<td>19 miles/gal</td>
</tr>
<tr>
<td>Total Cost per Trip</td>
<td>$11.27</td>
</tr>
</tbody>
</table>

If the load capacity of a F-150 truck is a half-ton, one truck can carry 1 macro bin of pomace (428 kg wet or 128 dry). Therefore, transportation costs equal approximately $0.09 per kg dry pomace WGP product.

### Energy Costs

<table>
<thead>
<tr>
<th>Extraction Equipment</th>
<th>Power (W)</th>
<th>Time Used (m)</th>
<th>kWh</th>
<th>Cost Per Use ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GAG-810 Audio Generator</td>
<td>8</td>
<td>30</td>
<td>0.004</td>
<td>0.0006</td>
</tr>
<tr>
<td>DC Power Supply PS-305D</td>
<td>0.72</td>
<td>30</td>
<td>0.00036</td>
<td>0.000054</td>
</tr>
<tr>
<td>Labconco Lyophilize</td>
<td>690</td>
<td>2400</td>
<td>27.6</td>
<td>4.14</td>
</tr>
<tr>
<td>Vacuum pump</td>
<td>586.5</td>
<td>2400</td>
<td>23.46</td>
<td>3.52</td>
</tr>
</tbody>
</table>

Average cost of electricity is approximately $0.15/kWh. [https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a](https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a)

### Startup Costs

<table>
<thead>
<tr>
<th>Licensing Fees</th>
<th>Business* $175 for 3 years (overestimate)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>*one time cost</td>
</tr>
<tr>
<td>OPEX</td>
<td></td>
</tr>
<tr>
<td>Utilities</td>
<td>Internet $65</td>
</tr>
<tr>
<td></td>
<td>Electricity $100 not including variable consumption</td>
</tr>
<tr>
<td>Rent</td>
<td>Office $2,000 $36,000/year</td>
</tr>
<tr>
<td></td>
<td>CNSI Lab Space $1,000 10 ft bench space</td>
</tr>
<tr>
<td>Total SG&amp;A</td>
<td>$3,265</td>
</tr>
<tr>
<td>General Liability</td>
<td>? $35 median $425/year</td>
</tr>
</tbody>
</table>
## Sales Revenue Forecast

### Powdered Wine Grape Pomace Product

<table>
<thead>
<tr>
<th>Year</th>
<th>Selling Price</th>
<th>Low WTP per kg</th>
<th>Unit Sales</th>
<th>Year</th>
<th>Selling Price</th>
<th>Low WTP per kg</th>
<th>Unit Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28.00</td>
<td>18.00</td>
<td>2,369</td>
<td>2</td>
<td>28.00</td>
<td>18.00</td>
<td>50,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28.00</td>
<td>18.00</td>
<td>300,000</td>
</tr>
<tr>
<td>2</td>
<td>43.00</td>
<td>43.00</td>
<td>2,369</td>
<td>2</td>
<td>43.00</td>
<td>43.00</td>
<td>11,845</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>43.00</td>
<td>43.00</td>
<td>71,070</td>
</tr>
</tbody>
</table>

### Liquid Extract Wine Grape Pomace Product

<table>
<thead>
<tr>
<th>Year</th>
<th>Selling Price</th>
<th>Low WTP per kg eq.</th>
<th>Unit Sales</th>
<th>Year</th>
<th>Selling Price</th>
<th>Low WTP per kg eq.</th>
<th>Unit Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>28.00</td>
<td>28.00</td>
<td>9,475</td>
<td>2</td>
<td>28.00</td>
<td>28.00</td>
<td>17,055</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>28.00</td>
<td>28.00</td>
<td>30,599</td>
</tr>
<tr>
<td>2</td>
<td>43.00</td>
<td>43.00</td>
<td>9,475</td>
<td>2</td>
<td>43.00</td>
<td>43.00</td>
<td>16,581</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>43.00</td>
<td>43.00</td>
<td>29,746</td>
</tr>
</tbody>
</table>

### Revenue Buildup - Year 1 (Low WTP Scenario)

<table>
<thead>
<tr>
<th>Customer Count</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Acquisition rate of 2/month)</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>18</td>
<td>20</td>
<td>22</td>
<td>24</td>
<td>26</td>
<td>28</td>
<td>30</td>
<td>32</td>
<td>2,369</td>
</tr>
</tbody>
</table>

#### Powder Product

- **Unit Sales**
  - Low WTP: 94, 113, 132, 150, 169, 188, 207, 226, 244, 263, 282, 301
  - Powder Product Total Units: 94, 113, 132, 150, 169, 188, 207, 226, 244, 263, 282, 301, 2,369

#### Average Unit Sales Price

- Low Price: 28.00

- **Powder Product Sales $**
  - 2,632, 3,158, 3,685, 4,211, 4,738, 5,264, 5,790, 6,317, 6,843, 7,370, 7,896, 8,422, 66,326

#### Liquid Extract Product

- **Unit Sales**
  - Low WTP: 376, 451, 526, 602, 677, 752, 827, 902, 978, 1,053, 1,128, 1,203, 9,475
  - Liquid Extract Product Total Units: 376, 451, 526, 602, 677, 752, 827, 902, 978, 1,053, 1,128, 1,203, 9,475

#### Average Unit Sales Price

- Low Price: 28.00

- **Liquid Extract Product Sales $**
  - 10,528, 12,634, 14,730, 16,836, 18,942, 21,048, 23,154, 25,260, 27,366, 29,472, 31,578, 33,684, 265,300

#### All Products Sales $

- 13,164, 15,790, 18,416, 21,032, 23,648, 26,264, 28,880, 31,496, 34,112, 36,728, 39,344, 41,960, 331,632
### Revenue Buildup - Year 1 (High WTP Scenario)

<table>
<thead>
<tr>
<th>Powder Product</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Sales</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2,369</td>
</tr>
<tr>
<td>High WTP</td>
<td>94</td>
<td>113</td>
<td>132</td>
<td>150</td>
<td>169</td>
<td>188</td>
<td>207</td>
<td>226</td>
<td>244</td>
<td>263</td>
<td>282</td>
<td>301</td>
<td>4,947</td>
</tr>
<tr>
<td>Product A Total</td>
<td>94</td>
<td>113</td>
<td>132</td>
<td>150</td>
<td>169</td>
<td>188</td>
<td>207</td>
<td>226</td>
<td>244</td>
<td>263</td>
<td>282</td>
<td>301</td>
<td>4,947</td>
</tr>
</tbody>
</table>

#### Average Unit Sales Price

<table>
<thead>
<tr>
<th>High Price</th>
<th>43.00</th>
<th>43.00</th>
<th>43.00</th>
<th>43.00</th>
<th>43.00</th>
<th>43.00</th>
<th>43.00</th>
<th>43.00</th>
<th>43.00</th>
<th>43.00</th>
<th>43.00</th>
<th>43.00</th>
<th>43.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powder Product Sales $</td>
<td>4,042</td>
<td>4,850</td>
<td>5,659</td>
<td>6,467</td>
<td>7,276</td>
<td>8,084</td>
<td>8,892</td>
<td>9,701</td>
<td>10,509</td>
<td>11,317</td>
<td>12,125</td>
<td>12,933</td>
<td>138,527</td>
</tr>
</tbody>
</table>

#### Liquid Extract Product

<table>
<thead>
<tr>
<th>Unit Sales</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>High WTP</td>
<td>376</td>
<td>451</td>
<td>526</td>
<td>602</td>
<td>677</td>
<td>752</td>
<td>827</td>
<td>902</td>
<td>978</td>
<td>1,053</td>
<td>1,128</td>
<td>1,203</td>
<td>9,475</td>
</tr>
<tr>
<td>Powder Product Total Units</td>
<td>376</td>
<td>451</td>
<td>526</td>
<td>602</td>
<td>677</td>
<td>752</td>
<td>827</td>
<td>902</td>
<td>978</td>
<td>1,053</td>
<td>1,128</td>
<td>1,203</td>
<td>9,475</td>
</tr>
</tbody>
</table>

#### Average Unit Sales Price

<table>
<thead>
<tr>
<th>High Price</th>
<th>43</th>
<th>43</th>
<th>43</th>
<th>43</th>
<th>43</th>
<th>43</th>
<th>43</th>
<th>43</th>
<th>43</th>
<th>43</th>
<th>43</th>
<th>43</th>
</tr>
</thead>
</table>

| All Products Sales $ | 20,210 | 24,252 | 28,294 | 32,336 | 36,378 | 40,420 | 44,462 | 48,504 | 52,546 | 56,588 | 60,630 | 64,672 | 509,290 |

### Revenue Buildup - Year 2 (Low WTP Scenario)

<table>
<thead>
<tr>
<th>Customer Acquisition</th>
<th>32</th>
<th>34</th>
<th>36</th>
<th>38</th>
<th>40</th>
<th>42</th>
<th>44</th>
<th>46</th>
<th>48</th>
<th>50</th>
<th>52</th>
<th>54</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Powder Product

<table>
<thead>
<tr>
<th>Unit Sales</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Low WTP</td>
<td>301</td>
<td>320</td>
<td>338</td>
<td>357</td>
<td>376</td>
<td>395</td>
<td>414</td>
<td>432</td>
<td>451</td>
<td>470</td>
<td>489</td>
<td>508</td>
<td>4,850</td>
</tr>
<tr>
<td>Powder Product Total Units</td>
<td>307</td>
<td>326</td>
<td>345</td>
<td>364</td>
<td>384</td>
<td>403</td>
<td>422</td>
<td>441</td>
<td>460</td>
<td>479</td>
<td>499</td>
<td>518</td>
<td>4,947</td>
</tr>
</tbody>
</table>

#### Average Unit Sales Price

<table>
<thead>
<tr>
<th>Low Price</th>
<th>28.00</th>
<th>28.00</th>
<th>28.00</th>
<th>28.00</th>
<th>28.00</th>
<th>28.00</th>
<th>28.00</th>
<th>28.00</th>
<th>28.00</th>
<th>28.00</th>
<th>28.00</th>
<th>28.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powder Product Sales $</td>
<td>8,591</td>
<td>9,128</td>
<td>9,665</td>
<td>2</td>
<td>9</td>
<td>5</td>
<td>2</td>
<td>9</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>7</td>
</tr>
</tbody>
</table>

#### Liquid Extract Product

<table>
<thead>
<tr>
<th>Unit Sales</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Low WTP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Powder Product Total Units</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

Fruit Forward | Eco-Entrepreneurship Thesis Project Final Report | 82
### Low WTP

<table>
<thead>
<tr>
<th>Liquid Extract Product Total Units</th>
<th>1,203</th>
<th>1,278</th>
<th>1,354</th>
<th>1,429</th>
<th>1,504</th>
<th>1,579</th>
<th>1,654</th>
<th>1,730</th>
<th>1,805</th>
<th>1,880</th>
<th>1,955</th>
<th>2,030</th>
<th>19,402</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Unit Sales Price</td>
<td>Low Price</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>28.00</td>
<td>28.00</td>
<td>28.00</td>
<td>28.00</td>
<td>28.00</td>
<td>28.00</td>
<td>28.00</td>
<td>28.00</td>
<td>28.00</td>
<td>28.00</td>
<td>28.00</td>
<td>28.00</td>
<td></td>
</tr>
<tr>
<td>Liquid Extract Product Sales $</td>
<td>34.36</td>
<td>36.51</td>
<td>38.65</td>
<td>40.80</td>
<td>42.95</td>
<td>45.10</td>
<td>47.25</td>
<td>49.39</td>
<td>51.54</td>
<td>53.69</td>
<td>55.84</td>
<td>57.98</td>
<td></td>
</tr>
<tr>
<td>All Products Sales $</td>
<td>42.95</td>
<td>45.63</td>
<td>48.32</td>
<td>51.00</td>
<td>53.69</td>
<td>56.37</td>
<td>59.06</td>
<td>61.74</td>
<td>64.43</td>
<td>67.11</td>
<td>69.80</td>
<td>72.48</td>
<td></td>
</tr>
</tbody>
</table>

#### Revenue Buildup - Year 2 (High WTP Scenario)

<table>
<thead>
<tr>
<th>Powder Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Sales</td>
</tr>
<tr>
<td>High WTP</td>
</tr>
<tr>
<td>Product A Total Units</td>
</tr>
<tr>
<td>307</td>
</tr>
<tr>
<td>Average Unit Sales Price</td>
</tr>
<tr>
<td>High Price</td>
</tr>
<tr>
<td>43.00</td>
</tr>
<tr>
<td>Powder Product Sales $</td>
</tr>
</tbody>
</table>

| Liquid Extract Product |
| Unit Sales |
| High WTP |
| Powder Product Total Units |
| 1,227 | 1,304 | 1,381 | 1,457 | 1,534 | 1,611 | 1,687 | 1,764 | 1,841 | 1,918 | 1,994 | 2,071 | 19,790 |
| Average Unit Sales Price |
| High Price |
| 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |       |
| Liquid Extract Product Sales $ |
| 52.77 | 56.07 | 59.36 | 62.66 | 65.96 | 69.26 | 72.56 | 75.86 | 79.15 | 82.45 | 85.75 | 89.05 |       |
| All Products Sales $ |
| 65.96 | 70.08 | 74.21 | 78.33 | 82.45 | 86.58 | 90.70 | 94.82 | 98.94 | 103.0 | 107.1 | 111.3 | 1,063.6 |

#### Revenue Buildup - Year 3 (Low WTP Scenario)

<table>
<thead>
<tr>
<th>Powder Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Acquisition</td>
</tr>
<tr>
<td>54</td>
</tr>
<tr>
<td>Jan</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>
### Unit Sales

**Low WTP**

<table>
<thead>
<tr>
<th>Units</th>
<th>508</th>
<th>526</th>
<th>545</th>
<th>564</th>
<th>583</th>
<th>602</th>
<th>620</th>
<th>639</th>
<th>658</th>
<th>677</th>
<th>696</th>
<th>714</th>
<th>7,332</th>
</tr>
</thead>
</table>

**Powder Product Total Units**

<table>
<thead>
<tr>
<th>Units</th>
<th>518</th>
<th>537</th>
<th>556</th>
<th>575</th>
<th>594</th>
<th>614</th>
<th>633</th>
<th>652</th>
<th>671</th>
<th>690</th>
<th>710</th>
<th>729</th>
<th>7,479</th>
</tr>
</thead>
</table>

**Average Unit Sales Price**

**Low Price**

<table>
<thead>
<tr>
<th>Units</th>
<th>28.00</th>
<th>28.00</th>
<th>28.00</th>
<th>28.00</th>
<th>28.00</th>
<th>28.00</th>
<th>28.00</th>
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<th>28.00</th>
<th>28.00</th>
<th>28.00</th>
<th>28.00</th>
<th>28.00</th>
</tr>
</thead>
</table>

**Powder Product Sales $**

<table>
<thead>
<tr>
<th>Units</th>
<th>7</th>
<th>4</th>
<th>1</th>
<th>8</th>
<th>5</th>
<th>2</th>
<th>9</th>
<th>6</th>
<th>2</th>
<th>9</th>
<th>6</th>
<th>3</th>
<th>2</th>
</tr>
</thead>
</table>

### Liquid Extract Product

**Unit Sales**

**Low WTP**

<table>
<thead>
<tr>
<th>Units</th>
<th>2,030</th>
<th>2,106</th>
<th>2,181</th>
<th>2,256</th>
<th>2,331</th>
<th>2,406</th>
<th>2,482</th>
<th>2,557</th>
<th>2,632</th>
<th>2,707</th>
<th>2,782</th>
<th>2,858</th>
<th>29,328</th>
</tr>
</thead>
</table>

**Liquid Extract Product Total Units**

<table>
<thead>
<tr>
<th>Units</th>
<th>2,071</th>
<th>2,148</th>
<th>2,224</th>
<th>2,301</th>
<th>2,378</th>
<th>2,455</th>
<th>2,531</th>
<th>2,608</th>
<th>2,685</th>
<th>2,761</th>
<th>2,838</th>
<th>2,915</th>
<th>29,915</th>
</tr>
</thead>
</table>

**Average Unit Sales Price**

**Low Price**

<table>
<thead>
<tr>
<th>Units</th>
<th>28.00</th>
<th>28.00</th>
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<th>28.00</th>
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<th>28.00</th>
<th>28.00</th>
<th>28.00</th>
<th>28.00</th>
<th>28.00</th>
</tr>
</thead>
</table>

**Liquid Extract Product Sales $**

<table>
<thead>
<tr>
<th>Units</th>
<th>57,98</th>
<th>60,13</th>
<th>62,28</th>
<th>64,43</th>
<th>66,57</th>
<th>68,72</th>
<th>70,87</th>
<th>73,02</th>
<th>75,17</th>
<th>77,31</th>
<th>79,46</th>
<th>81,61</th>
<th>837,60</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Units</th>
<th>8</th>
<th>6</th>
<th>4</th>
<th>1</th>
<th>9</th>
<th>7</th>
<th>4</th>
<th>2</th>
<th>0</th>
<th>8</th>
<th>5</th>
<th>3</th>
<th>8</th>
</tr>
</thead>
</table>

**All Products Sales $**

<table>
<thead>
<tr>
<th>Units</th>
<th>72,48</th>
<th>75,17</th>
<th>77,85</th>
<th>80,53</th>
<th>83,22</th>
<th>85,90</th>
<th>88,59</th>
<th>91,27</th>
<th>93,96</th>
<th>96,64</th>
<th>99,33</th>
<th>102,0</th>
<th>1,047,0</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Units</th>
<th>5</th>
<th>0</th>
<th>5</th>
<th>9</th>
<th>4</th>
<th>8</th>
<th>3</th>
<th>8</th>
<th>2</th>
<th>7</th>
<th>2</th>
<th>16</th>
<th>10</th>
</tr>
</thead>
</table>

### Revenue Buildup - Year 3 (High WTP Scenario)

**Powder Product**

**Unit Sales**

**High WTP**

<table>
<thead>
<tr>
<th>Units</th>
<th>508</th>
<th>526</th>
<th>545</th>
<th>564</th>
<th>583</th>
<th>602</th>
<th>620</th>
<th>639</th>
<th>658</th>
<th>677</th>
<th>696</th>
<th>714</th>
<th>7,332</th>
</tr>
</thead>
</table>

**Product A Total Units**

<table>
<thead>
<tr>
<th>Units</th>
<th>518</th>
<th>537</th>
<th>556</th>
<th>575</th>
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<th>7,479</th>
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</table>

**Average Unit Sales Price**

**High Price**

<table>
<thead>
<tr>
<th>Units</th>
<th>43.00</th>
<th>43.00</th>
<th>43.00</th>
<th>43.00</th>
<th>43.00</th>
<th>43.00</th>
<th>43.00</th>
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<th>43.00</th>
<th>43.00</th>
<th>43.00</th>
<th>43.00</th>
<th>43.00</th>
</tr>
</thead>
</table>

**Powder Product Sales $**

<table>
<thead>
<tr>
<th>Units</th>
<th>22.26</th>
<th>23.08</th>
<th>23.91</th>
<th>24.73</th>
<th>25.56</th>
<th>26.38</th>
<th>27.21</th>
<th>28.03</th>
<th>28.86</th>
<th>29.68</th>
<th>30.50</th>
<th>31.33</th>
<th>321,58</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Units</th>
<th>3</th>
<th>8</th>
<th>2</th>
<th>7</th>
<th>2</th>
<th>6</th>
<th>1</th>
<th>5</th>
<th>0</th>
<th>4</th>
<th>9</th>
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<table>
<thead>
<tr>
<th>High Price</th>
<th>43</th>
<th>43</th>
<th>43</th>
<th>43</th>
<th>43</th>
<th>43</th>
<th>43</th>
<th>43</th>
<th>43</th>
<th>43</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid Extract Product Sales $</td>
<td>89,05</td>
<td>92.35</td>
<td>95.65</td>
<td>98.94</td>
<td>102.2</td>
<td>105.5</td>
<td>108.8</td>
<td>112.1</td>
<td>115.4</td>
<td>118.7</td>
</tr>
<tr>
<td>All Products Sales $</td>
<td>111,3</td>
<td>115,4</td>
<td>119,5</td>
<td>123,6</td>
<td>127,8</td>
<td>131,9</td>
<td>136,0</td>
<td>140,1</td>
<td>144,2</td>
<td>148,4</td>
</tr>
<tr>
<td>$</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>8</td>
<td>46</td>
<td>45</td>
<td>43</td>
<td>41</td>
<td>40</td>
<td>38</td>
</tr>
</tbody>
</table>