Cascara Jelly Production Potential for Smallholder Farms in Huehuetenango, Guatemala

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Executive Summary

The goals of this project were to reduce agricultural waste and create additional revenue by developing a jelly condiment from cascara, the post-harvest coffee byproduct. This project included jelly recipe trials, a literature review of the socioeconomic and environmental impacts of cascara and estimates of its mass flow (the movement of material matter) and nutritional content, jelly sensory surveys, and a feasibility survey for Guatemalan farmers. A bilingual methodology was created for coffee producers.

Sensory survey results suggested cascara can be diverted from the waste stream and upcycled into marketable jelly with high liking scores. Based on estimated calculations from the literature, cascara jelly could be a good source of caffeine, chlorogenic acid, fiber, vitamins and antioxidants. As ruminant feed, spent cascara from the jelly-making produces a significant amount of methane in cow rumen; an indicator of low-digestibility. More research is needed to determine if spent cascara is more digestible than fresh cascara, which is commonly used in ruminant feed experiments.

The farmer survey revealed economic barriers to jelly production. Farmers now lack time, equipment and ingredients to produce cascara jelly in their homes, but are open to producing jelly if these barriers are removed. This suggests a coffee cooperative, with shared resources, could make jelly production possible. Participants indicated having product samples, and local market testing to determine if producing cascara jelly was economically feasible was necessary before investing in jelly production.

The potential environmental benefits of cascara jelly are high; it may divert nitrogen, biological and chemical oxygen demand, environmentally-toxic chemicals, and carbon dioxide from the wastestream. However, more research is needed to test these calculated estimates.

Introduction

The Socioeconomic and Environmental Weight of Cascara

Coffee production is susceptible to market volatility and is labor-intensive. Coffee farmers often struggle financially; an example is the dramatic drop in national coffee prices in the 2000s. Most farmers earn a few dollars per day (Equal Exchange, 2019). *Cascara*, the bittersweet fruit surrounding the coffee bean, could potentially supplement farm income. Cascara offers a wide range of potential food products, from those already gaining a market to those not yet produced. Among the novel products is a jelly made from fresh cascara, which did not have a published methodology before this study. A market for "upcycled" cascara products also presents a strategy to tackle food waste, considering the immense volume generated by the coffee value chain.

The greatest source of on-farm coffee waste results from de-pulping the coffee cherries from the beans. The resulting cascara pulp has a high moisture and sugar content and spoils quickly. Cascara constitutes ~50% of coffee cherry fresh weight, and ~ 29% of dry weight (Coffee Cherry Co., 2019; Blinová, 2017; Bressani & Braham, 1979; Rotta et al., 2021). Each 100 lbs of harvested coffee fruit yields 47.1 lbs of fresh cascara, but only 13.1 lbs of roasted coffee (Rotta et al., 2021). So for each conventional 1 lb bag of coffee sold, 3.6 lbs of cascara is left to rot or compost, earning the farmer no additional revenue. Most cascara is discarded and becomes a major soil and water pollutant as it ferments and degrades quickly, is very acidic and has a high biochemical oxygen demand in water (Otalora & Felipe, 2018). The high caffeine and tannin content in cascara are anti-nutritional factors for plants and animals as well (Galanakis, 2017). While some cascara is used as compost, its high nitrogen content and the anti-nutritional factors make composting it labor and land-intensive (Sanchez et al., 1999). Annually, the global

coffee industry generates 23 million tons of cascara waste. The depulping and washing of 1 kg of coffee generates an amount of water and contaminant material equivalent to that produced by six people in one day (Jaramillo Lopez & Ramirez Velez, 2017). Cascara waste issues are escalating as the coffee industry expands; global coffee production increased 7.9% from 2017-2018 to over 170 million 60 kg bags (coffee's standard unit of measurement) (International Coffee Organization, 2019). Using cascara for food products offers socioeconomic and environmental benefits to the entire coffee value chain, but the little research that has been done on cascara processing is not accessible to farmers and processors in coffee-producing regions. More open-source research is needed to develop methodologies that are adaptable and feasible for farmers.

Current Coffee Upcycling Initiatives

Initiatives aimed at reducing coffee waste have been largely successful but focus primarily on upcycling coffee grounds in coffee-consuming countries. Spent grounds have been used to create fabrics and biofuel, grow mushrooms and to replace palm oil. However, agricultural waste upcycling lacks momentum in coffee-producing countries largely due to lack of resources. Consequently, coffee-producing regions are strongly impacted by their unused waste stream. For example, the Jimma zone in Ethiopia produces a lot of coffee with wet processing, and the water used to remove the pulp becomes contaminated with organic matter and nutrients leached from the coffee fruit. A 2012 study monitored the oxygen, organic load, total dissolved solids, pH, phosphorus, nitrate, ammonia and macroinvertebrate communities in river water both upstream and downstream from coffee processing plants. Results showed significant reductions in downstream water quality during the coffee season; a large increase in organic loads, nutrients, and solids resulted in dissolved oxygen levels as low as 0.1 mg/L water.

During the processing peak, the average pH of river waters dropped from 7 to 6.2. These changes decreased the diversity of macroinvertebrates (Beyene et al., 2012). However, cascara is not inherently a waste product.

Earlier researchers demonstrated cascara has potential value. Cascara's chemical and biological properties for human utilization was reported in the 1970s (Bressani & Braham, 1979). Cascara is a "superfood" due to a high nutrient profile and the synergistic biological effects of the phytochemicals caffeine and polyphenols. Cascara also contains components that can be used as natural colorants, aromas, texturizers, etc. (Galanakis, 2017). In the 2010s, novel cascara food products became commercially available in the U.S. So far, coffee flour (dried and milled cascara) and cascara beverages have the biggest retail presence (Easlon, 2019). Feed the Future describes coffee flour as having "a unique flavor profile that ranges from dark roasted fruit notes (think plums and currants) from varietals grown in Central and South America to savory elements that are reminiscent of green tea and layers of that hard-to-define umami aspect from cherries grown in Vietnam" (Feed the Future, 2015). One coffee farmer in El Salvador reported that selling cascara earned her a 480% premium over coffee beans: $7 per pound of cascara versus the average of around $1.20/pound of coffee (Perez & Patton, 2018). Each truckload (40,000 lbs) of dried Coffee Cherry that the Coffee Cherry Co. purchases directly from farmers eliminates 280,702 lbs of coffee pulp from polluting land and water, and 222,783 lbs of CO_2 from polluting the air; One purchase also provides $1,200 in new revenue to farmers and cascara-processing mills create new jobs, which are made more available to women (Coffee Cherry Co., 2019). A major barrier, however, is that consumer awareness and/or tastes have not fueled adequate demand for coffee flour (Shock, J., Inside Sales and Customer Service, Alvarado Street Bakery Co-Op, email communication, November 4, 2019).

A global cascara industry has immense potential, but currently an oligopoly exists among cascara processors; most successful product innovations and research are patented or closed-source within coffee-importing companies. For example, Olam Coffee, a branch of the major agri-business company based in Singapore, announced in 2020 that it now offers dry cascara, liquid cascara concentrates and soluble cascara powder for use in food ingredients and for nutraceutical and cosmetic use as an antioxidant supplement. However, the corporation press release states that "Olam Coffee will work with companies and brands directly to co-create bespoke cascara products," (Olam, 2020); knowledge-sharing is therefore limited to large corporations. The final result is an underdeveloped cascara industry in coffee-producing regions due to the lack of 1) market collaboration and 2) local expertise in cascara processing in coffee-producing regions, and 3) patented processing methods that are inaccessible and unadaptable for most farmers.

Currently, a multitude of patents detail methods of cascara processing for food products (Laux & Huhn, 2018; Miljkovic, et al, 2003; Moretti & Yamaguchi, 2014). Patents are awarded to the inventor in exchange for public disclosure of the methodologies, and give the owners the legal right to exclude others from using their methods for a limited period of years. Although a variety of cascara patents exist, none exist for jelly. Open-access methods of cascara processing, via online search and in academic journals, are also limited (Galanakis et al., 2015). Additionally, many academic publications are not available to read without a university affiliation, or in languages other than English.

Addressing the Literature Gap with an Open-Access Product Recipe

The purpose of this research is to provide an interdisciplinary and open-access methodologies for processing cascara jelly and similar products. Thereafter, this promising

environmental and socioeconomic advancement could be widely implemented, particularly by farmers in coffee-producing regions who lack the resources required for most patented methods. This research objective was to create a reliable recipe for cascara jelly that was highly-rated by consumer panels, which would then be the subject of a feasibility survey of on-farm and small-scale cascara jelly processing for coffee farmers in Huehuetenango, Guatemala. The goal of this research is to publish a simple cascara jelly cooking method that can be implemented on-farm or through local processors and produces a product for local or for export markets. With a global market for valorized cascara products, coffee farmer income could ideally increase to a greater degree than the increase in workload, thus improving their quality of life. Diversifying coffee farm outputs with a new agricultural product stream may lessen the farmers' socioeconomic risk associated with the global commodity market, as well as the risks to crop security posed by climate change.

Hypotheses & Objectives

Hypothesis: Cascara, a coffee post-harvest byproduct, can be diverted from the waste stream and upcycled into marketable, value-added jelly by coffee farmers and cooperatives in Huehuetenango, Guatemala.

Objectives: With the goal of reducing agricultural waste and creating additional revenue streams for farmers, this mixed-methods study aims to determine a methodology of producing cascara jelly that is accessible and feasible for coffee farmers in Huehuetenango by:

1. Creating a reliable cascara jelly recipe in a modern kitchen setting, with flexibility in ingredient

variations that meet food safety standards.

2. Conducting jelly and consumer liking sensory surveys to confirm palatability and predict market success.
3. Conducting a farmer survey via remote communication with a key informant in Guatemala in order to gauge interest, feasibility and cost/benefit of processing jelly locally.
4. Publishing the methodology in two forms: for academia and for coffee-producing regions. The academic paper will discuss the socioeconomic and environmental impacts of the upcycled product, with a focus on the results of the on-farm feasibility survey and consumer panels. It will include a literature review of the cascara waste stream and estimates of mass flow and nutritional content, as well as recommendations for future extension and training plans, if deemed appropriate through the farmer survey. The farmer-focused publication will be a mixed-media bilingual recipe and information guide for producing cascara jelly.

Methods

Literature Review

Before conducting any research, the literature on jelly-making and food safety was reviewed thoroughly. A literature review was also conducted on the cascara post-harvest waste stream, environmental impact, economic potential and nutritional information, and existing cascara upcycling initiatives.

Review of Jelly-Making Basics

Jelly is composed of three essential ingredients: sugar, pectin, and acid. Pectins are chains of sugar molecules that are found in plant cell walls, particularly in fruit peel. Pectin plays a vital role in setting jelly, as boiling the juice releases pectins from the fruit. With the correct acidity and sugar content, the pectin chains can bind and form a gel at the “setting point” of jelly,

approximately 104˚C. Once cooled and set, the gel network traps the water content in the jelly, which is important for reducing microbial activity. The pectin content of fruits varies, and usually a higher-pectin fruit or a concentrated form of pectin must be used in addition to the primary fruit of the jelly. Sugar is vital for taste, gelling and food-safety. Conventional jelly recipes recommend a 1:1 ratio of fruit to sugar, or 4:3 at the least (Bureau of Home Economics, 1942). Sugar not only sweetens the jam, but it improves both the gelling of the pectin and the preservativation of the final product. By binding to water molecules, sugar reduces the amount of available water in the jelly to the point that is too low for microbial growth. The final sugar content of jam should be between 65-69%. Acids, such as citric acid in lemon juice, help jelly set by lowering its pH. Without the addition of acid, the ionized, negatively-charged carboxyl groups in pectin cause repulsion that prevents the pectin chains from forming a gel network. Jelly needs additional acid to bring the pH to 2.8-3.3, the point at which the carboxyl groups are no longer ionized (Compound Interest, 2014).

Product Development & Testing

Fresh cascara was collected from Frinj Coffee in Santa Barbara, CA and transported in coolers to freeze at the U.C. Davis Coffee Center. The cascara was composed of a mix of coffee varieties from Frinj's farm (35% Caturra Rojo, 35% Geisha, 15% Cincateco, 15% Pacamara) and Toro farm (85% Geisha, 5% Caturra Rojo, 10% Pacas). Experimental trials were conducted to identify initial jelly recipes (Table 1; Appendix 1). In each trial, cook temperature and time, quantities of sugar, cascara, lemon and pectin were varied until satisfactory. Both Calamansi and Meyer lemon, as well as white, brown and demerara sugar, were used in different trials to test consistency of the recipes to account for variability of locally-accessible fruits and sugars. The

minimum quantity of sugar was used in the final recipes to keep hypothetical costs low for farmers, but at levels adequate to maintain a food-safe low water content. Also to keep hypothetical cost low, the amount of pectin was varied to determine the lowest palatable quantity that allowed for gelling, and required equipment was kept simple.

Note: The cascara from Frinj Coffee used in this study was loosely depulped, meaning that a significant amount of green beans were left in the cascara. Despite another depulping attempt with a food mill, the beans were too difficult to remove and therefore rendered jam production unfeasible. Only jelly was made since it involves boiling the fruit to extract the juice, then straining out the spent fruit solids.

Figure 1: Process Flow diagram of cascara jelly production.

Table 1: Final jelly ingredient proportions for varying Pectin:Juice ratios				
1:2				
Cascara (by volume)	Water (by volume)	Pectin (by volumetric ratio)	Lemon (by volume)	Sugar (by weight)
6 cups	2 cups	½ cup	9 tbsp	303.75 g
1:4				
6 cups	2 cups	¼ cup	13 tbsp	300g
1:8				
6 cups	2 cups	⅛ cup	11 tbsp*	258.8 g

*pH and volume of the jelly mixture at each stage in the recipe depends on the concentration of the juice and pectin used, which is determined by chemical contents of the cascara and lemon and by cook time. This leads to variable ingredient proportions.

Sensory & Farmer Surveys

All survey materials were approved by the U.C. Davis IRB Administration (IRB ID 1768032-1; Appendix 10)

Preliminary Sensory Survey

The purpose of the preliminary sensory survey was to test the best initial recipes with students and faculty working at the UC Davis Coffee Center to identify flavor notes and areas of improvement. Participation was voluntary and unpaid. Participants were unsupervised, and asked to taste the jelly left in the breakroom refrigerator at their leisure. They were asked to fill out a paper survey (Appendix 3) that captured qualitative data that identified flavor notes and drivers of liking. The recipe was altered based on the results of this survey; specifically sugar content was reduced and lemon pectin was swapped for commercial powdered pectin.

Sensory Survey - U.C. Davis Coffee Center

Once the recipe was improved based on preliminary survey results, three batches of jelly were made with varying proportions of lemon pectin. Determining the desirable range of pectin was important because making or purchasing pectin is the limiting factor in this cascara jelly recipe; farmers must purchase or grow lemons and isopropyl alcohol, and wait for the pectin to set. The survey aimed to determine a) if the amount of pectin was a driver of liking b) if cascara syrup (no pectin) was a desirable product.

Each of the three jars were labeled with randomized identifier numbers, and were available at a booth in the UC Davis Coffee Center for attendees of the Site Dedication - many of whom were professionals in the coffee industry. Participation was voluntary and unpaid. Participants were instructed to read the consent form (Appendix 5) and ask any questions before starting the survey. The study investigators served each participant jelly on a spoon or cracker, and the participants filled out the survey via a QR code on their phone or on paper (Appendix 4). The survey was administered in a mobile format through a UC Davis account on RedJade sensory software.Participants had the option of having saltine crackers and water in between samples. Participants were encouraged to read the jelly process flow poster (Figure 1), but not to discuss their reactions with other participants at the booth.

Sensory Survey - Trader Joes, Davis, CA

Permission was granted by the Regional Manager of Trader Joe's in Davis to do tastings and surveys with the crew members privately to limit the company's liability. In a similar method as the sensory survey in the UC Davis Coffee Center Site Dedication, the crew members at Trader Joe's have experience doing food and drink tastings as part of the company's culture of

gaining product knowledge and being able to share honest feedback about each product to its customers; Crew members are free to participate in monthly to quarterly food and drink tastings that include a wide range of products from wine to vegan entrees, which also include jams and jellies.

Participants were surveyed alone due to the restriction that participants could only do the survey on their breaks which were scheduled individually. Participants were instructed to read the consent form and ask any questions before starting the consumer survey. Cascara jelly samples were tasted on spoons with the option of having saltine crackers and water between samples. The survey was administered in a mobile format through a UC Davis account on RedJade sensory software.

For the privacy and safety of the participants, no personally identifying information was asked during the survey. Survey responses on RedJade are anonymous. Participants were not required to answer any of the questions if they chose not to answer, and it was emphasized that participation in research is completely voluntary.

Key Informant Communication & Farmer Surveys

The key informant conversations and farmer surveys focused on the technical and economic feasibility, environmental impacts, food safety measures, and farmer willingness. The survey aimed to identify barriers to entry (such as access to capital, equipment, and clean water), production challenges, risk management, identifying a market, and identifying a product price.

Communication with the key informant was done primarily through online messaging and phone, considering limited access to stable internet and international calling rates. The key informant was first sent instructions and an Informed Consent to sign (Appendix 7 a & b).

Thereafter, the informant was sent the final Spanish-language jelly recipe (Appendix 2) so that he could confirm that farmers could purchase or otherwise access all the ingredients and equipment, and then estimate the itemized cost. The informant was also sent a spreadsheet to input the jelly production costs and log his hours at the minimum wage in Davis, CA of $14/hour or 108.28 GTQ (Appendix 8c).

The key informant was asked to distribute the Consent Form (Appendix 7c) and Farmer Feasibility Survey (Appendix 7d) to as many friends and family as possible. Each respondent was paid $10 (77.34 GTQ) by the key informant. He was asked to provide assistance in filling out the survey to respondents who could not read and/or write. He was paid by check after the surveys were completed. Due to the informal and unsupervised distribution of the surveys (the key informant had no formal training), the results were analyzed on a more qualitative basis similar to a focus group, rather than a quantitative survey.

Cascara as Ruminant Feed

Cascara is a nutrient-dense feed ingredient for ruminant animals in terms of caloric value and fiber, but some of its constituents (potassium, caffeine, tannins and other polyphenols) cause issues in digestibility, nutrient bioavailability and voluntary feed intake. Cascara feed could be improved if the anti-nutritional factors are eliminated or degraded to a minimal level. Spent cascara from jelly production may have decreased anti-nutritional activity if the boiling process extracts soluble compounds such as caffeine. One potential indicator of decreased anti-nutritional factors, and thus increased digestibility, is methane production in ruminant stomachs. To test this, spent cascara from a jelly recipe trial was sent to the U.C. Davis Animal Science lab for an in-vitro test of methane emission in rumen as an indicator for cascara digestibility. See Appendix 9 for Anderson & Hess 2021 methods. A literature review was also conducted.

Information Dissemination to Farmers

Bilingual recipe guides in both print and video format, were shared with the key informant and all survey participants to use and share as they please. The visual guide and video were posted on UC Davis' Coffee Center and International Agricultural Development websites for public viewing. The recipe guide can be found in Appendix 2.

Results

Sensory Survey

The purpose of the sensory survey was to determine liking scores and flavor notes. Preliminary recipe trials produced cascara jelly with ingredients (cascara, sugar, lemons and water) available to Guatemalan farmers. Multiple kitchen trials indicated the appropriate proportions of ingredients that resulted in a palatable and food-safe jelly that adheres to industry identity standards (Overdiep & Shaw, 2020). A preliminary sensory survey of students and faculty in the UC Davis Coffee Center demonstrated high liking scores of the jelly, which suggests promise for the domestic market. On a scale from "extremely dislike" to "extremely like," none of the 7 respondents rated the jelly negatively: 4 "moderately liked," 1 "liked very much," and 2 "extremely liked" (Appendix 3).

The second, larger-scale sensory survey showed promising results for the chosen trial recipes and a final "best" recipe was determined. The graphs below show that the overall liking scores were high for all three samples, but the recipe that included pectin at a volumetric ratio of 1:2 with cascara juice received the highest review (Figures 2 a & b). Open response questions produced mostly answers such as: "It's wonderfully complex, beautifully balanced, something I would enjoy regularly" and "The flavor profile is delicious and unique" and "It checked all the

boxes for me. I'd purchase this for home." Although the majority of the comments were positive, the most common negative comment was that the jelly was slightly too sweet. Other negative feedback points to the importance of making the jelly promptly after harvest, to avoid fermentation of the cascara: three participants pointed out a "medicinal taste and slightly over-fermented" and "strange aftertaste, slightly bitter at end." Complete results can be found in Appendix 6.

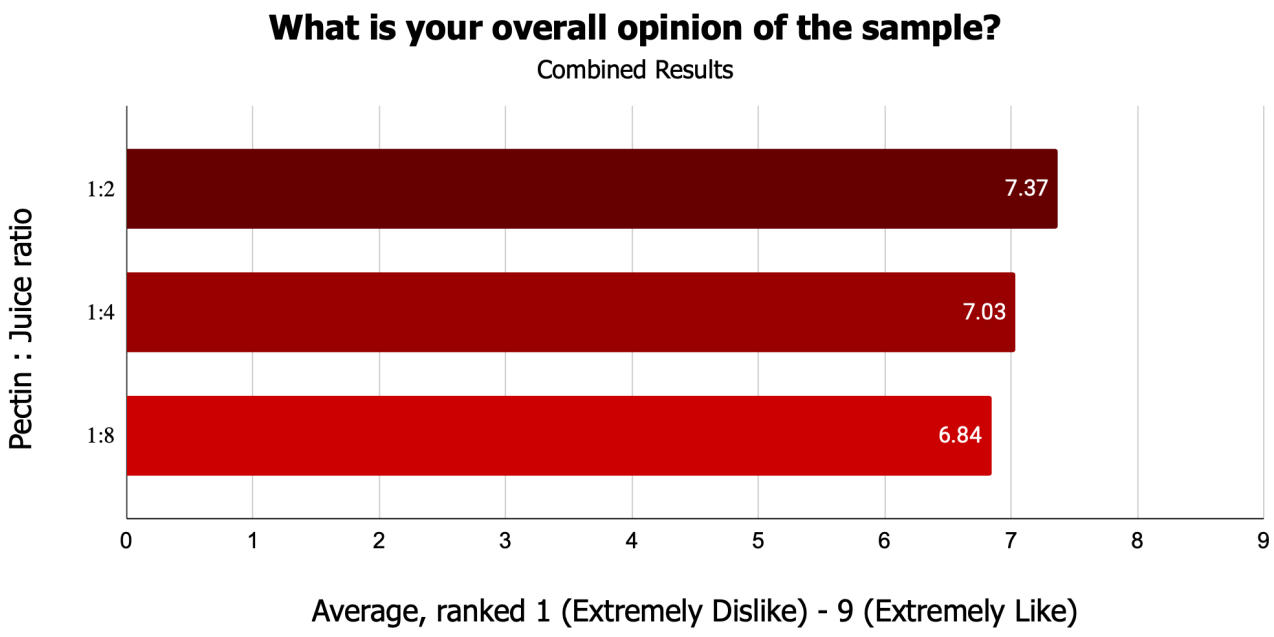

Figure 2a: Mean responses to "What is your OVERALL OPINION of the sample?" for three cascara jelly samples of varying pectin. Pectin : cascara juice ratios 1:2 = high pectin (n=63), 1:4 = medium pectin (n=29), 1:8 = low pectin (n= 63).

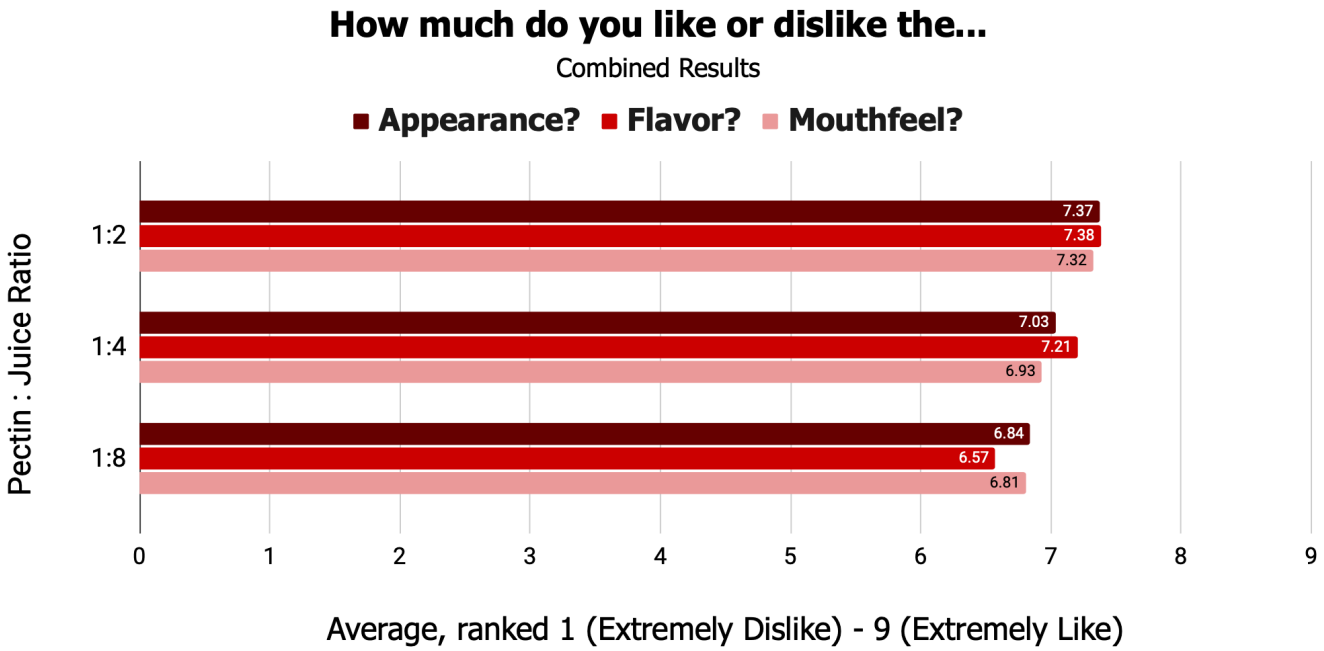

Figure 2b: Mean responses to liking scores for appearance, flavor and mouthfeel for three cascara jelly samples of varying pectin. Pectin : cascara juice ratios 1:2 = high pectin (n=63), 1:4 = medium pectin (n=29), 1:8 = low pectin (n= 63).

As seen in the sensory word cloud and graphs below (Figures 3 a & b), the most prominent flavor notes are fruity (mostly fig and plum) and sweet (mostly honey, caramel/brown sugar, molasses), while some earthy and floral notes were detected by tasters. The mouthfeel was predominantly smooth and gelatinous, while participants' holistic/hedonistic evaluations were largely desirable (balanced/blended, aromatic, complex). Very few participants detected defects or other undesirable flavors.

Figure 3a: Word cloud of flavor attributes for combined results of three cascara jelly samples of varying pectin; High pectin (n=63), medium pectin (n=29), low pectin (n= 63).

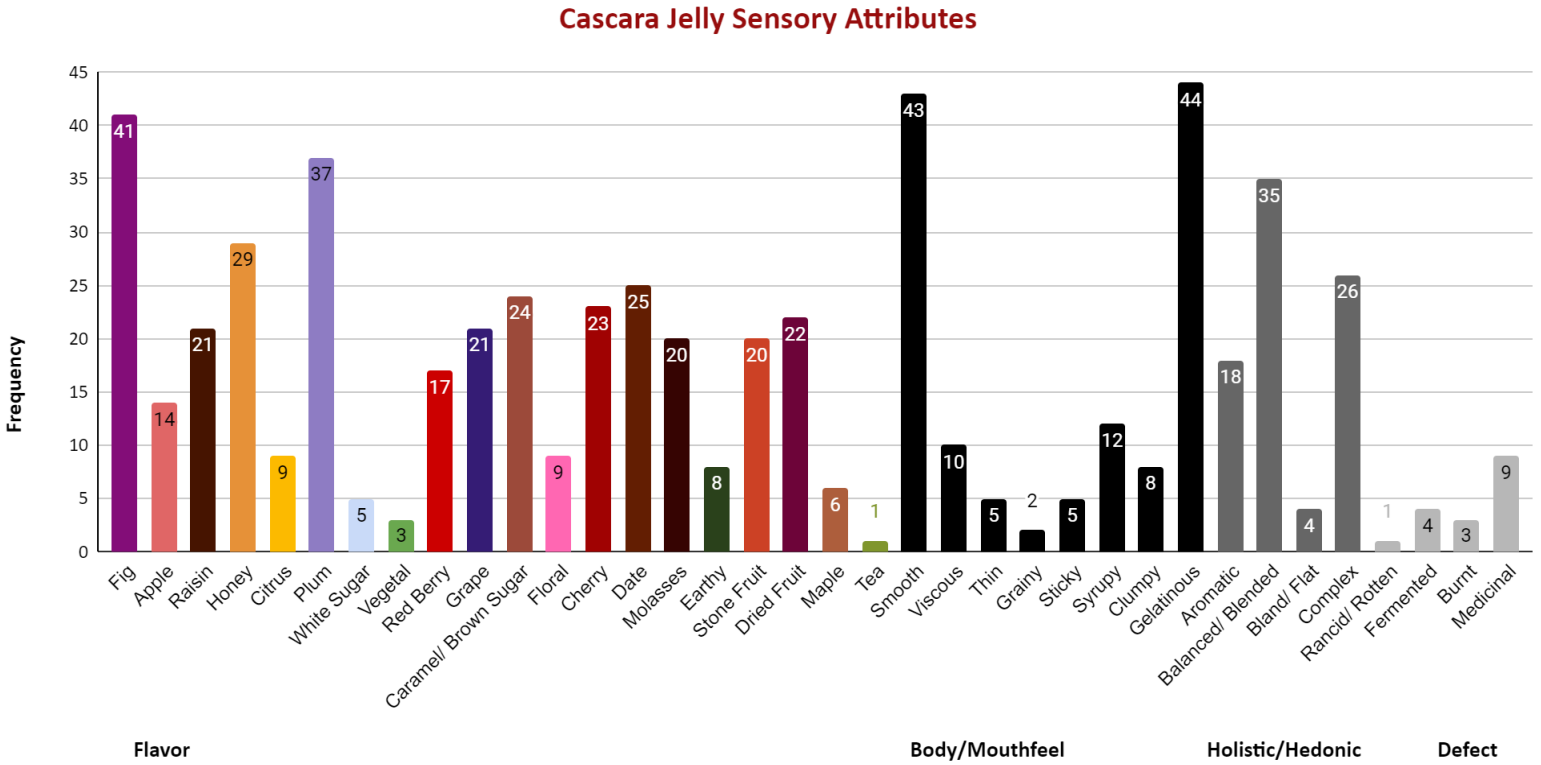

Figure 3b: Response frequencies of attributes for combined results of three cascara jelly samples of varying pectin; high pectin (n=63), medium pectin (n=29), low pectin (n= 63).

On-farm Feasibility Survey

The key informant distributed surveys to 20 participants from three larger coffee-grower associations and cooperatives: thirteen were members of *Asociación Barillense de Agricultores* (Asobagri), a relatively large cooperative centered in Barillas, Huehuetenango; four were members of *Asociación Nacional de Café* (Anacafé), a private association that represents coffee farmers with an office in Huehuetenango; and three were members of *Federación de Cooperativas Agrícolas de Productores de Café de Guatemala* (Fedecocagua), a secondary cooperative based in Guatemala City. Five participants were coffee roasters, while the rest were *cafeteros* -- farmers whose main crop is coffee. All participants worked for a small farm or small business (roasters), i.e. less than five workers to up to 10 workers, on farms between 1 - 5 hectares. Six were farm/business owners and the rest were employees. All identified as male, ages 18 - 34. Most participants completed secondary education, but two completed only primary school (Table 2).

Table 2: Participant Demographics

Membership	Job Title	Job Position	Farm/Business Size	Highest Education	Gender	Age
Asobagri	**Coffee Farmer**	**Owner**	**1 - 5 hectares**	**Primary**	**Male**	**18 - 24**
13	15	6	20	2	20	7
Anacafe						
4	**Coffee Roaster**	**Employee**	**<5 - 10 employees**	**Secondary**		**25 - 34**
Fedecocagua	5	14	20	14		13
3						

All participants indicated that they would consider making the jelly recipe, either for their families (11 participants) or to sell locally (9), either in their homes (16) or at their cooperative (4), where they all have access to clean water, space and equipment. However, the participants noted some obstacles they would have to overcome to do so (Table 3).

Table 3: Jelly Production Logistics			
Recipe comprehension	**Free time to make jelly on a typical workday**	**Access to clean water**	**Byproduct generation & use**
Most of the steps aren't clear or are difficult to understand	**1 - 3 hours**	**At the coop**	**Spent cascara & citrus remains**
7	20	3	20
Some steps aren't clear or are difficult to understand		**At the workplace**	
8		1	**Use for compost and/or fertilizer**
Everything is easy to follow & understand		**At home**	20
5		16	

First, a majority of the respondents said that either some or all of the recipe was unclear or difficult to understand. This confusion stemmed primarily from lack of easy access to specific ingredients and equipment for the recipe. Second, all respondents had very little free time to make the jelly on a typical workday; participants only had 1-3 hours of free time, approximately how long it takes to prepare, make and clean up after a batch of jelly (about 3 jars). This means that, if participants planned on making the jelly to sell or on a larger scale, they may need to reduce coffee picking or roasting.

The most salient finding from the survey was the agreement that it would be difficult to access all the equipment and ingredients; obtaining the necessary food scale, non-reactive pot, a refrigerator and a sufficient amount of citrus fruits, as well as a candy thermometer and steamer basket/canning rack (which are not necessary), is difficult. Having funds to purchase the equipment upfront was a concern as well as local availability. To make the recipe feasible, most participants would need to adapt locally available equipment and ingredients. Also, most participants indicated an initial sample product was required for local market tastings to determine if a local market could be developed and adapted.

Human & Ruminant Nutritional Benefits - Literature Review & Calculated Estimates

The main nutritional benefits of cascara for humans are the antioxidant activity (total polyphenols), vitamins, fiber, calories and of course, caffeine. Figures 4 and 5 show the high nutritional profile of dried cascara. Cascara is high in fiber, low in fat and a good source of potassium, calcium, magnesium and vitamin C (Iriondo-DeHond et al., 2020). These benefits are especially important for communities that have low access to fresh fruits and vegetables containing essential vitamins, minerals and antioxidants, a common situation in remote farming communities. Additionally, antioxidants and caffeine are currently a major selling point in Western markets.

NUTRITIONAL INFORMATION PER 100G OF INGREDIENT *(TYPICAL AVERAGED VALUES, DOES NOT EQUAL 100%)*

Calories	**144.9 kcal**	**Vitamins & Minerals**		**Moisture**	12% Max
Total Fat	**2.3 g**	Vitamin A	505.3 I.U.	**Caffeine**	530 mg
Saturated Fats	0.5 g	Vitamin C	< 0.1 mg	**Antioxidants**	22 µmol
Unsaturated Fats	0 g	Calcium	425 mg		
Cholesterol	< 5 mg	Sodium	15.7 mg		
Protein	**11.4 g**	Magnesium	333 mg		
Total Carbohydrates	**66.3 g**	Phosphorus	391 mg		
Sugars	2.9 g	Potassium	11,808 mg		
Added Sugars	None	Copper	4.1 mg		
Total Dietary Fiber	51 g	Sulfur	527 mg		
Soluble Fiber	8.4 g	Zinc	4.5 mg		
Insoluble Dietary Fiber	42.5 g	Iron	49.6 mg		
		Manganese	8.5 mg		

Figure 4: Nutrition information of dried cascara (Coffee Cherry Co. 2021)

Contents	Proportion (%)
Ether extract	0.48
Crude fibre	21.40
Crude protein	10.10
Ash	1.50
Nitrogen-free extract	31.30
Tannins	7.80
Pectin substances	6.50
Nonreducing sugars	2.00
Reducing sugars	12.40
Chlorogenic acid	2.60
Caffeine	2.30
Total caffeic acid	1.60

Figure 5: Composition of dried coffee pulp (Rattan et al, 2015).

Averaging data from 12 coffee cultivars, one study found that the composition of phenolic compounds in fresh cascara consists primarily of chlorogenic acid (42.2%) as well as epicatechin, (21.6%), isochlorogenic acid II (19.3%), isochlorogenic acid I, isochlorogenic acid III, catechin, rutin, protocatechuic acid, and ferulic acid (Ramirez-Martinez, 1988). Fresh cascara is composed of 2.6 - 2.71% chlorogenic acid (Bressani & Braham, 1979). Research suggests that consumption of foods rich in chlorogenic acids may reduce the risk of developing many chronic diseases (Moretti & Yamaguchi, 2014). This is because chlorogenic acid is an important biologically active substance with antibacterial and antiviral properties; it can elevate white blood cells, combat tumors and free radicals, lower blood pressure and blood lipid, and serve many other biological benefits. Cascara offers a better avenue for chlorogenic acid consumption than brewed coffee because roasting the beans causes an 8-10% loss of the acid, while chlorogenic acid can be extracted in water from the cascara (Sichuan Shenghu Biotech., 2015).

Therefore, cascara jelly, in which the water used to extract the cascara sugars and flavor is retained in the jelly, may be a good source of chlorogenic acid.

Caffeine

Most caffeine content is reported on a dry weight basis; by dry weight, cascara is composed of 0.51 - 3% caffeine (Pandey et al., 2000; Bressani & Braham, 1979; Iriondo-DeHond et al., 2020). One study found the caffeine content was 2.3% of coffee pulp after wet processing (wet and dry processing may alter caffeine content) on a dry weight basis (Rattan et al,. 2015). Fresh cascara is 65% water (moisture content), and is 0.28% caffeine (Bressani & Braham, 1979) .

Caffeine & chlorogenic acid per jar - Calculations

- Each batch of cascara jelly uses approximately 500g of cascara.
- Fresh coffee pulp is 0.28% caffeine and 2.6 - 2.71 % chlorogenic acid (Bressani & Braham, 1979)
- It is assumed that all caffeine and chlorogenic acid is transferred into the juice since caffeine is highly soluble in boiling water (Caffeine solubility, content in coffee beans and extraction, 2016) and chlorogenic acid can be extracted in water as well.

500g cascara x 0.0028 = 1.4 g = 1400 mg caffeine/batch (~ 2, 8-oz jars), or 700 mg caffeine/jar

16 tbsp per 8-oz jar: 700 mg caffeine / 16 = **43.75 mg caffeine per 1 tbsp serving**

500g cascara x 0.0265 = 13.25 g = 13,250 mg chlorogenic acid/batch, or 6,630 mg/jar

6,630 mg chlorogenic acid / 16 = **414.38 mg chlorogenic acid per 1 tbsp serving**

These estimates bode well for the cascara jelly market, as caffeine levels vary around 50-200 mg per typical cup of coffee (Ludwig et al., 2014) and chlorogenic acid vary around 6-300 mg per typical cup (Ludwig et al., 2014; Trugo & Macrae, 1984).

Ruminant Nutrition

Nutritional benefits for ruminant animals focus on caloric value, fiber, anti-nutritional factors and voluntary intake. On a dry weight basis, cascara contains an average of 50% carbohydrate, 18% fiber, 10% protein and 2.5% fat. With this nutrition profile, cascara can be a useful feed supplement for animals. However, several studies have found that other cascara constituents—caffeine (1.25-3%), tannins (1.8 - 8.56%) and other polyphenols (1%), result in low feed intake, nitrogen retention and issues in protein digestibility, which overall interfere with nutrient bioavailability and utilization in animals. Potassium content is also an anti-nutritional factor due to its effect of ionic imbalance (Bressani & Braham, 1979). Voluntary intake is "the quantity of feed animals consume when given free access to it;" studies show that ruminants are reluctant to eat cascara-based feed, but voluntary intake increases when cascara is supplemented with other palatable feedstuffs. Studies indicate that cascara should only compose 20-30% of the total feed (Bressani & Braham, 1979). Thus, cascara could be a main feed ingredient if the anti-nutritional factors are eliminated, neutralized or degraded to a minimal level (Pandey et al., 2000). Spent cascara from jelly production could potentially show decreased anti-nutritional activity if the boiling process extracts soluble compounds such as caffeine. One potential indicator of decreased anti-nutritional factors, and thus increased digestibility, is methane production in ruminant stomachs.

Results from Anderson & Hess 2021 show that spent cascara does not reduce methane production in cows at any of the three inclusion rates (2%, 5%, 10%) that were tested in

quadruplicate for the spent cascara (Figure 6). These results, however, do not necessarily mean that antinutritional factors are not extracted through. More chemical analysis is needed. Materials & Methods can be found in Appendix 9.

Treatment	CH_4 (mL/g feed)	SE*	P	CO_2 (mL/g feed)	SE*	P	Total Gas (mL/g feed)	SE*	P
- Control	20.3	-	-	88.7	-	-	109	-	-
+ Control	0.7	0.82	0.03	98.1	6.04	0.25	98.8	5.43	0.17
Spent Cascara (2%)	20.5	4.66	0.96	87.8	6.20	0.90	108	6.41	0.92
Spent Cascara (5%)	26.4	1.55	0.02	83.3	5.24	0.45	109	4.12	0.88
Spent Cascara (10%)	21.8	3.38	0.68	78.4	6.88	0.23	100	7.13	0.29

Table 1. Methane, CO_2, and Total Gas Yield on a Per Gram of Feed Basis of Spent Cascara at Varying Dosage Levels (2%, 5%, 10%).
*Pooled SEs and P-values as between treatment indicated and negative control. SEs and P-values calculated in RStudio.

Figure 6: Average methane, CO_2, and total gas production for the negative & positive control, and spent cascara vessels. Negative control = artificial rumen system without cascara added (Anderson & Hess 2021).

Economic Considerations- Time Poverty

The economic considerations for cascara jelly production are vast, but this study focuses on production feasibility, namely the cost of time. The issue of time is an overlooked dimension of poverty, especially for rural farmers for which both accessing and producing goods can be much less time-efficient than their counterparts in technologically-advanced communities. Referred to as "time poverty," the lack of time can worsen farmer's asset and income poverty because participation in time- and labor-intensive activities reduces farmers' availability to 1) participate in more economically productive activities, 2) expand their capabilities through education and skills development, 3) participate in collective actions which are time-intensive,

but important for improved economic conditions (Lyon, Mutersbaugh, & Worthen, 2017). Given the results from the farmer feasibility survey (Table 3), time is a scarce ingredient of this recipe.

Due to the gendered division of labor, women have worse time poverty issues than men (Lyon, Mutersbaugh, & Worthen, 2017). Therefore, the next step in determining farmer feasibility should include female participants, especially the question about extra time in the workday. Further steps would be to calculate the sale price to account for time, equipment, ingredients and processing of cascara jelly to ensure that the product is truly value-added for the consumer and producer. Another important step before production would be a projection of value-added potential for both a small farm and cooperative for producing jelly versus their current core business. Additional consumer surveys could ask participants to indicate a price range in which they would buy the jelly, so that those price preferences could be compared to the cost of production for farmers or cooperatives.

Environmental Impacts

Environmental indicators of focus are: organic waste mass, biological and chemical oxygen demand, nitrogen and carbon dioxide. The most significant additional waste stream created by cascara jelly production is the use of citrus fruits. Three to four lemons are used per batch of pectin and jelly. Lemons are a limiting ingredient in the recipe due to barriers to access, and the lemon pectin is time-consuming to make and requires refrigeration. In the feasibility survey, all participants responded that the only byproducts would be citrus fruit remains and spent cascara, both of which they would use as fertilizer and/or compost (Table 3).

Biological oxygen demand (the amount of dissolved oxygen needed by aerobic microorganisms to break down organic waste in water) can be as high as 15,000 mg/liter for coffee pulp wastewater. Even worse, the chemical oxygen demand (the amount of dissolved

oxygen required to oxidize chemicals leached from waste in water) could be between 15,000 - 25,000 mg/l. High biological and chemical oxygen demand limits the oxygen available for aquatic life. The main component of coffee wastewater is organic matter from de-pulping and mucilage removal. The oxygen demand to break down the pulp is so great that water bodies with high amounts of coffee waste water can be depleted of oxygen and made highly acidic by the decomposition of the pulp's quickly fermenting sugars. Other constituents of wastewater from coffee processing include chemicals that are toxic to waterways: tannins, caffeine and polyphenols (Rattan et al., 2015). Removing hundreds of grams of cascara ber patch of jelly from water bodies would significantly reduce biological and chemical oxygen demand and environmentally-toxic chemicals. More research is needed to determine the impact of cascara removal on the basis of fresh weight of cascara instead of volume of wastewater. However, we can estimate the potential reduction of caffeine by weight (in the calculations above), as well as carbon dioxide and nitrogen by weight (calculations below).

Nitrogen

Excess nitrogen is problematic in waterways, as is a driver of eutrophication when in excess in the nitrogen cycle. So, removing the high-nitrogen cascara from the coffee processing waste stream may be important in improving local environmental health. Coffee pulp contains up to 1.94% nitrogen by dry weight, and fresh coffee pulp has a moisture content of 65 - 77% i.e. 23 - 35% is dry weight (Bressani & Braham, 1979; Sanchez et al 1999). Considering a typical jelly recipe uses 500 g of cascara per batch, it can be estimated:

- 500g fresh cascara x 0.29 = 145g dry weight
- 145g dried cascara x 0.0194 = **2.813 g N diverted per batch of jelly**

Air, soil and water pollution diverted per batch

Given that Coffee Cherry Co. calculated that diverting 280,702 lbs of coffee pulp from polluting land and waterways also diverts 222,783 lbs CO_2 of air pollution (Coffee Cherry Co., 2019), it can be estimated:

- 500g cascara/batch jelly= 1.1 lbs cascara= **1.1 lbs soil & water pollution diverted/batch**
- 222,783 lbs CO_2 diverted / 280,702 lbs cascara = 0.794 lbs CO_2 / 1 lb cascara
    - 0.794 x 1.1 lbs = **0.873 lb CO_2 diverted per batch**

Conclusions and Recommendations

Sensory survey results clearly demonstrate cascara jelly is a marketable product with high liking scores. Cascara jelly is a good source of caffeine, chlorogenic acid, fiber, vitamins and antioxidants for humans. For ruminant feed, spent cascara from jelly-making produces a significant amount of methane in cow rumen, an indicator of low-digestibility. More research is needed to determine if spent cascara can be used in higher proportions in ruminant feed than its fresh counterpart.

The farmer survey indicated that economic barriers exist for farmers in jelly production. Individual farmers generally lack access to time, equipment and ingredients to produce cascara jelly in their homes, but are open to producing jelly if these barriers are removed. Therefore, a coffee cooperative, where farmers can share resources, is a more feasible option for jelly production. Participants also indicated a product sample would be crucial in determining a local market for cascara jelly before allocating their time to its production.

The potential environmental benefits of cascara jelly are high; it may divert nitrogen, biological and chemical oxygen demand, environmentally-toxic chemicals, nitrogen and carbon

dioxide from the wastestream. However, more research is needed to test these calculated estimates.

Limitations and Confounding Factors

Because this study was not conducted in the country of focus, Guatemala, some limitations and confounding factors exist.

Frinj Coffee, the supplier of our cascara, is located in Santa Barbara, CA. Different coffee cultivars from different geographic regions have different nutritional profiles; particularly the caffeine and Brix content. Therefore the cascara from Huehuetenango coffee varieties could have different pH and Brix levels, and require adaptation of the jelly recipe developed using the cascara from California coffee cultivars.

As mentioned earlier, loose depulping of the cascara used in this study allowed only for jelly production. Future studies should attempt making jam recipes, as jam incorporates the entire fruit and therefore would utilize a significantly higher proportion of byproduct from the waste stream. Cascara jam would also take significantly less time to make as it does not require straining the juice from the spent pulp. Also, our cascara was frozen for storage, so jelly made with fresh cascara may have a different flavor profile, nutritional values, pectin content, and other properties that could change the final jelly quality.

One issue that may arise from cascara jelly production is the extra water required to rinse the cascara after depulping. If depulping is done on a clean surface, rinse water use may be minimal. A limitation of this study was our inability to visit a Guatemalan farm to measure the volume of water used. A confounding factor that arose from our inability to travel to Huehuetenango was that the key informant had no formal training in survey distribution. In the

farmer survey, full confidentiality was impossible since some participants have limited reading and writing skills, requiring the key informant to read and write for them. This limitation suggests more in-person data collection from a wider range of ages and from women, and a focus group for follow-up questions to ensure the participants fully comprehend the jelly recipe and the survey.

Future Recommendations

If farmers and/or cooperatives were interested in pursuing jelly production, specific steps should be taken. First, safety and quality control measures must be in place, such as a test for shelf stability and microbial analyses. An extension and education plan for farmers should be created with a focus on capacity training of local farmers to instruct their peers. A business plan for smallholder farmers is essential to ensure the financial sustainability of production. This could be part of a larger Monitoring & Evaluation plan that keeps track of time spent, gendered participation in the household, and cost of jelly production.

Ideally, once farmers are comfortable with jelly production, they could assume the lead in local innovation and research on product development. For example, under-ripe fruit has higher pectin levels (HGIC, 2020). Farmers could experiment in using discarded under-ripe coffee fruit as a source of pectin. This not only decreases the need for the less available lemons but decreases the temptation to leave unripe berries in the harvested fruit destined for coffee production, thus lowering final coffee quality and value. They could also experiment with making cascara juice without additional ingredients or cascara syrup by adding sugar and possibly lemon. Both products could potentially be marketed to product manufactures.

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Other coffee nutritional sources:

Bioactives of Coffee Cherry Pulp...

Phenols and caffeine in wet-processed coffee beans and coffee pulp

Biological treatments affect the chemical composition of coffee pulp

Effects of drying on ...phenolic compounds and antioxidant capacity of Robusta wet coffee pulp

Use Of Coffee Pulp For The Production Of Briquettes And Pellets For Heat Generation

Appendix

1. Cascara Jelly Recipe Development Trials

Trial 1—Preliminary Jelly & Jam Tests—3/14/21		
Step	**Details**	**Measurements/Yield**
Prep	Test ph meter & refractometer on DI water Measure pH of Davis tap water	pH: ~5.8 pH: 8.02 - 8.08
	Boil glass jars & appropriate utensils 10 mins in 10 L non-reactive pot	
	Juice lemons (Meyer)	
	Thaw __? cups frozen cascara 5-10 mins, then depulp further in a food mill	Unsuccessful; too many beans still left in pulp. Go forward making jelly only, not jam.
Boil	-Add enough water to prevent scorching, which should cover cascara ¾ of the way to the top of cherries in a single layer in a 10 L pot -Bring cascara to a boil, then low boil for 10 minutes to extract juice -mash fruit frequently and stir occasionally	

	-Remove pot from heat	
	-Strain juice and discard spent pulp (now leached of color and sweetness) -Measure pH	1.25 cups juice pH 4.5
Add lemon	-Return juice to cooled pot -Add lemon	1 tsp lemon juice
Add sugar	1 cup organic cane sugar for the jelly standard of identity: 55 (max) sugar: 45 (min) juice by weight -Add sugar to juice in the pot and bring to a boil. May need to reduce to low heat to prevent overflowing	
Boil	Bring to a boil (this may take a few minutes) then boil rapidly for 1-2 min only (critical for activating, but not breaking down pectin), stir constantly.	
Jar	Pour directly into sterilized jars with 1/4in headspace	1 jar
Measure Brix	Measured cooled, unset jelly Brix using refractometer	Unsuccessful; Brix too high to measure without dilution
Water bath	Boil jars 5 mins in water bath	
Set	Stir jelly in jars, flip jars after 1 hr of setting Let set 24-72 hours	Did not set after 72 hrs.

Trial 2—Jelly, No Pectin Addition—3/24/21 Adapted from (NCHFP, 2005)		
Follow steps from Trial 1 except where noted below		
Step	**Details**	**Measurements/Yield**
Prep	Thaw 6 cups cascara	
Boil	Boil cascara 10 mins	¾ cups juice Brix: 14 pH: 4.46
Lemon	-Testing each addition of lemon juice with pH meter, add enough lemon juice to bring pH to adequate acidity for pectin to set (<3.5)	4 tbsp (¼ cup) lemon juice 1 cup cascara + lemon juice Brix: 12 pH: 3.45

Sugar	Add sugar in 55 sugar: 45 fruit juice by weight ratio	149g juice / 182g sugar = 45:55 Used 149g cane sugar (~⅞ cup)
Set	Let set 24-72 hours	Did not set after 72 hrs. Needs pectin and/or pH 2.8 - 3.3 for pectin to set (Compound Interest, 2014).

Trial 3—No Pectin Addition—4/1/21		
Follow steps sequentially from Trials 1&2 except where noted below		
Step	**Details**	**Measurements/Yield**
Prep	Calibrate pH meter with buffers	
	Thaw 6 cups cascara + 2 cups water	Yields of juice ~⅞ cups
Boil	Boil in 2 cups water	
	Remove some juice after after straining to measure pH and Brix	Brix: 14 pH: 4.49
Lemon	Add enough lemon juice for a pH low enough for proper setting	Cascara juice + 10 tbsp lemon juice Brix: 11 pH: 3.06
Sugar	Add enough sugar for pectin to set (55%)	55 sugar / 45 juice by weight = 332.44g sugar / 272g juice
Brix	Since unset jelly is off the refractometer scale, dilute w/water at equal masses (~50% dilution), then double Brix	Dilution: 16g jelly + 21g water = 1.3 dilution with 24 Brix 16g jelly/ 37g jelly + water = 0.43 = 43% dilution 24/x = 0.43/1 yields <u>55.8 Brix</u>
Set	Yields 2 jars. Did not set. With this amount of lemon juice, lemon dominates over cascara flavor.	

Trial 4—Pectin + Calcium, Calamansi Limes—4/1/21
Follow steps sequentially from Trials 1-3 except where noted below

Step	Details	Measurements/Yield
Prep	Prepare Ca water as directed by Pomona's Pectin: ½ tsp Ca powder in ½ cup water	
Lemon	Add enough lemon juice to pH for proper setting	10 tbsp lemon + cascara juice yields ~1 cup juice w/pH: 3.03
	-Use 1:1 ratio of cups juice to pectin and Ca water (in tsp) - Add 1 tsp Ca water to pot w/ cascara/lemon juice	1 cup juice + 1 tsp pectin + 1 tsp Ca water
Boil	-Bring juice to a full boil, THEN add sugar + pectin	
Sugar	-Measure weight of juice to find 45:55 ratio of sugar: 332g juice/271.6g sugar -In a separate bowl, measure out 1 tsp pectin and mix thoroughly with sugar -Boil 1-2mins, reducing heat if necessary to avoid boiling over.	
Set	Too much lemon flavor, but Calamansi seem to work interchangeably w/Meyer lemon	

Trial 5—Pectin + Calcium, Calamansi, Demerara Sugar, Double Batch—4/8/21		
Follow steps sequentially from Trials 1-4 except where noted below		
Step	**Details**	**Measurements/Yield**
Boil	12 cups cascara + 4 cups water	Yields 2.75 cups juice
Lemon	Add 19 tbsp (1.2 cups) Calamansi juice	pH = 3.33 12 tbsp lemon = pH 3.44 Yields ~4 cups cascara/lemon juice
Calcium	Add 1:1 ratio Ca water to juice	4 tsp Ca water
Demerara Sugar	Measure weight of juice for 45 juice: 55 sugar ratio	762g juice: 931.3g sugar
Pectin	Add 4 tsp pectin to sugar & mix well! Otherwise it will clump in the juice & ruin the jelly!	

Boil	-Bring juice + Ca to a full boil, then add sugar + pectin, mix well! -Boil 1-2 minutes	
Brix	Measure Brix of final unset jelly w/50% dilution	27-28 diluted Brix measured = 55 final Brix
Water bath & Set	Water bath jars 5 mins	Yields ~7 jars set! But grainy since pectin did not adequately mix

Trial 6—Pectin + Ca, Demerara Sugar, Double Batch—4/12/21 For Coffee Center Sensory Survey		
Follow steps sequentially from Trials 1-5 except where noted below		
Step	**Details**	**Measurements/Yield**
	12 cups cascara + 4 cups water	Yields 2 cups juice pH = 4.77 Brix = 15
Lemon	Add lemon juice for adequate pH	~4 large lemons yields 1 cup + 2 tbsp juice pH 3.1 - 3.36 Yields 3 cups cascara/lemon juice = 661g juice
Pectin	Add 1:1 ratio pectin & Ca water	3 tsp each
Demerara Sugar	Add sugar 45 juice : 55 sugar	661g juice : 807.89g sugar
Yields 5.5 jars. Jelly set! See Survey results for evaluation.		

Trial 7—Lemon Peel Pectin + ¾ Demerara Sugar—4/28/21		
Follow steps sequentially from Trials 1-6 except where noted below		
Step	**Details**	**Measurements/Yield**
Lemon Seed Pectin	Seed pectin (Adamant, 2019): 75 seeds to 4 cups water, simmer 30 mins -Stir intermittently so seeds don't stick -Looks like water, didn't pass the alcohol test, so I reboiled until it showed some yellow color and	

	tested again: it clumped, but not a lot. Doesn't make much	
Lemon Peel Pectin	Peel pectin (Meredith, 2019): Remove zest, 1lb rind to ½ cup lemon juice, 4 cups water, (I let sit overnight, strained in a cloth strainer). -Use ¼ cup pectin per cup cascara juice (Stafford, 2019). -Test pectin of cascara juice, cascara + lemon juice via alcohol test (HGIC, 2020)	Passed the alcohol pectin test! Very yellow & thick.
	Boil cascara in water for longer (up to 20 mins, or until color is gone from fruits) -Boiled 10 mins (seems like water was getting lost) - 6 cups cascara + 2 cups water	Made 1 ⅛ cups (236g)
	Used ½ cup peel pectin per cup cascara	Used 7 tbsp lemon juice pH 3.33 Makes 373g juice Brix = 11
	¾ sugar : 1 juice ratio is acceptable for jellies (Bureau of Home Economics, 1942)	373g juice x ¾ = 280g sugar
Strain & Boil	-Fabric strainer (should be damp) -Boil jelly rapidly (not a simmer), slow boiling destroys the pectin in the fruit juice.	
Sheet / Spoon Test: (HGIC, 2020)	Dip a cool metal spoon into the boiling jelly mixture. Raise the spoon about 12 inches above the pan (out of steam). Turn the spoon so the liquid runs off the side. When the mixture first starts to boil, the drops will be light and syrupy. As the syrup continues to boil, the drops will become heavier and will drop off the spoon two at a time. The jelly is done when the syrup forms two drops that flow together and sheet or hang off the edge of the spoon. -Temp test: 220F boiling point jelly	
Yields 2 jars. The most gelled jelly yet! Tastes good and has a clearer, brighter color.		

Trial 8—Lemon Peel Pectin + ¾ Demerara Sugar, Double Batch—5/6/21 For Ruminant Feed Test

Follow steps sequentially from Trials 1-7 except where noted below		
Step	**Details**	**Measurements/Yield**
Boil	Boil cascara in water for longer (up to 20 mins, or until color is gone) Boil cascara 10-15 mins mins: 13 mins (light orange-red color 12 cups cascara + 4 cups water	Made 1.5 cups, 337g Brix=16
Lemon Peel Pectin	½ cup per cup cascara	3/4 cup pectin Makes 588g juice (2.75 cups) Brix = 11
Lemon		10 tbsp lemon juice = pH 3.3
Sugar		588g juice x ¾ = 441g sugar
Yields 3.25 jars		

Trial 9—Lemon Peel Pectin + ¾ Demerara/Organic Cane Sugar, Double Batch—5/13/21 Sent to Frinj Coffee		
Follow steps sequentially from Trials 1-8 except where noted below		
Step	**Details**	**Measurements/Yield**
Boil	-12 cups cascara + 4 cups water -Boil cascara 10-15mins mins: 15 mins -Keep lid on while cascara water is heating up to reduce water loss, then take off when it starts to boil -Mash with whisk throughout	Made 2 ⅛ cups, 489g
Lemon Peel Pectin	¼ cup per cup cascara juice pectin (min) = 1 cup pectin	
Lemon		13 tbsp lemon juice = 3.37 pH Makes 840g juice
Sugar		840g juice x ¾ = 630g sugar (½ organic cane/ ½ demerara)
Boil	Boil jelly rapidly (not a simmer). Took longer than usual to reach full overboil	

Yields 4 jars with great consistency & taste.

Trial 10—Min. Lemon & Lemon Pectin + ¾ Organic Cane Sugar, Half Batch—5/13/21		
Follow steps sequentially from Trials 1-9 except where noted below		
Step	**Details**	**Measurements/Yield**
Pectin Prep	3 medium lemons	Yields: ¾ -1 cup juice 150g rind (1/3 lb) for pectin
Prep	3 cups cascara	Yields <1/2 cups juice
Add Pectin	Use 1/4 cup pectin per cup cascara:	1/8 cup (2 tbsp)
Add Lemon	Enough lemon for max food safe pH of 4.6	Add 2 tbsp lemon juice for pH 3.85 Yield 114g (cascara juice + lemon juice + pectin)
Add Sugar	3 : 4 ratio sugar : juice by weight	85.5g cane sugar
Yields ½ jar that jelled , but denser/less light & gelatinous than Trial 9		

Trials 11-13—Varying Pectin 1:2, 1:4 & 1:8 Pectin : Juice—6/25/21 For Coffee Center Site Dedication Sensory Survey		
Follow steps sequentially from Trials 1-10 except where noted below		
Step	**Details**	**Measurements/Yield**
1:2 Pectin : Juice (Sample 201)		
Boil	Boil cascara in water 10 mins	Yields 1 cup juice, Brix: 17
Pectin	Add ½ cup pectin	
Lemon	Add 9 tbsp lemon juice for adequate pH	Yields 2 cups (405g) Brix: 11 pH 3.34
Sugar	Add ¾ demerara sugar by weight	303.75g Demerara
Yields 2 jars with great consistency		
1:4 Pectin : Juice (Sample 365)		

Boil	Boil cascara in water 10 mins	Yields >1 cup juice, Brix: 17
Pectin	Add ¼ cup pectin	
Lemon	Add 13 tbsp lemon juice for pH as close as possible to 201 (without lemon overpowering)	Yields 2 cups (400g) Brix: 11 pH 3.79
Sugar	• Add ¾ demerara sugar by weight: 300g	
Yields 2 jars with dense/sticky consistency, but still well gelled		
1:8 Pectin : Juice (Sample 978)		
Boil	Boil cascara in water 10 mins	Yields 1 cup juice, Brix: 17
Pectin	Add ⅛ cup (2 tbsp) pectin	
Lemon	Add 11 tbsp lemon juice for pH as close as possible to 201 & 365 (without lemon overpowering)	Yields <2 cups (345g) pH 3.59
Sugar	Add ¾ demerara sugar by weight	258.8g Demerara
Yields 1.75 jars with syrupy consistency		
Trials 14 & 15—Varying Pectin 1:2 & 1:8 Pectin : Juice—7/12/21 **For Trader Joe's Sensory Survey**		
Follow steps sequentially from Trials 1-13 except where noted below 1:2 pectin calculations • X cup / 0.25 cups lemon juice = 262g pectin rind / 226.8g pectin = 0.29 = ⅓ cups lemon juice • X cups water / 2 cups water = 262g rind / 226.8g rind = 2.3 = 2 ⅓ cups water 1:8 pectin calculations • 6 lemons makes ⅞ cups juice • 3 lemons makes ¼ cup pectin (101g rinds only) ○ X cup / 0.25 cups lemon juice = 101g pectin rind / 226.8g pectin = 0.111 cups lemon juice • 2 tbs lemon juice • 0.89 cups water / 2 cups water = 101g / 226.8g		
Step	**Details**	**Measurements/Yield**
1:2 Pectin : Juice (Sample 201)		

Boil	Boil cascara in water 14 mins (1-3 mins w/ lid on)	Yields 1.5 cup juice (373g), Brix: 12 (didn't boil enough?)
Pectin	Add ¾ cup pectin	
Lemon	Add 9 tbsp lemon juice for adequate pH	Yields >2 cups (533g) Brix: 11 pH 3.29
Sugar	Add ¾ demerara sugar by weight	400g
Yields 3 jars that are slightly less gelled than usual		
1:8 Pectin : Juice (Sample 978)		
Boil	Boil cascara in water 14 mins (first few w/ lid)	Yields 1 cup (231g) juice Brix: 16
Pectin	Add ⅛ cup (2 tbsp) pectin	
Lemon	Add 5 tbsp lemon juice (pectin was much more concentrated than usual, thus higher pH)	Yields > 2 cups (300g) pH 3.51
Sugar	Add ¾ demerara sugar by weight	225g
Yields 1.5 jars (notas syrupy/more gelled than it was supposed to be)		

2. Jelly Recipe - Visual Guide: English Espanol **Video: https://youtu.be/qJVhmn2om0w**

3. Informal Sensory Survey Results (UCD Coffee Center 4/15/21)

- Ingredients: Demerara sugar, organic cascara, lemon juice, water, pectin, calcium
- Made 4/12/21
- Total survey responses: 7

Liking

What is your OVERALL OPINION of this sample? (circle your answer):

Extremely Dislike	Dislike Very Much	Moderately Dislike	Slightly Dislike	Neither Like nor Dislike	Slightly Like	Moderately Like ||||	Like Very Much |	Extremely Like ||

How much do you like or dislike the APPEARANCE of this sample? (circle your answer):

Extremely	Dislike	Moderately	Slightly	Neither	Slightly	Moderately	Like Very	Extremely

Dislike	Very Much	Dislike	Dislike	Like nor Dislike ||	Like |	Like ||	Much ||	Like

How much do you like or dislike the FLAVOR of this sample? (circle your answer):

Extremely Dislike	Dislike Very Much	Moderately Dislike	Slightly Dislike	Neither Like nor Dislike	Slightly Like	Moderately Like |||	Like Very Much ||	Extremely Like ||

How much do you like or dislike the MOUTHFEEL of this sample? (circle your answer):

Extremely Dislike	Dislike Very Much	Moderately Dislike	Slightly Dislike	Neither Like nor Dislike	Slightly Like ||	Moderately Like ||	Like Very Much |||	Extremely Like

Adequacy of Select Attributes – Just-About-Right (JAR) Scaling

Flavor (Aroma, Taste & Trigeminal) – Please indicate how you feel about the flavor of the jelly (circle your answer):

Much Too Weak	Somewhat Too Weak |	Just About Right |||||	Somewhat Too Strong |	Much Too Strong

Acidity - Please indicate how you feel about the acidity of the jelly (circle your answer):

Much Too Low	Somewhat Too Low	Just About Right |||||	Somewhat Too High ||	Much Too High

Sweetness - Please indicate how you feel about the sweetness of the jelly (circle your answer):

Much Too Sweet |	Somewhat Too Sweet |||	Just About Right |||	Somewhat Too Sour	Much Too Sour

Consistency - Please indicate how you feel about the consistency of the jelly (circle your answer):

Much Too Thin/Runny	Somewhat Too Thin/Runny |||||*	Just About Right |	Somewhat Too Thick/Gelled ||*	Much Too Thick/Gelled

**"both (inconsistent)"

Description of the Jelly – Check-All-That-Apply (CATA)

From the list of attributes/features in each category below, please circle all that apply to this jelly:

Flavor (Aroma, Taste & Trigeminal)

Fruity ||||| ||	Vegetal
Citrus ||||| |	Floral ||
Red Berry |	Earthy
Cherry |||	Sugar |||||
Stone Fruit ||	Caramel/Brown Sugar |||
Grape ||||	Molasses
Apple |||	Maple |
Fig ||	Honey ||||
Date ||	**Other**: ● Lemon & lime ● Marmalade ● Lemon

Body/Mouthfeel

Smooth |||	Viscous ||||	Thin ||
Grainy |	Sticky ||||	Syrupy |||||
Clumpy |	Gelatinous	Thick ||
Other:		

Holistic/Hedonic

Aromatic II	Balanced/Blended IIIII	Bland/Flat
Complex III	**Other:**	

Defects

Rancid/Rotten	Fermented II	Burnt
Medicinal I	**Other:** • Vinegary aroma specifically; fermented/vinegary aroma - not off putting to me but maybe to others	

Open Comments

What specifically did you **like** about this jelly:

- The fruity flavor was refreshing and sharp, I liked the texture, good balance of sweet and sour
- Balance between sweet and tart, lemon was not overpowering, good aromatics
- Surprised! First time trying coffee cherry jam, tastes like some kind of berry jam. I like the complexity and fresh feeling fruity flavor.
- I liked that it was smooth and overall had a nice flavor that wasn't too overpowering in any way.
- Flavor was clean and very fruity, like a marmalade. Very sweet which was balanced in flavour.
- Sour/sweet contrast, overall flavor is great
- I like that its citrusy w/ lemon. I like the complex fruity.

What specifically did you **dislike** about this jelly:

- Almost had an astringent aftertaste, color was a little dull but not too off-putting
- A bit more syrupy/runny than I like, I want to be able to put it on a cracker without dripping
- Too sweet
- I thought it was more syrupy than most jellies and was a tad too sweet
- It is not a jam, not a jelly. It's in the in between
- A little too sweet, also too runny. It has an almost candy-like feel, where I would feel bad if I ate a lot.
- It would be better if the mouthfeel was more consistent. The lumpy clumps feel weird in my mouth.

Other Comments:

- Amazing product overall!
- Thank you!
- Better than any jelly I've ever had. Smells like sugar!

4. Formal Sensory Survey (UCD Coffee Center Site Dedication Event 6/25/21)

Survey was distributed through a QR code at the sampling booth. Paper surveys were offered as well in the following format:

Cascara Jelly Sensory Survey

Cascara Jelly Ingredients: organic cascara juice, demerara sugar, water, lemon juice, lemon pectin
Sample batches made on: 6/23/21

Taste-testing instructions: Please taste one spoonful of the jelly sample indicated on the survey (201, 978, 365) alone or on a cracker. Drink water and/or eat a cracker in between each sample. You may taste the sample again throughout the survey if necessary. Answer the following questions:

Liking

What is your OVERALL OPINION of the sample? (Mark the box you choose):

Extremely Dislike	Dislike Very Much	Moderately Dislike	Slightly Dislike	Neither Like nor Dislike	Slightly Like	Moderately Like	Like Very Much	Extremely Like

How much do you like or dislike the APPEARANCE of the sample? (Mark the box you choose):

Extremely Dislike	Dislike Very Much	Moderately Dislike	Slightly Dislike	Neither Like nor Dislike	Slightly Like	Moderately Like	Like Very Much	Extremely Like

How much do you like or dislike the FLAVOR of the sample? (Mark the box you choose):

Extremely Dislike	Dislike Very Much	Moderately Dislike	Slightly Dislike	Neither Like nor Dislike	Slightly Like	Moderately Like	Like Very Much	Extremely Like

How much do you like or dislike the MOUTHFEEL of the sample? (Mark the box you choose):

Extremely Dislike	Dislike Very Much	Moderately Dislike	Slightly Dislike	Neither Like nor Dislike	Slightly Like	Moderately Like	Like Very Much	Extremely Like

Adequacy of Select Attributes

Flavor – Please indicate how you feel about the flavor of the jelly sample (Mark the box you choose):

Much Too Weak	Somewhat Too Weak	Just About Right	Somewhat Too Strong	Much Too Strong

Acidity - Please indicate how you feel about the acidity of the sample (Mark the box you choose):

Much Too Low	Somewhat Too Low	Just About Right	Somewhat Too High	Much Too High

Sweetness - Please indicate how you feel about the sweetness of the sample (Mark the box you choose):

Much Too Low	Somewhat Too Low	Just About Right	Somewhat Too High	Much Too High

Consistency - Indicate how you feel about the consistency of the sample (Mark the box you choose):

Much Too Thin/Runny	Somewhat Too Thin/Runny	Just About Right	Somewhat Too Thick/Gelled	Much Too Thick/Gelled

Description of the Jelly

From the list of attributes/features in each category below, mark all boxes that apply to the sample:

Flavor (Aroma, Taste & Trigeminal)

Fig	Apple	Raisin	Honey
Citrus	Plum	White Sugar	Vegetal
Red Berry	Grape	Caramel/Brown Sugar	Floral
Cherry	Date	Molasses	Earthy
Stone Fruit	Dried Fruit	Maple	**Other**:

Body/Mouthfeel

Smooth	Viscous	Thin	**Other:**
Grainy	Sticky	Syrupy	
Clumpy	Gelatinous	Thick	

Holistic/Hedonic

Aromatic	Balanced/Blended	Bland/Flat	Complex	**Other:**

Defects

Rancid/Rotten	Fermented	Burnt	Medicinal	**Other:**

Open Comments

What specifically did you **like** about this jelly:

What specifically did you **dislike** about this jelly:

Other Comments:

5. Sensory Survey Consent Form

University of California, Davis

INFORMED CONSENT FORM FOR PARTICIPATING IN:
Sensory Evaluation and Marketing Research

Title of study: Potential Economic & Environmental Benefits of Upcycling Coffee Byproducts: A Feasibility Study of Cascara Jelly Production on Smallholder Farms in Huehuetenango, Guatemala and Negros, Philippines.

Investigators: Melina Devoney and Timothy Buensalido

Introduction and Purpose
You are being invited to join a research study of cascara jelly sensory and marketing evaluation. The purpose of this study is to determine the feasibility of cascara jelly production for smallholder farmers in Huehuetenango, Guatemala and Negros, Philippines.

If you agree to participate in this research, you will be asked to taste cascara jelly samples and complete a survey. The survey includes questions about the samples and about your thoughts on cascara jelly and similar products. It will take about 10 minutes to complete the survey.

Benefits and Risks
There is no direct benefit to you from taking part in this study. We hope that the research will share insight on the potential of upcycling some waste generated during coffee production, increasing farmer income and lessening environmental impacts of cascara waste.

The risks of this research are minimal. If you have prior experience of any allergic reactions to any of the cascara jelly ingredients, you should not participate in this study. If you experience allergic reactions any time during the study, you should discontinue the study. Cascara jelly may contain caffeine. Other ingredients of the cascara jelly are listed here and on the survey: organic cascara juice, demerara sugar, water, lemon juice, lemon pectin.

You may skip any of the survey questions you do not want to answer. You are free to withdraw from the study at any time and for any reason. We also reserve the rights to terminate your participation of the study at any time and for any reason.

Confidentiality
As with all research, there is a chance that confidentiality could be compromised; however, we are taking precautions to minimize this risk. Your responses to the survey questions will not include information that identifies you. However, individuals from UC Davis who oversee research may access your data during audits or other monitoring activities.

To minimize the risks of breach of confidentiality, we will not ask questions that identifies participants' identity. Data collected will be accessed only by principal researchers and immediate major professors overseeing the project.

Compensation
You will not be paid for taking part in this study.

Rights
Participation in research is completely voluntary. You are free to decline to take part in the project. You can decline to answer any questions and you can stop taking part in the project at any time. Whether or not you choose to participate, or answer any question, or stop participating in the project, there will be no penalty to you or loss of benefits to which you are otherwise entitled.

Questions
If you have any questions about this research, please feel free to contact the investigators at +1 213-804-0231/ +1 443-642-1464 or mldevoney@ucdavis.edu/timbuensalido@ucdavis.edu.

If you have any questions about your rights or treatment as a research participant in this study, please contact the University of California Davis, Institutional Review Board at 916-703-9158 or HS-IRBEducation@ucdavis.edu.

Consent for adult participants (over 18 years old)
I have read and understand the above information and voluntarily consent to participate in this study. I have been given a copy of this consent form.

_____
Name (Print)

_____ _____
Signature Date

Parental/Guardian consent (for children under 18 years old).
I have read and understand the above consent form and voluntarily agree that my child may participate in this study.

_____
Parent/Guardian Name (Print)

_____ _____
Parent/Guardian Signature Date

6. Compiled Sensory Survey Results

7. Farmer Feasibility Study

7. a. Key Informant Instructions (Spanish)

Saludos _____,

Aquí están las direcciones para la encuesta de jalea de cáscara:

1. Favor de leer y firmar el Consentimiento Informado.
2. Lea la receta de jalea, confirme que los cafeteros puedan comprar o acceder a todos los ingredientes y equipos través de ASOBAGRI. Estime el costo de todo el equipo en su Hoja de tiempos. No necesita comprar los ingredientes o equipos.
3. Saque el dinero en efectivo para pagar a los participantes. Cada participante recibirá 77 GTQ. Guarde todos los recibos y envíeme fotos de ellos.
4. Registre sus horas y costos en la hoja de cálculo, para que pueda pagarle (108.28 GTQ por hora). El reembolso lo recibirá a través de una transferencia bancaria de Remitly.
5. Distribuya las encuestas a los cafeteros, tostadores y procesadores de ASOBAGRI. Es posible que deba leer el formulario de consentimiento y la encuesta a algunos participantes. _____ también distribuirá encuestas, así que asegúrese de que ustedes dos no encuesten al mismo participante dos veces.
6. Su pago lo recibirá una vez que crea que haya terminado con las encuestas y me haya enviado los resultados.
7. Si le interesa, puedo incluirlo a usted y a ASOBAGRI como colaboradores en la publicación del proyecto.

He adjuntado los siguientes documentos:
-La Encuesta (por favor, avíseme si los participantes tienen alguna duda o pregunta)
-Su Formulario de Consentimiento
-El Formulario de Consentimiento de los Participantes
-La Receta de Jalea

¿Puede imprimir una receta y un formulario para cada participante de la encuesta?
Por favor, imprima la receta en color, si es posible.

Muchas Gracias!
Melina

7.b. Key Informant Informed Consent (Spanish)

Universidad de California, Davis

FORMULARIO DE CONSENTIMIENTO INFORMADO
DE INFORMANTES PRINCIPALES PARA PARTICIPAR EN:
Encuesta de Viabilidad

Título del estudio: Potential Economic & Environmental Benefits of Upcycling Coffee Potencial económico y beneficios ambientales del reciclaje del café Byproducts: A Feasibility Study of Cascara Jelly Production on Smallholder Farms in Huehuetenango, Guatemala.

Investigadores: Melina Devoney y Timothy Buensalido

Introducción y Propósito

Usted está siendo invitado a unirse a un estudio de investigación de la producción de jalea de cáscara de café. El objetivo de este estudio es determinar la viabilidad de la producción de jalea de cáscara para las familias de pequeños agricultores en Huehuetenango, Guatemala. Si acepta participar en esta investigación, se le pedirá que imagine que producirá la jalea de cáscara descrita en la receta proporcionada. Se le pedirá que estime los costos de los ingredientes y el equipo, y la facilidad con la que podría adquirirlos.

A continuación, se le pedirá que complete una encuesta de viabilidad que incluye preguntas sobre su opinión sobre la jalea de cáscara. La encuesta le tomará aproximadamente 10 minutos. Se le pedirá que distribuya la encuesta a tantos trabajadores en el sector del café que deseen participar. Cada participante tendrá que leer y firmar un formulario de consentimiento antes de completar la encuesta.

Beneficios y Riesgos

El beneficio directo para usted de participar en este estudio es un salario de 108.28 GTQ por hora. El dinero se le enviará directamente a usted electrónicamente a través de Remitly (un método de transferencia bancaria). Se le permite utilizar esta receta para cualquier propósito que elija, ya que no está patentada.

Los riesgos de esta investigación son mínimos. Puede omitir cualquiera de las preguntas de la encuesta que no desee responder. Usted es libre de retirarse del estudio en cualquier momento y por cualquier motivo. También nos reservamos el derecho de terminar su participación en el estudio en cualquier momento y por cualquier motivo.
Es importante destacar que sus respuestas a la encuesta con respecto a su capacidad y deseo de hacer la jalea de cáscara NO afectarán su compensación, ni comprometen el éxito de este estudio. Esperamos que su cooperación proporcione información sobre el potencial de reciclaje de residuos generados durante la producción de café para aumentar los ingresos de los agricultores y disminuir los impactos ambientales de los residuos de cáscara en su comunidad, por lo que queremos que los datos sobre los éxitos y fracasos de la producción de jalea sean precisos.

Confidencialidad

Usted puede solicitar que no se divulgue su nombre y/o información de identificación. Sus respuestas a la encuesta no incluirán información que lo identifique, excepto su país de residencia y su afiliación a ASOBAGRI. Sin embargo, las personas de la Universidad de California, Davis que supervisan la investigación pueden acceder a sus datos durante las auditorías u otras actividades de monitoreo. Los datos recopilados solo serán accedidos por los investigadores y los profesores principales inmediatos que supervisan el proyecto.

Derechos

La participación en la investigación es completamente voluntaria. Usted es libre de negarse a participar en el proyecto. Puede negarse a responder a cualquier pregunta y puede dejar de participar en el proyecto en cualquier momento. Ya sea que elija o no participar, o responder a cualquier pregunta, o dejar de participar en el proyecto, no habrá ninguna penalización para usted o pérdida de beneficios a los que tiene derecho.

Preguntas

Si tiene alguna pregunta sobre esta investigación, no dude en ponerse en contacto con la investigadora al correo mldevoney@ucdavis.edu.

Si tiene alguna pregunta sobre sus derechos o su papel como participante de la investigación en este estudio, comuníquese con la Junta de Revisión Institucional de la Universidad de California Davis al 916-703-9158 o HS-IRBEducation@ucdavis.edu.

Consentimiento para participantes adultos (mayores de 18 años)

He leído y entiendo la información anterior y doy mi consentimiento voluntario para participar en este estudio. He recibido una copia de este formulario de consentimiento.

_____

Nombre (Imprimir)

_____ _____

Firma Fecha de firma

7.c. Farmery Feasibility Survey Participants Informed Consent (Spanish)

Universidad de California, Davis

FORMULARIO DE CONSENTIMIENTO INFORMADO DE PARTICIPANTES GUATEMALTECOS PARA PARTICIPAR EN: Encuesta de Viabilidad

Título del estudio: Potential economic & environmental benefits of upcycling coffee byproducts: A feasibility study of cascara jelly production on smallholder farms in Huehuetenango, Guatemala.

Investigadores: Melina Devoney y Timothy Buensalido

Introducción y propósito

Usted está siendo invitado a unirse a un estudio de investigación de la producción de jalea de cáscara de café. El propósito de este estudio es determinar la viabilidad de la producción de jalea de cáscara para familias de pequeños agricultores en Huehuetenango, Guatemala.
Si acepta participar en esta investigación, se le pedirá que imagine que hará la jalea de cáscara como se describe en la receta proporcionada. A continuación, se le pedirá que complete una encuesta de viabilidad que incluye preguntas sobre su opinión sobre la jalea de cáscara. La encuesta le tomará aproximadamente 10 minutos.

Beneficios y Riesgos

El beneficio directo para usted de participar en este estudio es un pago único de 77 GTQ en efectivo desembolsado a usted por el distribuidor de la encuesta. Se le permite utilizar esta receta para cualquier propósito que elija, ya que no está patentada.

Los riesgos de esta investigación son mínimos. Puede omitir cualquiera de las preguntas de la encuesta que no desee responder. Usted es libre de retirarse del estudio en cualquier momento y por cualquier motivo. También nos reservamos el derecho de terminar su participación en el estudio en cualquier momento y por cualquier motivo.
Es importante destacar que sus respuestas a la encuesta con respecto a su capacidad y deseo de hacer la jalea de cáscara NO afectarán su compensación, ni comprometen el éxito de este estudio de viabilidad. Esperamos que su participación proporcione información sobre el potencial de reciclaje de residuos generados durante la producción de café para aumentar los ingresos de los agricultores y disminuir los impactos ambientales de los residuos de cáscara en su comunidad. Por lo tanto, queremos que los datos sobre los éxitos y fracasos de la producción de jalea sean precisos.

Confidencialidad

Usted puede solicitar que no se divulgue su nombre y/o información de identificación. Sus respuestas a la encuesta no incluirán información que lo identifique, excepto información sobre su país de residencia y su afiliación de ASOBAGRI, si aplica. Sin embargo, las personas de la Universidad de California, Davis que supervisan la investigación pueden acceder a sus datos durante las auditorías u otras actividades de monitoreo. Los datos recopilados solo serán accedidos por los investigadores y los profesores principales inmediatos que supervisan el proyecto.

Derechos

Su participación en la investigación es completamente voluntaria. Usted es libre de negarse a participar en el proyecto. Puede negarse a responder a cualquier pregunta y puede dejar de participar en el proyecto en cualquier momento. Ya sea que elija o no participar, o responder a cualquier pregunta, o dejar de participar en el proyecto, no habrá ninguna penalización para usted o pérdida de beneficios a los que tiene derecho.

Preguntas

Si tiene alguna pregunta sobre esta investigación, no dude en ponerse en contacto con la investigadora en: mldevoney@ucdavis.edu.

Si tiene alguna pregunta sobre sus derechos o tratamiento como participante de la investigación en este estudio, comuníquese con la Junta de Revisión Institucional de la Universidad de California Davis al 916-703-9158 o HS-IRBEducation@ucdavis.edu.

Consentimiento para participantes adultos (mayores de 18 años)

He leído (o me han leído este formulario de consentimiento) y entiendo la información anterior y me consiento voluntariamente para participar en este estudio. Me han entregado una copia de este formulario de consentimiento y he recibido mi pago de 77 GTQ en efectivo.

_____

Nombre (Imprimir)

_____ _____

Firma Fecha de firma

Consentimiento parental o del tutor (para niños menores de 18 años).

He leído (o tenía este formulario de consentimiento leído a mí) y entiendo el formulario de consentimiento anterior y estoy de acuerdo en que mi hijo(a) participe de manera voluntaria en este estudio. Me han entregado una copia de este formulario de consentimiento y mi hijo(a) ha recibido su pago de 77 GTQ en efectivo.

_____

Nombre del padre/tutor (imprimir)

_____ _____

Firma Fecha de firma

7.d. Farmer Feasibility Survey (Spanish)

Jalea de Cáscara Encuesta de Viabilidad

¡Muchas gracias por participar! Sus respuestas honestas serán de gran ayuda para nuestra investigación.

¿Cuál es su ocupación? Marque todas las casillas que apliquen:

☐Cafetero (mi cultivo principal es café) ☐Granjero (mi cultivo principal no es café)

☐Tostador de café ☐ Procesador de café

☐Otro (descríbalo aquí): _____

¿Es miembro de alguna cooperativa?

☐Sí (nómbrela aquí): _____ ☐No

¿Qué tan grande es el área de la granja / instalación que posee o en la que trabaja (dimensiones específicas o descripción general)?

¿Cuál es su papel en esta granja / instalación?
☐Soy el propietario
☐Soy un empleado
☐ Ayudante voluntario o aprendiz (trabajo sin pago)
☐Otro (descríbalo): _____

¿Cuántas personas trabajan en esta granja / instalación?
☐Menos de 5 ☐5 – 10 ☐10 – 50 ☐50 -100 ☐Más de 100

Considerando la receta de jalea, ¿Consideraría producir esta jalea en su casa/granja/instalación? Marque todas las casillas que correspondan:
☐Sí, para mi familia
☐Sí, para vender localmente
☐Sí, para exportar
☐No (por favor explique porqué en las preguntas siguientes)

¿Dónde cocinaría la jalea? Marque todas las casillas que correspondan:
☐Una casa
☐Una granja
☐Una instalación (explique):_____
☐Una cooperativa (nómbrela):_____
☐Otro (explique):_____

¿Cuántas personas en esta granja / instalación podrían potencialmente ayudarle a hacer la jalea de cáscara?
☐Menos de 5 ☐5 – 10 ☐10 – 50 ☐50 -100 ☐Más de 100

¿Qué tan clara y comprensible le pareció esta receta?
☐Todo es fácil de seguir y comprender
☐Algunos pasos no están claros o son difíciles de entender
☐La mayoría de los pasos no están claros o son difíciles de entender.

Si aplica, ¿qué pasos en la receta de jalea le parecen difíciles de seguir?

¿Qué problemas crees que encontrarías al hacer esta receta?

¿Cuánto tiempo extra tendrías en un día de trabajo típico para hacer esta jalea? (sin o con la ayuda de otros)?

¿Cómo podría adaptar esta receta para que sea factible para usted?

¿Tiene acceso a suficiente agua limpia para realizar todos los pasos de lavado / esterilización en la receta? Marque todas las casillas que correspondan:
☐Sí, en la casa
☐Sí, en la granja
☐Sí, en la instalación
☐Sí, en la cooperativa
☐No

¿Qué subproductos o desperdicios podría generar esta receta?

¿Qué está haciendo actualmente con sus restos de pulpa de café? Marque todas las casillas que correspondan:
☐Mezclarlo en composta para uso agrícola
☐Tirar en tierra vacante
☐Tirar en agua
☐Alimentar al ganado
☐No aplica
☐ Otro: _____

¿Qué otra información necesitaría saber para decidir si consideraría hacer jalea de cáscara en lugar de continuar lo que hace actualmente con la cáscara?

Preguntas demográficas: Puede dejar respuestas en blanco si no se siente cómodo(a) respondiendo.

Indique su sexo:

☐Femenino ☐Masculino ☐Otro: _____

Indique su rango de edad:
☐Menor de 18 ☐18-24 ☐25-34 ☐35-44 ☐45-54
☐55-64 ☐65+

¿En qué región de Huehuetenango vive?

Indique su nivel de educación más alto completado:
☐Ninguno ☐Escuela primaria ☐Escuela secundaria
☐Alguna universidad / escuela profesional ☐Título universitario / profesional
☐Título de posgrado ☐Prefiero no contestar

8. Budget

8.a. Jastro Project Budget

8.b. Recipe Trials Budget

Yeild: 24-40 (8oz) jars	**# needed**	**Unit price ($)**	**Cost ($)**	**Notes**
Canning rack + tongs	1	18	18	
8oz jam jars w/lids (20 count)	3	32	96	
Oakton pHTestr® 50 Pocket Tester	1	N/A	N/A	property of Coffee Center
Ozeri digital kitchen scale		N/A	N/A	property of CC.
Hand held refractomer (ATC*)	1	N/A	N/A	property of CC
Kim wipes (Kimtech)	1	N/A	N/A	property of the CC. (To clean refractometer)
Potato masher/mixing spoon, lemon juicer, x-large & small pot (stainless steel or aluminum)	1	N/A	N/A	property of M. Devoney
Food mill (to depulp beans)	1	25	25	Not used for final recipe
Sugar (64oz/4lbs/8 cups) - need 12 cups	2	3.5	7	
Sugar 10lb	1	15.85	15.85	

Panela/demerara sugar (10lbs)	1	29	29	Locally accessible white sugar substitute in Guatemala
non-iodized canning salt (4 lbs)	1	10	10	
Lemons (criollo, persa, and/or calamansi)*	3	0.5	1.5	Locally accessible pectin substitute in Guatemala
Powdered pectin (2 x (1.1oz, makes 22 8oz jars))	1	9	9	Not used in final recipe
Total			**211.35**	

8.c. Key Informant Budget & Equipment List

Hoja de tiempos y gastos

				108.2	GTQ/hora
Trabajo	**Fecha**	**Actividad**	**Horas**	**Pago diario**	**Pago total**
Ejemplo	*6 de junio*	*recoger cascara de la finca*	*1*	*108.2*	
				0	
				0	
Gastos	**Equipo/ ingrediente**	**Uso**	**Costo (GTQ)**	**Gastos Totales**	
Ejemplo	*escala de alimentos*	*pesar ingredientes*	*5*		
6 tazas cáscara (fresca o congelada)					
2 limones y/o limas medianos o largos (con una corteza de limón espesa)					
Azúcar (Demerara y/o de caña)					
Agua limpia					
Olla grande (~10L no reactiva) (acero inoxidable o recubierta esmaltado) con tapa					
Recipiente no reactivo mediano (acero inoxidable, vidrio o esmaltado)					
Colador de tela o metal fino					
Batidor o espátula					
Tenazas					

Temporizador					
Frascos (se puede lavar y reutilizar)					
Tapas (siempre debe usar nuevas)					
Estante de conservas o canasta vaporera					
Zester de cítricos, pelador de verduras y / o cuchillo afilado					
Fuente de calor alto (estufa o fuego)					
Escala de alimentos					
Jabón para platos					
Tazas medidoras, cucharas medidoras					
Alcohol isopropílico					
Tenedor y cuchara metales					
Vaso transparente (vidrio o plástico)					
lápiz/marcador y etiqueta					
cucharas para probar para participantes					
opcional: medidor de pH					
opcional: medidor de pH					

9. Ruminant Feed Methane Materials & Methods

Anderson, E. & Hess, M. (2021) [Unpublished]

In-vitro Feed and Agricultural Product Collection and Preparation:

In this experiment, dry cow total mixed ration (TMR; 50% wheat hay, 25% alfalfa hay, 21.4% almond hulls, and 3.6% mineral pellet), a common dairy cow diet, was used for feed. The TMR was oven-dried at 55ºC for 72 hours and ground to ~2mm. *Asparagopsis taxiformis* seaweed, provided by the Commonwealth Scientific and Industrial Research Organization (CSIRO) Australia, was used as a positive control due to its methane-reducing efficacy as a feed additive in Roque et al. (2019). Agricultural waste products (at inclusion rates of 2, 5, 10%) and seaweed (at a 5% inclusion rate) were

measured on a Mettler AE200 (Mettler Toledo, Columbus, OH, United States). Dry cow ration was weighed on a Mettler Toledo PB1502-5.

Rumen Fluid Collection:

All animal procedures were performed with the accordance of the Institutional Care and Use Committee (IACUC) at the University of California, Davis, under protocol number 21117. Rumen fluid was collected from one rumen fistulated Holstein cow housed at the UC Davis Dairy facility. The donor cow was fed a dry cow TMR. Four liters of rumen fluid were collected 90 minutes after feeding. Rumen fluid was collected via transphonation using a perforated PVC pipe, a 500 mL dosing syringe, and Tygon tubing (Saint-Gobain North America, PA, United States). Fluid was strained through a colander into two 4 L pre-warmed, vacuum-insulated thermos containers and transported to the laboratory.

Experimental Design:

General Overview: For each run, rumen fluid was homogenized with an artificial saliva buffer in a 3:1 ratio. After homogenization, 75 mL of the mixture was added to each 100 mL serum bottle that contained 1 g of dried, ground TMR feed and the appropriate dosage level of feed additive (2, 5, or 10%). The vessel was shaken by hand to homogenize the dry and liquid components and sealed with a perforated rubber stopper (size 00) that was connected via Tygon plastic tubing (3/16” inner diameter, 5/16” outer diameter) (Saint-Gobain North America, PA, United States) to 1L foil gas collection bags (Restek, United States). Vessels were placed in a Precision temperature-controlled circulating water bath at 39°C for 24 hours (Thermo Fisher Scientific, United States). Each water bath can contain up to 25 vessels; treatment vessels were assorted randomly to a grid location within the water baths. After the 24-hour run, the gas collection bags were detached from the serum bottle vessels so that gas analysis could be performed (see Greenhouse Gas Analysis section).

Greenhouse Gas Analysis:

Methane and carbon dioxide (CO_2) concentrations from the gas bags were measured using an SRI Gas Chromatograph (8610C, SRI, Torrance, CA, United States) fitted with a 3' x 1/8" stainless steel Haysep D Column and a flame ionization detector with methanizer (FID-met). The oven temperature was held at 90°C for 5 min. Carrier gas was high purity hydrogen at a flow rate of 30 mL/min. The FID was held at 300 °C. Depending on gas content, a 1mL to 10mL sample was diluted with high purity nitrogen to a total volume of 30mL of diluted sample that was injected directly onto the column. Calibration curves were developed with an Airgas certified CH_4 and CO_2 standard (Airgas, United States).

Sources:

Roque, B. M., C. G. Brooke, J. Ladau, T. Polley, L. J. Marsh, N. Najafi, P. Pandey, L. Singh, R.

Kinley, J. K. Salwen, E. Eloe-Fadrosh, E. Kebreab, and M. Hess. 2019. Effect of the macroalgae Asparagopsis taxiformis on methane production and rumen microbiome assemblage. Anim. Microbiome. 1:3. doi:10.1186/s42523-019-0004-4.

10. IRB Approval

UC DAVIS
OFFICE OF RESEARCH

OFFICE OF RESEARCH
IRB Administration
TELEPHONE: 916 703-9151

SACRAMENTO, CALIFORNIA 95817

June 21, 2021

Jim Hill, PhD
Department: Plant Sciences
Phone: 530-752-3458
Email: jehill@ucdavis.edu

On June 21, 2021 the UC Davis IRB reviewed the following protocol:

Type of Review:	New Project
Title:	Cascara Jelly, Jams, Syrup & Beverages
Investigator:	Hill, Jim, PhD
IRB ID:	1768032-1
Funding:	Department
Grant ID and Title:	None
IND, IDE or HDE:	N/A
Documents Submitted:	• Advertisement - Cascara Jelly Recruitment Material.docx • Application Form - IRB form.pdf • Consent Form - HRP-502-Consent-for-Survey-Interview-Research Devoney and Buensalido.docx • Protocol - HRP-503-TEMPLATE-PROTOCOL-Surveys-Questionnaires-Focus-Groups-Observations Devoney and Buensalido.docx • Questionnaire/Survey - Cascara Jelly Liking Survey.docx • Questionnaire/Survey - Cascara Jelly Farmer Survey-Interview.docx • Questionnaire/Survey - Cascara Jelly Tasting Survey.docx • UC Davis - Initial Review Application

Determination:	Exempt *[2]*
Comments/Conditions:	This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are being considered and there are questions about whether IRB review is needed, please submit a modification request to the IRB for another determination. In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

This Assurance, on file with the Department of Health and Human Services, covers this determination:

FWA No: 00004557
Expiration Date: January 05, 2024
IORG: 0000251